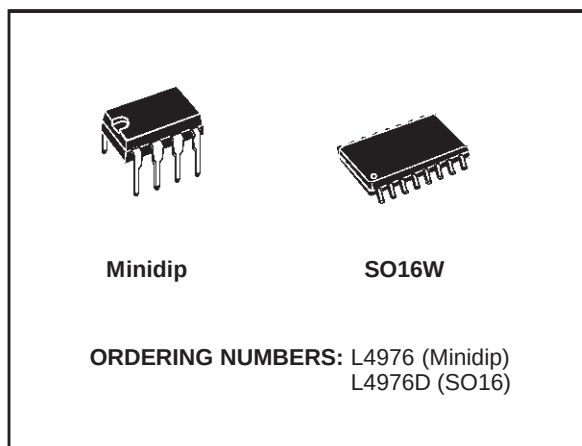


## 1A STEP DOWN SWITCHING REGULATOR

- UP TO 1A STEP DOWN CONVERTER
- OPERATING INPUT VOLTAGE FROM 8V TO 55V
- PRECISE 5.1V REFERENCE VOLTAGE
- OUTPUT VOLTAGE ADJUSTABLE FROM 0.5V TO 50V
- SWITCHING FREQUENCY ADJUSTABLE UP TO 300KHz
- VOLTAGE FEEDFORWARD
- ZERO LOAD CURRENT OPERATION
- INTERNAL CURRENT LIMITING (PULSE-BY-PULSE AND HICCUP MODE)
- PROTECTION AGAINST FEEDBACK DISCONNECTION
- THERMAL SHUTDOWN

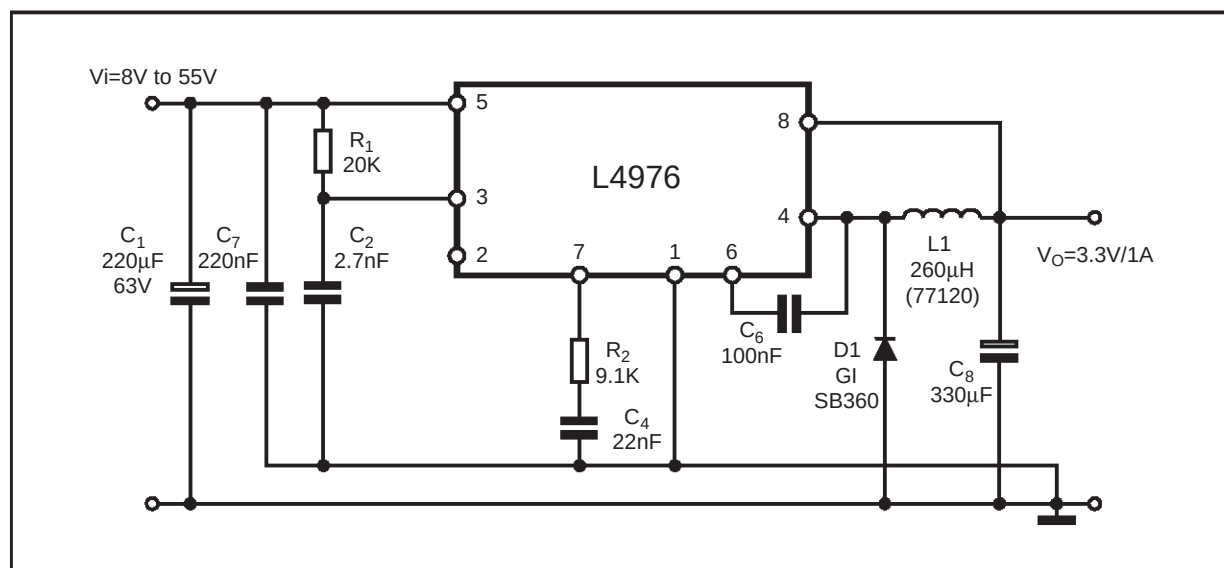
### DESCRIPTION

The L4976 is a step down monolithic power switching regulator delivering 1A at a voltage between 3.3V and 50V (selected by a simple external divider). Realized in BCD mixed technology, the device uses an internal power D-MOS transistor (with a typical  $R_{ds(on)}$  of  $0.25\Omega$ ) to obtain very high efficiency and high switching speed. A switching frequency up to 250KHz is achievable (the maximum power dissipation of the pack-

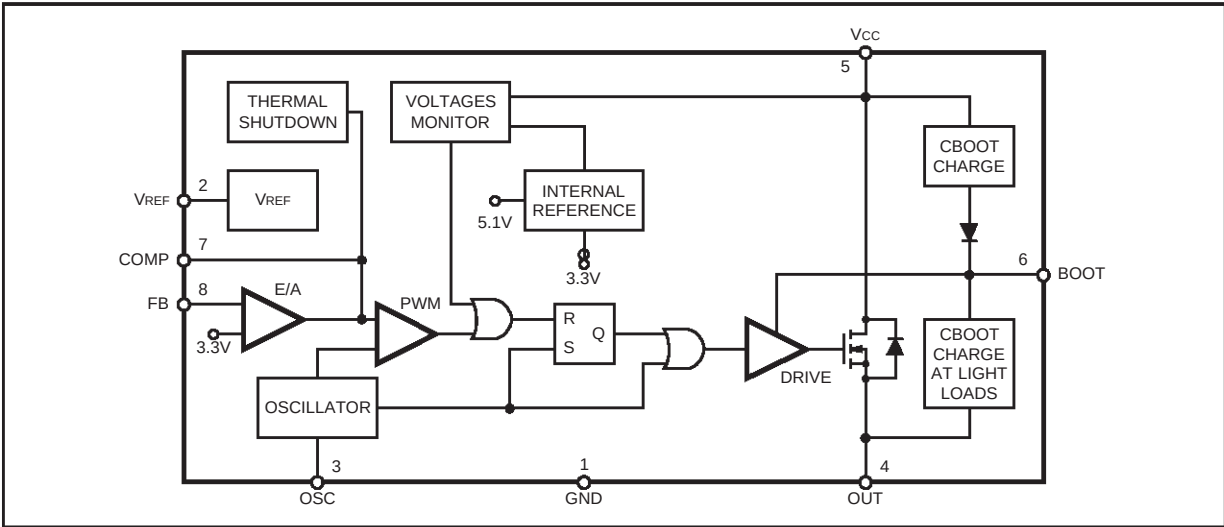


ages must be observed). A wide input voltage range between 8V to 55V and output voltages regulated from 3.3V to 40V cover the majority of today's applications. Features of this new generations of DC-DC converter include pulse-by-pulse current limit, hiccup mode for short circuit protection, voltage feedforward regulation, protection against feedback loop disconnection and thermal shutdown. The device is available in plastic dual in line, MINIDIP 8 for standard assembly, and SO16W for SMD assembly.

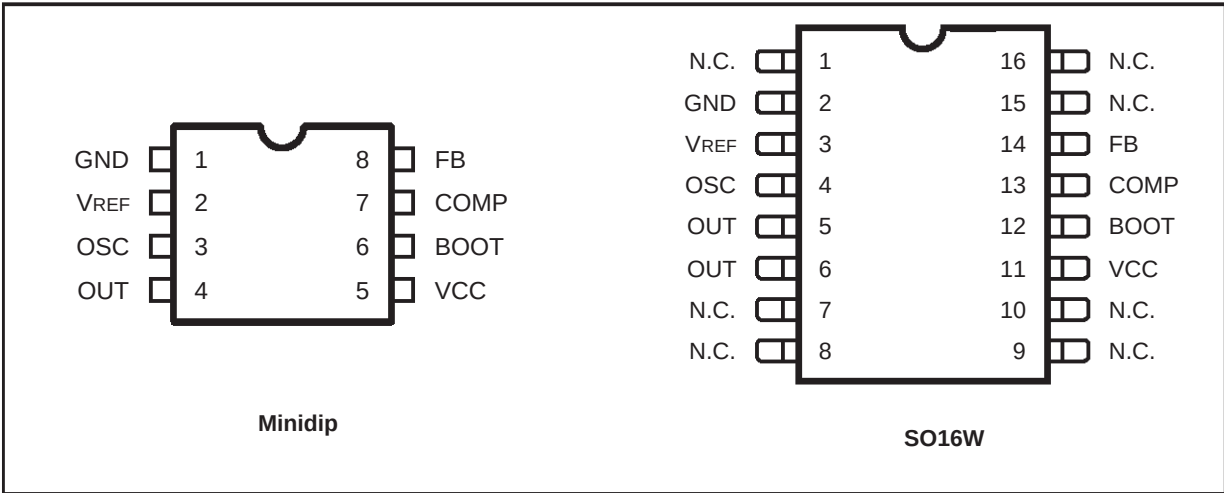
### TYPICAL APPLICATION CIRCUIT



# BLOCK DIAGRAM



# PIN CONNECTIONS



# PIN FUNCTIONS

| DIP | SO (*) | Name | Function                                                                                                                                                                                                       |
|-----|--------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | 2      | GND  | Ground                                                                                                                                                                                                         |
| 2   | 3      | VREF | 5.1V Reference voltage with 20mA current capability.                                                                                                                                                           |
| 3   | 4      | OSC  | An external resistor connected between the unregulated input voltage and this pin and a capacitor connected from this pin to ground fix the switching frequency. (Line feed forward is automatically obtained) |
| 4   | 5, 6   | OUT  | Stepdown regulator output                                                                                                                                                                                      |
| 5   | 11     | Vcc  | Unregulated DC input voltage                                                                                                                                                                                   |
| 6   | 12     | BOOT | A capacitor connected between this pin and OUT allows to drive the internal VDMOS                                                                                                                              |
| 7   | 13     | COMP | E/A output to be used for frequency compensation                                                                                                                                                               |
| 8   | 14     | FB   | Stepdown feedback input. Connecting directly to this pin results in an output voltage of 3.3V. An external resistive divider is required for higher output voltages.                                           |

(\*) Pins 1, 7, 8, 9, 10, 15 and 16 are not internally, electrically connected to the die.

## THERMAL DATA

| Symbol          | Parameter                              | Minidip     | SO16    | Unit |
|-----------------|----------------------------------------|-------------|---------|------|
| $R_{th(j-amb)}$ | Thermal Resistance Junction to ambient | Max. 90 (*) | 110 (*) | °C/W |

(\*) Package mounted on board.

## OPERATING TEMPERATURE RATING

| Symbol | Parameter                  | Value      | Unit |
|--------|----------------------------|------------|------|
| $T_J$  | Junction Temperature Range | -40 to 150 | °C   |

## ABSOLUTE MAXIMUM RATINGS

| Symbol                           |                                  | Parameter                                     | Value       | Unit   |   |
|----------------------------------|----------------------------------|-----------------------------------------------|-------------|--------|---|
| Minidip                          | S016                             |                                               |             |        |   |
| V <sub>5</sub>                   | V <sub>11</sub>                  | Input voltage                                 | 58          | V      |   |
| V <sub>4</sub>                   | V <sub>5</sub> ,V <sub>6</sub>   | Output DC voltage                             | -1          | V      |   |
|                                  |                                  | Output peak voltage at t = 0.1μs f=200KHz     | -5          | V      |   |
| I <sub>4</sub>                   | I <sub>5</sub> ,I <sub>6</sub>   | Maximum output current                        | int. limit. |        |   |
| V <sub>6</sub> -V <sub>5</sub>   | V <sub>12</sub> -V <sub>11</sub> |                                               | 14          | V      |   |
| V <sub>6</sub>                   | V <sub>12</sub>                  | Bootstrap voltage                             | 70          | V      |   |
| V <sub>7</sub>                   | V <sub>13</sub>                  | Analogs input voltage (V <sub>CC</sub> = 24V) | 12          | V      |   |
| V <sub>8</sub>                   | V <sub>14</sub>                  | (V <sub>CC</sub> = 20V)                       | 6<br>-0.3   | V<br>V |   |
| P <sub>tot</sub>                 |                                  | Power dissipation a T <sub>amb</sub> ≤ 60°C   | Minidip     | 1      | W |
|                                  |                                  |                                               | S016        | 0.8    | W |
| T <sub>j</sub> ,T <sub>stg</sub> |                                  | Junction and storage temperature              | -40 to 150  | °C     |   |

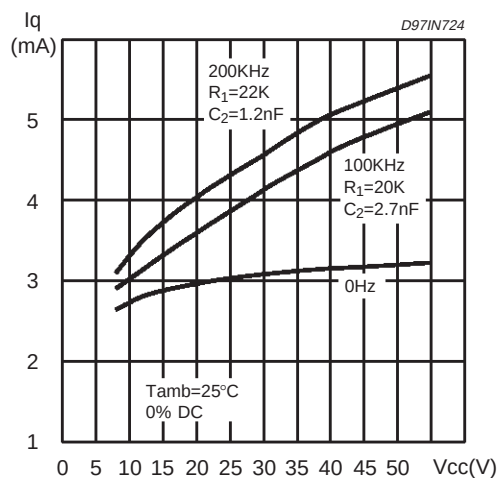
**ELECTRICAL CHARACTERISTICS** ( $T_J = 25^\circ C$ ,  $C_{osc} = 2.7nF$ ,  $R_{osc} = 20k\Omega$ ,  $V_{CC} = 24V$ , unless otherwise specified.) \* Specification Referred to  $T_J$  from 0 to  $125^\circ C$

| Symbol                        | Parameter                                | Test Condition                                                                  |   | Min.  | Typ. | Max.  | Unit |
|-------------------------------|------------------------------------------|---------------------------------------------------------------------------------|---|-------|------|-------|------|
| <b>DYNAMIC CHARACTERISTIC</b> |                                          |                                                                                 |   |       |      |       |      |
| $V_I$                         | Operating input voltage range            | $V_O = 3.3$ to $50V$ ; $I_O = 1A$                                               | * | 8     |      | 55    | V    |
| $V_O$                         | Output voltage                           | $I_O = 0.5A$                                                                    |   | 3.33  | 3.36 | 3.39  | V    |
|                               |                                          | $I_O = 0.2$ to $1A$                                                             |   | 3.292 | 3.36 | 3.427 | V    |
|                               |                                          | $V_{CC} = 8$ to $55V$                                                           | * | 3.22  | 3.36 | 3.5   | V    |
| $V_d$                         | Dropout voltage                          | $V_{CC} = 10V$ ; $I_O = 1A$                                                     |   |       | 0.44 | 0.55  | V    |
|                               |                                          |                                                                                 | * |       |      | 0.88  | V    |
| $I_i$                         | Maximum limiting current                 | $V_{CC} = 8$ to $55V$                                                           | * | 1.5   | 2    | 2.5   | A    |
|                               | Efficiency                               | $V_O = 3.3V$ ; $I_O = 1A$                                                       |   |       | 85   |       | %    |
| $f_s$                         | Switching frequency                      |                                                                                 | * | 90    | 100  | 110   | KHz  |
| SVRR                          | Supply voltage ripple rejection          | $V_I = V_{CC} + 2V_{RMS}$ ; $V_O = V_{ref}$ ; $I_O = 1A$ ; $f_{ripple} = 100Hz$ |   | 60    |      |       | dB   |
|                               | Voltage stability of switching frequency | $V_{CC} = 8$ to $55V$                                                           |   |       | 3    | 6     | %    |
|                               | Temp. stability of switching frequency   | $T_J = 0$ to $125^\circ C$                                                      |   |       | 4    |       | %    |

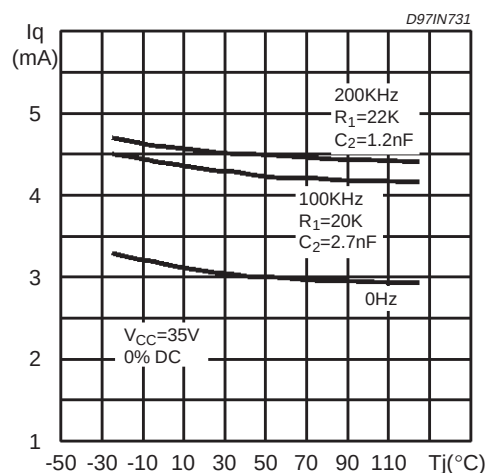
## ELECTRICAL CHARACTERISTICS (continued)

| Symbol                    | Parameter                             | Test Condition                                           | Min. | Typ.   | Max.     | Unit     |
|---------------------------|---------------------------------------|----------------------------------------------------------|------|--------|----------|----------|
| <b>Reference Section</b>  |                                       |                                                          |      |        |          |          |
|                           | Reference Voltage                     |                                                          | 5.0  | 5.1    | 5.2      | V        |
|                           |                                       | $I_{ref} = 0$ to 10mA;<br>$V_{CC} = 8$ to 55V            | *    | 4.950  | 5.1      | 5.250 V  |
|                           | Line Regulation                       | $I_{ref} = 0$ mA;<br>$V_{CC} = 8$ to 55V                 |      | 5      | 10       | mV       |
|                           | Load Regulation                       | $V_{ref} = 0$ to 5mA;<br>$V_{CC} = 0$ to 20mA            |      | 2<br>6 | 10<br>25 | mV<br>mV |
|                           | Short Circuit Current                 |                                                          | 30   | 65     | 100      | mA       |
| <b>DC Characteristics</b> |                                       |                                                          |      |        |          |          |
| $I_{qop}$                 | Total operating quiescent current     |                                                          |      | 4      | 6        | mA       |
| $I_q$                     | Quiescent current                     | Duty Cycle = 0; $V_{FB} = 3.8$ V                         |      | 2.5    | 3.5      | mA       |
| <b>Error Amplifier</b>    |                                       |                                                          |      |        |          |          |
| $V_{FB}$                  | Voltage Feedback Input                |                                                          | 3.33 | 3.36   | 3.39     | V        |
| $R_L$                     | Line regulation                       | $V_{CC} = 8$ to 55V                                      |      | 5      | 10       | mV       |
|                           | Ref. voltage stability vs temperature |                                                          | *    | 0.4    |          | mV/°C    |
| $V_{oH}$                  | High level output voltage             | $V_{FB} = 2.5$ V                                         | 10.3 |        |          | V        |
| $V_{oL}$                  | Low level output voltage              | $V_{FB} = 3.8$ V                                         |      |        | 0.65     | V        |
| $I_{o\ source}$           | Source output current                 | $V_{comp} = 6$ V; $V_{FB} = 2.5$ V                       | 180  | 220    |          | μA       |
| $I_{o\ sink}$             | Sink output current                   | $V_{comp} = 6$ V; $V_{FB} = 3.8$ V                       | 200  | 300    |          | μA       |
| $I_b$                     | Source bias current                   |                                                          |      | 2      | 3        | μA       |
| SVRR E/A                  | Supply voltage ripple rejection       | $V_{comp} = V_{fb}$ ; $V_{CC} = 8$ to 55V                | 60   | 80     |          | dB       |
|                           | DC open loop gain                     | $R_L = \infty$                                           | 50   | 57     |          | dB       |
| gm                        | Transconductance                      | $I_{comp} = -0.1$ to 0.1mA<br>$V_{comp} = 6$ V           |      | 2.5    |          | ms       |
| <b>Oscillator Section</b> |                                       |                                                          |      |        |          |          |
|                           | Ramp Valley                           |                                                          | 0.78 | 0.85   | 0.92     | V        |
|                           | Ramp peak                             | $V_{CC} = 8$ V                                           | 2    | 2.15   | 2.3      | V        |
|                           |                                       | $V_{CC} = 55$ V                                          | 9    | 9.6    | 10.2     | V        |
|                           | Maximum duty cycle                    |                                                          | 95   | 97     |          | %        |
|                           | Maximum Frequency                     | Duty Cycle = 0%<br>$R_{osc} = 13$ kΩ, $C_{osc} = 820$ pF |      |        | 500      | kHz      |

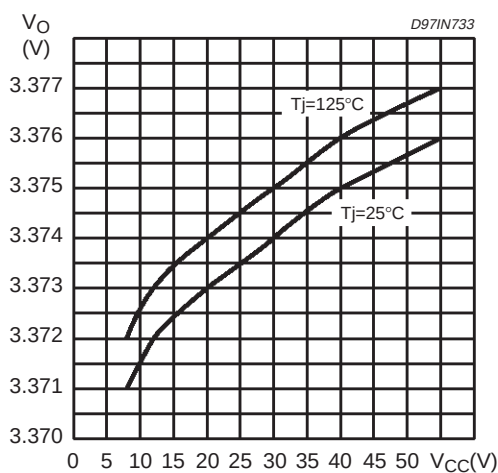
**Figure 1. Quiescent drain current vs. input voltage.**



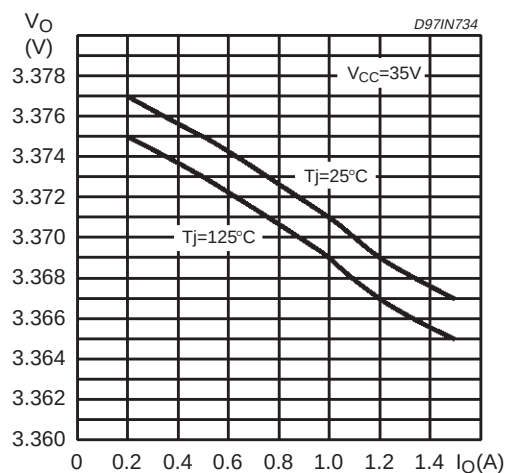
**Figure 2. Quiescent current vs. junction temperature**



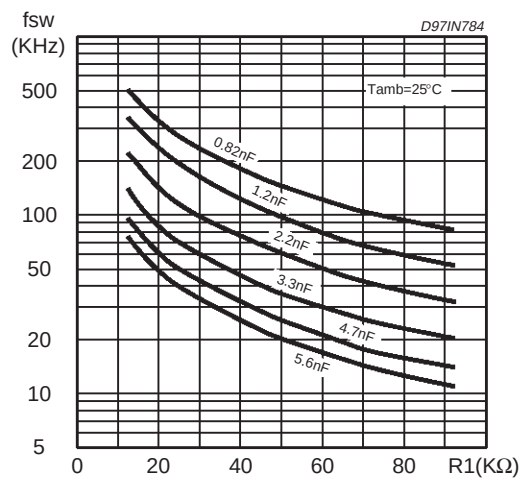
**Figure 3. Line Regulation**



**Figure 4. Load regulation**



**Figure 5. Switching frequency vs. R1 and C2**



**Figure 6. Switching Frequency vs. input voltage.**

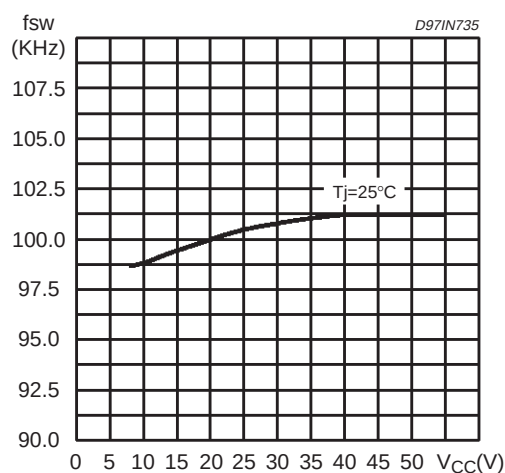


Figure 7. Switching frequency vs. junction temperature.

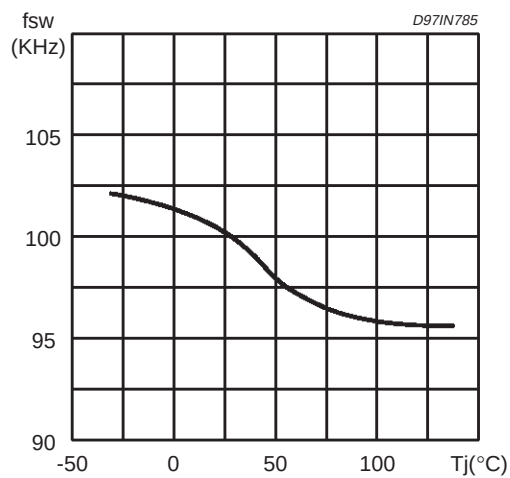


Figure 8. Dropout voltage between pin 5 and 4.

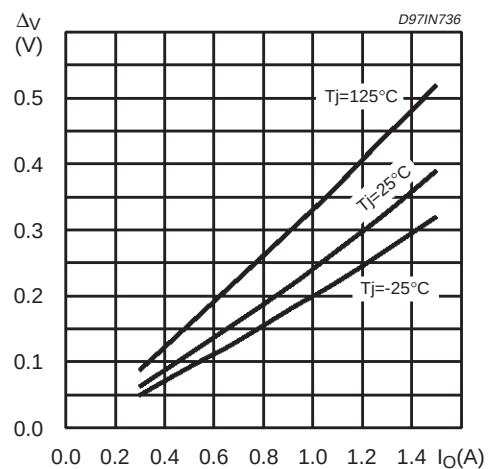


Figure 9. Efficiency vs. output voltage.

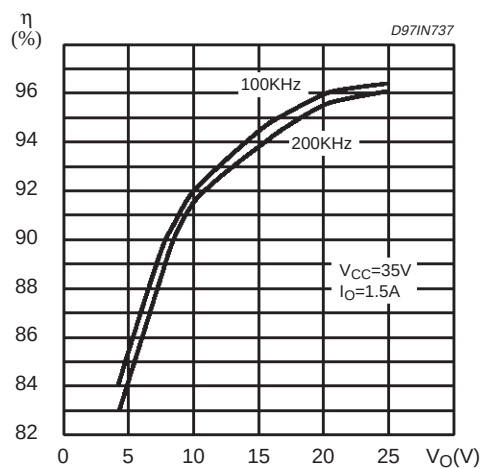


Figure 10. Efficiency vs. output current.

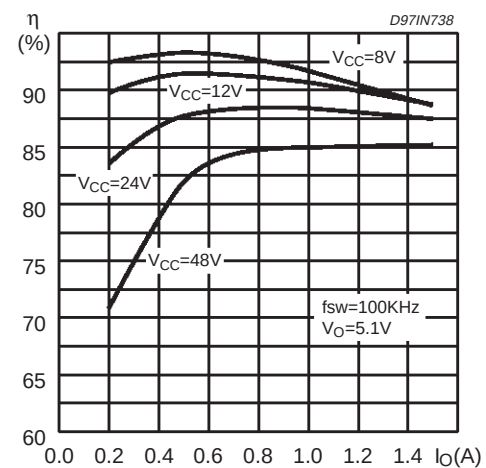


Figure 11. Efficiency vs. output current.

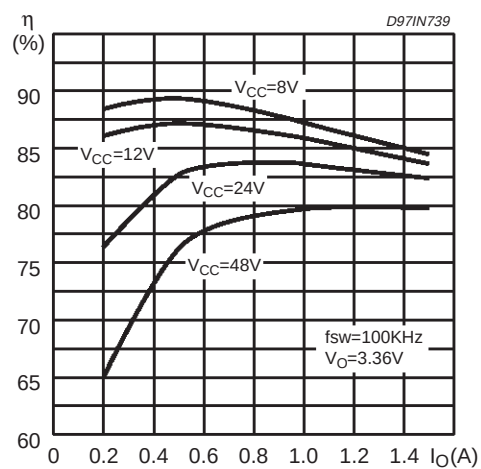


Figure 12. Efficiency vs. output current.

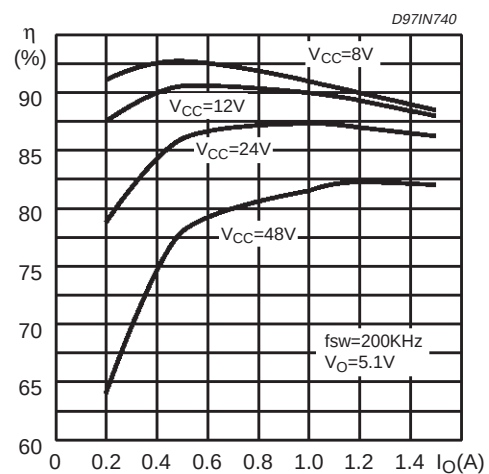


Figure 13. Efficiency vs. output current.

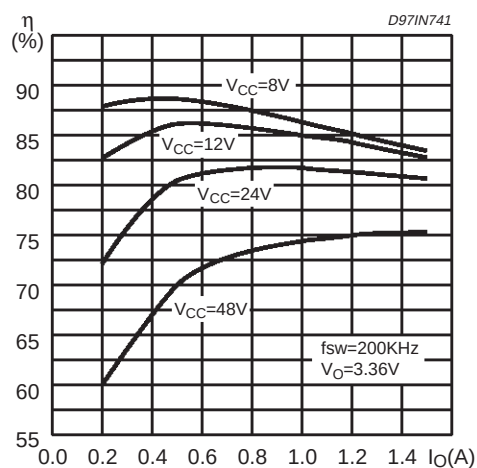


Figure 14. Efficiency vs. Vcc.

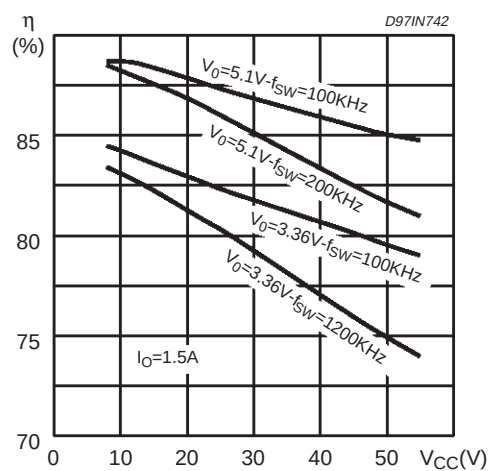


Figure 15. Power dissipation vs. Vcc.

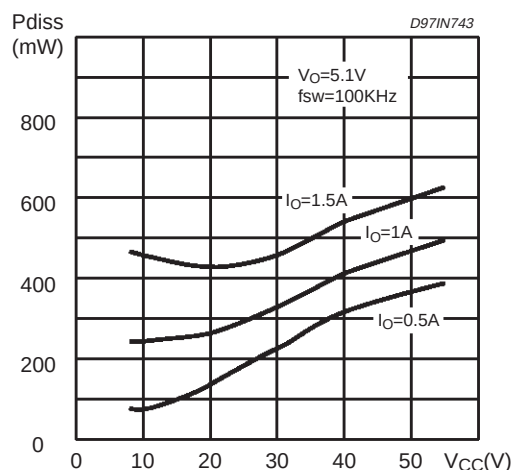


Figure 16. Efficiency vs. V\_O.

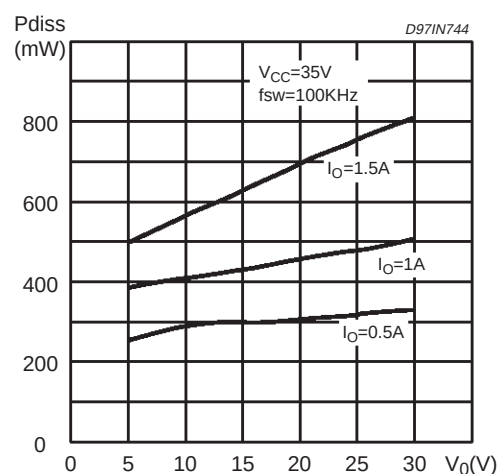


Figure 17. Pulse by pulse limiting current vs. junction temperature.

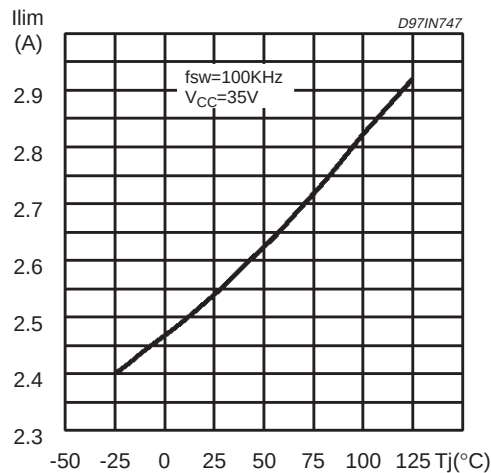


Figure 18. Load transient.

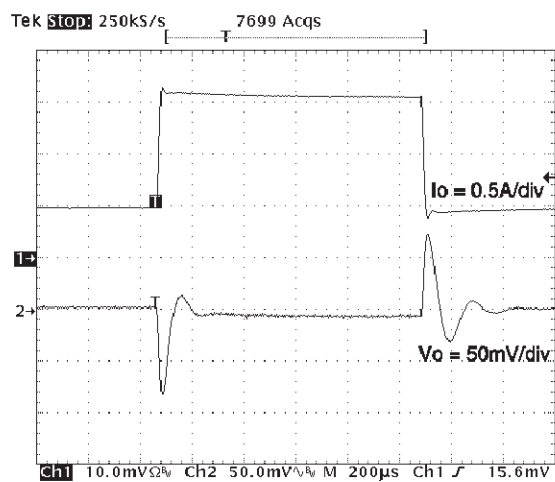


Figure 19. Line transient.

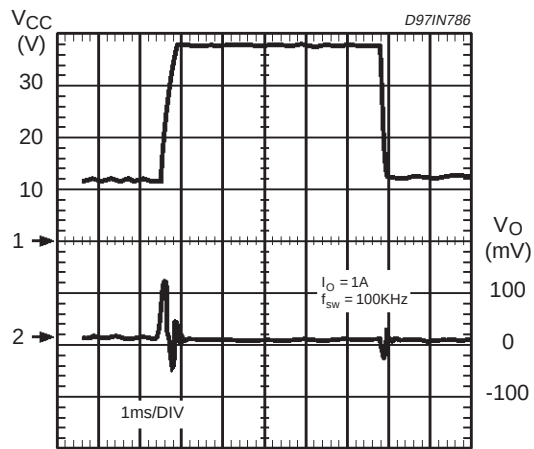
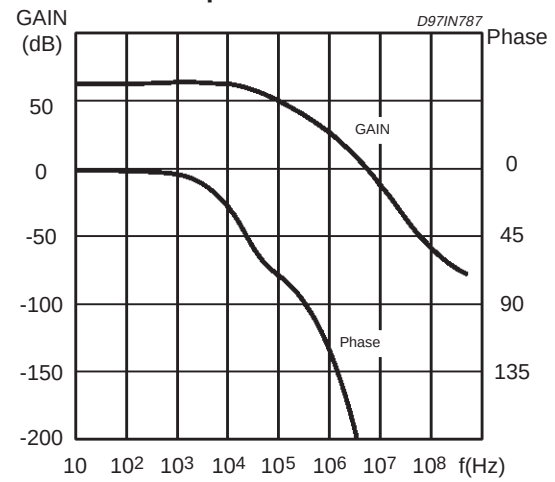


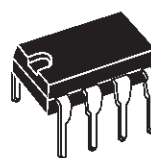
Figure 20. Open loop frequency and phase of error amplifier



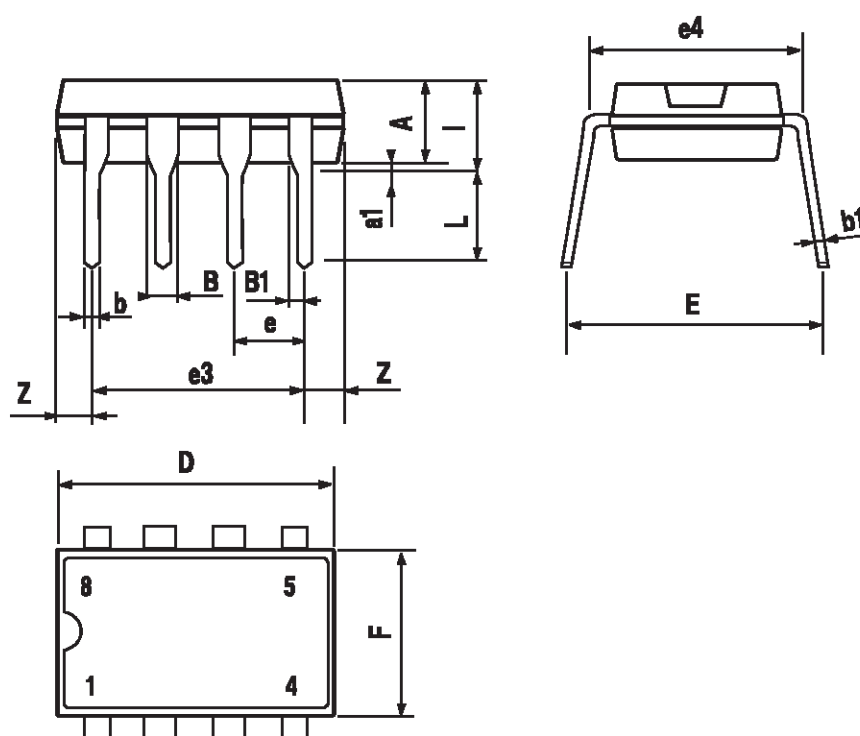


| DIM. | mm    |      |       | inch  |       |       |
|------|-------|------|-------|-------|-------|-------|
|      | MIN.  | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    |       | 3.32 |       |       | 0.131 |       |
| a1   | 0.51  |      |       | 0.020 |       |       |
| B    | 1.15  |      | 1.65  | 0.045 |       | 0.065 |
| b    | 0.356 |      | 0.55  | 0.014 |       | 0.022 |
| b1   | 0.204 |      | 0.304 | 0.008 |       | 0.012 |
| D    |       |      | 10.92 |       |       | 0.430 |
| E    | 7.95  |      | 9.75  | 0.313 |       | 0.384 |
| e    |       | 2.54 |       |       | 0.100 |       |
| e3   |       | 7.62 |       |       | 0.300 |       |
| e4   |       | 7.62 |       |       | 0.300 |       |
| F    |       |      | 6.6   |       |       | 0.260 |
| I    |       |      | 5.08  |       |       | 0.200 |
| L    | 3.18  |      | 3.81  | 0.125 |       | 0.150 |
| Z    |       |      | 1.52  |       |       | 0.060 |

## OUTLINE AND MECHANICAL DATA

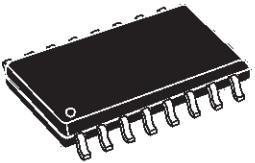


**Minidip**

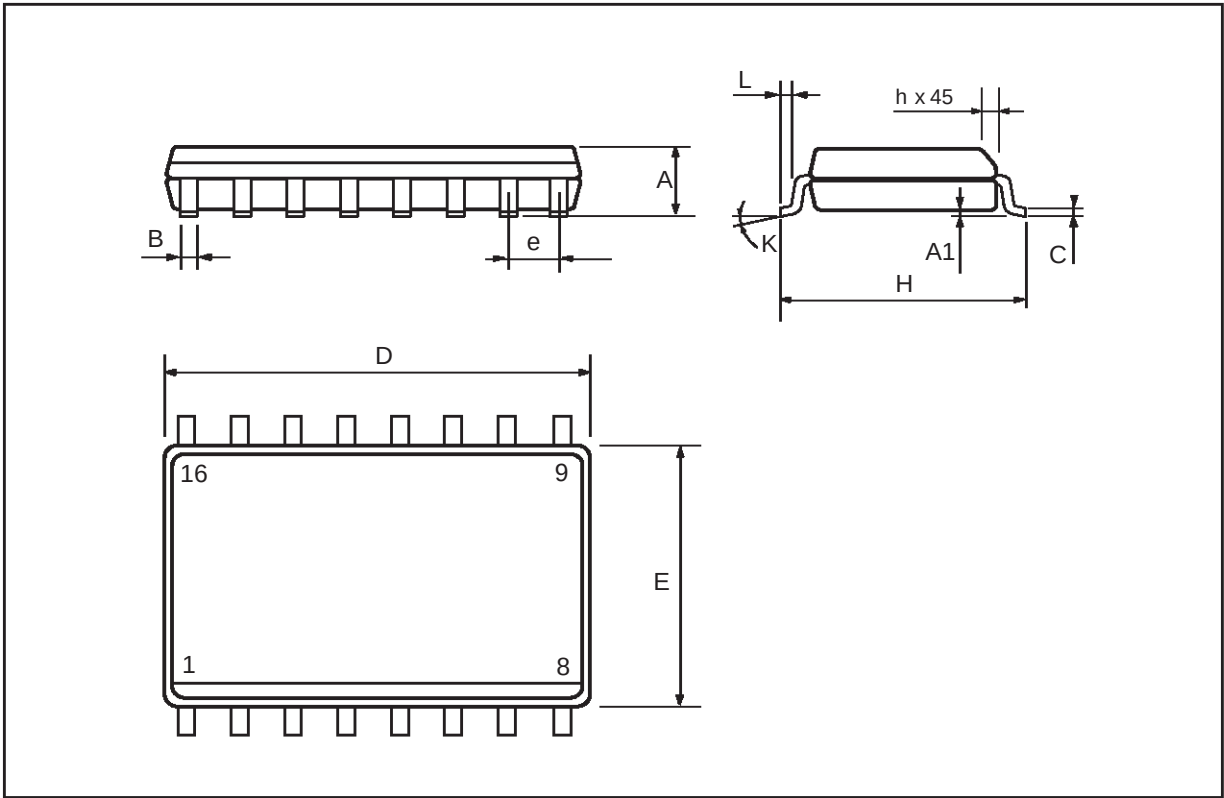


| DIM. | mm                 |      |       | inch  |       |       |
|------|--------------------|------|-------|-------|-------|-------|
|      | MIN.               | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 2.35               |      | 2.65  | 0.093 |       | 0.104 |
| A1   | 0.1                |      | 0.3   | 0.004 |       | 0.012 |
| B    | 0.33               |      | 0.51  | 0.013 |       | 0.020 |
| C    | 0.23               |      | 0.32  | 0.009 |       | 0.013 |
| D    | 10.1               |      | 10.5  | 0.398 |       | 0.413 |
| E    | 7.4                |      | 7.6   | 0.291 |       | 0.299 |
| e    |                    | 1.27 |       |       | 0.050 |       |
| H    | 10                 |      | 10.65 | 0.394 |       | 0.419 |
| h    | 0.25               |      | 0.75  | 0.010 |       | 0.030 |
| L    | 0.4                |      | 1.27  | 0.016 |       | 0.050 |
| K    | 0° (min.)8° (max.) |      |       |       |       |       |

**OUTLINE AND  
MECHANICAL DATA**



**SO16 Wide**



Information furnished is believed to be accurate and reliable. However, STMicroelectronics assumes no responsibility for the consequences of use of such information nor for any infringement of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of STMicroelectronics. Specification mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied. STMicroelectronics products are not authorized for use as critical components in life support devices or systems without express written approval of STMicroelectronics.

The ST logo is a registered trademark of STMicroelectronics

© 2001 STMicroelectronics GROUP OF COMPANIES

Australia - Brazil - China - Finland - France - Germany - Hong Kong - India - Italy - Japan - Malaysia - Malta - Morocco -  
Singapore - Spain - Sweden - Switzerland - United Kingdom - U.S.A.

<http://www.st.com>