

## POWER FACTOR CORRECTOR

- VERY PRECISE ADJUSTABLE INTERNAL OUTPUT OVERVOLTAGE PROTECTION
- HYSTERETIC START-UP  
( $I_{START-UP} < 0.5mA$ )
- VERY LOW QUIESCENT CURRENT  
( $< 3.5mA$ )
- INTERNAL START-UP TIMER
- TRANSITION MODE OPERATING
- TOTEM POLE OUTPUT CURRENT:  $\pm 400mA$
- DIP8/SO8 PACKAGES

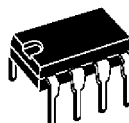
### DESCRIPTION

The L6560/A is a monolithic integrated circuit in Minidip and SO8 packages, designed as a controller and driver of a discrete power MOS transistor for the implementation of active power factor correction, for sinusoidal line current consumption.

Realized in mixed BCD technology, the chip integrates:

- An undervoltage lockout with micropower start-up and hysteresis.
- An internal temperature compensated precise band gap reference.
- A stable error amplifier.

### MULTIPOWER BCD TECHNOLOGY



Minidip



SO8

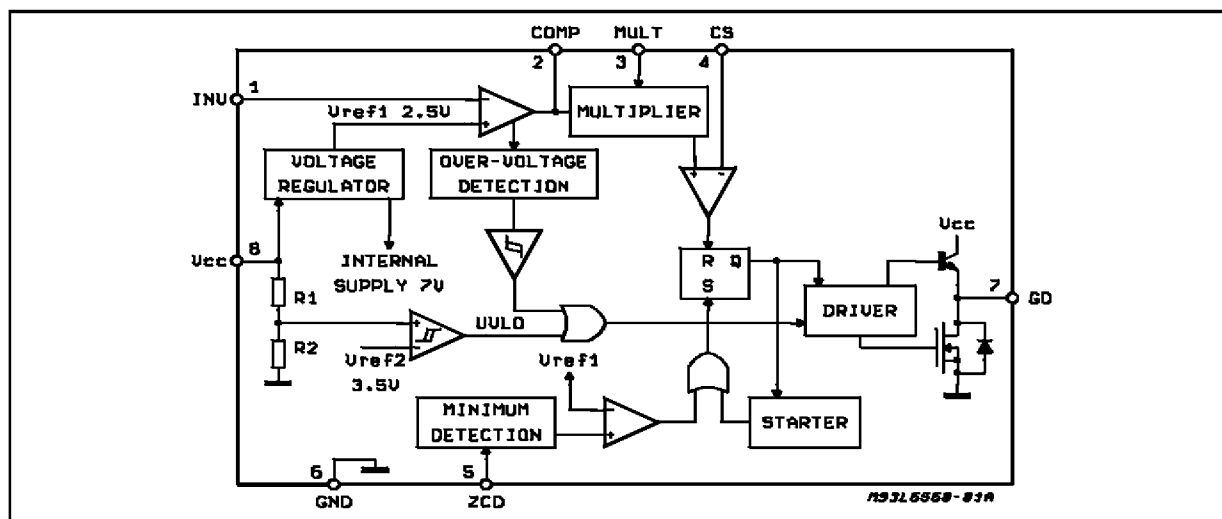
#### ORDERING NUMBERS:

L6560  
L6560A

L6560D  
L6560AD

- One quadrant multiplier.
- Current sense comparator.
- An output overvoltage protection circuit.
- A totem-pole output stage able to drive a POWER MOS or IGBT devices with source and sink current of 400mA. The chip works in transition mode and is particularly intended for lamp ballast applications and for low power SMPS.

### BLOCK DIAGRAM

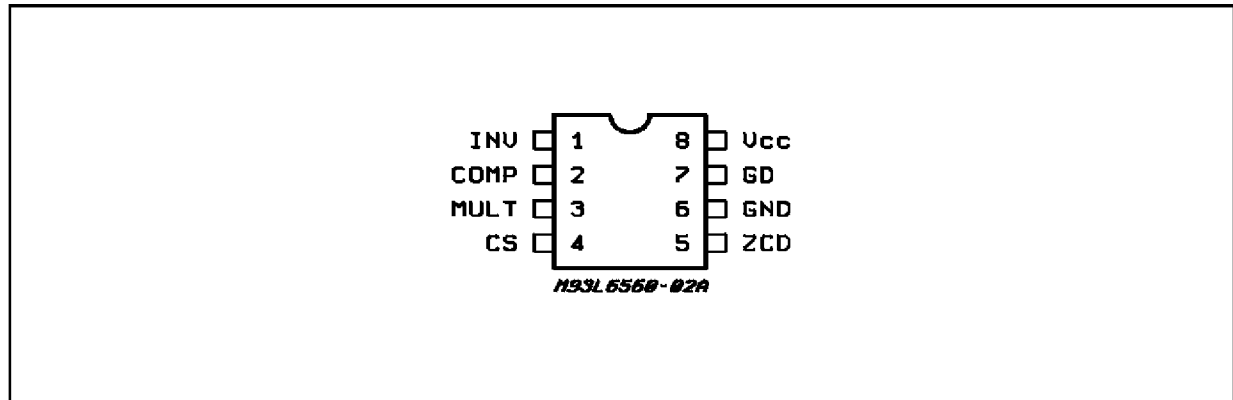


## L6560 - L6560A

### ABSOLUTE MAXIMUM RATINGS

| Symbol            | Pin     | Parameter                                                         | Value                   | Unit     |
|-------------------|---------|-------------------------------------------------------------------|-------------------------|----------|
| I <sub>VCC</sub>  | 8       | I <sub>CC</sub> + I <sub>Z</sub>                                  | 30                      | mA       |
| I <sub>GD</sub>   | 7       | Output Totem Pole Peak Current (2μs)                              | ±700                    | mA       |
| INV, COMP<br>MULT | 1, 2, 3 | Analog Inputs & Outputs                                           | -0.3 to 7               | V        |
| CS                | 4       | Current Sense Input                                               | -0.3 to 7               | V        |
| ZCD               | 5       | Zero Current Detector                                             | 5 (source)<br>10 (sink) | mA<br>mA |
| P <sub>tot</sub>  |         | Power Dissipation @T <sub>amb</sub> = 50 °C<br>(Minidip)<br>(SO8) | 1<br>0.65               | W        |
| T <sub>j</sub>    |         | Junction Temperature Operating Range                              | -25 to 150              | °C       |
| T <sub>stg</sub>  |         | Storage Temperature                                               | -55 to 150              | °C       |

### PIN CONNECTION



### THERMAL DATA

| Symbol                | Parameter                           | SO 8 | MINIDIP | Unit |
|-----------------------|-------------------------------------|------|---------|------|
| R <sub>th j-amb</sub> | Thermal Resistance Junction-ambient | 150  | 100     | °C/W |

### PIN FUNCTIONS

| N. | Name | Function                                                                                                                                                                 |
|----|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | INV  | Inverting input of the error amplifier. A resistive divider is connected between output regulated voltage and this point, to provide the voltage feedback.               |
| 2  | COMP | Output of error amplifier. A feedback compensation network is placed between this pin and the INV pin.                                                                   |
| 3  | MULT | Input of the multiplier stage. A resistive divider connects to this pin the rectified mains. A voltage signal, proportional to the rectified mains, appears on this pin. |
| 4  | CS   | Input to the comparator of the control loop. The current is sensed by a resistor and the resulting voltage is applied to this pin.                                       |
| 5  | ZCD  | Zero current detection input.                                                                                                                                            |
| 6  | GND  | Ground of the control section.                                                                                                                                           |
| 7  | GD   | Gate driver output. A push pull output stage is able to drive the Power MOS with peak current of 400mA (source and sink).                                                |
| 8  | VCC  | Supply voltage of driver and control circuits.                                                                                                                           |

**ELECTRICAL CHARACTERISTICS** ( $V_{CC} = 14.5V$ ;  $T_j = 25^\circ C$  unless otherwise specified)**SUPPLY VOLTAGE SECTION**

| Symbol        | Pin | Parameter          | Test Condition | Min.                          | Typ.       | Max.       | Unit                 |
|---------------|-----|--------------------|----------------|-------------------------------|------------|------------|----------------------|
| $V_{CC}$      | 8   | Operating Range    | after turn-on  | 11                            |            | 18         | V                    |
| $V_{CC\ ON}$  | 8   | Turn-on Threshold  |                | <b>L6560</b><br><b>L6560A</b> | 13.5<br>11 | 14.5<br>12 | 15.5<br>13<br>V<br>V |
| $V_{CC\ OFF}$ | 8   | Turn-off Threshold |                | <b>L6560</b><br><b>L6560A</b> | 9<br>8.7   | 10<br>9.6  | 11<br>10.5<br>V<br>V |
| Hys           | 8   | Hysteresis         |                | <b>L6560</b><br><b>L6560A</b> | 4.3<br>2.5 | 4.7<br>2.8 | 5.1<br>3.1<br>V<br>V |

**SUPPLY CURRENT SECTION**

| Symbol               | Pin | Parameter                | Test Condition                                                            | Min. | Typ. | Max. | Unit |
|----------------------|-----|--------------------------|---------------------------------------------------------------------------|------|------|------|------|
| I <sub>START-U</sub> | 8   | Start-up Current         | before turn-on at:<br>$V_{CC} = 13V$ (L6560)<br>$V_{CC} = 10.5V$ (L6560A) |      | 0.3  | 0.5  | mA   |
| I <sub>CC</sub>      | 8   | Operating Supply Current | $C_L = 0nF @ 70KHz$                                                       |      | 2.5  | 3.5  | mA   |
|                      |     |                          | $C_L = 1nF @ 70KHz$                                                       |      | 3.2  | 4    | mA   |
|                      |     |                          | in OVP condition $V_{pin1} = 2.7V$                                        |      | 0.9  | 1.3  | mA   |
| V <sub>Z</sub>       | 8   | Zener Voltage            | I <sub>CC</sub> = 25mA                                                    | 18   | 20   | 22   | V    |

**ERROR AMPLIFIER SECTION**

| Symbol            | Pin | Parameter                          | Test Condition                                        | Min. | Typ. | Max. | Unit    |
|-------------------|-----|------------------------------------|-------------------------------------------------------|------|------|------|---------|
| V <sub>INV</sub>  | 1   | Voltage Feedback Input Threshold   |                                                       | 2.46 | 2.5  | 2.54 | V       |
|                   |     |                                    | $-25 \leq T_j \leq 85^\circ C$ ; $12V < V_{CC} < 18V$ | 2.43 |      | 2.56 |         |
| T <sub>S</sub>    |     | Temperature Stability              | $T_{amb} = -25$ to $85^\circ C$                       |      | 0.5  |      | %       |
| R <sub>L</sub>    |     | Line Regulation                    | $V_{CC} = 11$ to $18V$                                |      | 1    | 4    | mV      |
| I <sub>INV</sub>  | 1   | Input Bias Current                 |                                                       |      | 0.1  | 1    | $\mu A$ |
| G <sub>V</sub>    |     | Voltage Gain                       | Open loop                                             | 60   | 80   |      | dB      |
| I <sub>COMP</sub> | 2   | Source Current ( $V_1 < V_{ref}$ ) | $V_{COMP} = 5V$                                       | 0.14 | 0.2  |      | mA      |
|                   |     | Sink Current ( $V_1 > V_{ref}$ )   |                                                       | 0.5  | 1    |      | mA      |

**MULTIPLIER SECTION**

| Symbol                                  | Pin | Parameter         | Test Condition                                                 | Min.     | Typ.     | Max. | Unit |
|-----------------------------------------|-----|-------------------|----------------------------------------------------------------|----------|----------|------|------|
| V <sub>MULT</sub>                       | 3   | Operating Voltage |                                                                | 0 to 2.5 | 0 to 4.2 |      | V    |
| $\frac{\Delta V_{CS}}{\Delta V_{mult}}$ |     | Output Max. Slope | $V_{MULT} = \text{from } 0V \text{ to } 1V$<br>$V_{COMP} = 6V$ | 0.9      | 1.25     | 1.6  |      |
| K                                       |     | Gain              | $V_{MULT} = 1V$ $V_{COMP} = 5V$                                | 0.45     | 0.65     | 0.85 | 1/V  |

**CURRENT SENSE COMPARATOR**

| Symbol               | Pin | Parameter          | Test Condition                    | Min. | Typ. | Max. | Unit    |
|----------------------|-----|--------------------|-----------------------------------|------|------|------|---------|
| V <sub>CS</sub>      | 4   | Voltage Threshold  | $V_{MULT} = 2.5V$ $V_{COMP} = 6V$ | 1.6  |      | 1.9  | V       |
| I <sub>CS</sub>      | 4   | Input Bias Current |                                   |      |      | 5    | $\mu A$ |
| t <sub>d</sub> (H-L) | 4   | Delay to Output    |                                   |      | 200  | 400  | ns      |

**ELECTRICAL CHARACTERISTICS (continued)**
**ZERO CURRENT DETECTOR**

| Symbol           | Pin | Parameter                           | Test Condition          | Min. | Typ. | Max. | Unit |
|------------------|-----|-------------------------------------|-------------------------|------|------|------|------|
| V <sub>ZCD</sub> | 5   | Input Threshold Voltage Rising Edge |                         | 1.8  |      | 2.3  | V    |
|                  |     | Hysteresis                          |                         | 0.3  | 0.5  | 0.7  | V    |
| V <sub>ZCD</sub> | 5   | Clamp Voltage                       | I <sub>ZCD</sub> = 3mA  | 5    | 5.7  | 6.4  | V    |
| V <sub>ZCD</sub> | 5   | Clamp Voltage                       | I <sub>ZCD</sub> = -3mA | 0.4  | 0.7  | 1    | V    |

**OUTPUT SECTION**

| Symbol          | Pin | Parameter                | Test Condition                | Min. | Typ. | Max. | Unit |
|-----------------|-----|--------------------------|-------------------------------|------|------|------|------|
| V <sub>GD</sub> | 7   | Dropout Voltage          | I <sub>GDsource</sub> = 200mA |      | 1.2  | 2    | V    |
|                 |     |                          | I <sub>GDsource</sub> = 20mA  |      | 0.7  | 1    | V    |
|                 |     |                          | I <sub>GDsink</sub> = 200mA   |      |      | 1.5  | V    |
|                 |     |                          | I <sub>GDsink</sub> = 20mA    |      |      | 0.3  | V    |
| t <sub>r</sub>  | 7   | Output Voltage Rise Time | CL = 1nF                      |      | 50   | 120  | ns   |
| t <sub>f</sub>  | 7   | Output Voltage Fall Time | CL = 1nF                      |      | 40   | 100  | ns   |

**OUTPUT OVERVOLTAGE SECTION**

| Symbol           | Pin | Parameter              | Test Condition | Min. | Typ. | Max. | Unit |
|------------------|-----|------------------------|----------------|------|------|------|------|
| I <sub>OVP</sub> | 2   | OVP Triggering Current |                | 36   | 40   | 44   | μA   |

**RESTART TIMER**

| Symbol             | Pin | Parameter   | Test Condition | Min. | Typ. | Max. | Unit |
|--------------------|-----|-------------|----------------|------|------|------|------|
| t <sub>START</sub> |     | Start Timer |                | 45   | 60   |      | μs   |

**OVER VOLTAGE PROTECTION OVP**

The output voltage is expected to be kept by the operation of the PFC circuits close to its reference value that is set by the ratio of the two external resistors R<sub>1</sub> and R<sub>2</sub> (see fig. 2), taking into consideration that the non inverting input of the error amplifier is biased inside the L6560 at 2.5V.

In steady state conditions, the current through R<sub>1</sub> and R<sub>2</sub> is:

$$I_{SC} = \frac{\Delta V_{outsc} - 2.5}{R_1}$$

$$\text{or } I_{SC} = \frac{2.5}{R_2}$$

and, if the external compensation network is made only with a capacitor C, the current through C is equal zero.

When the output voltage increases abruptly the current through R<sub>1</sub> becomes:

$$I_{R1} = \frac{V_{out} - 2.5}{R_1}$$

$$I_{R1} = \frac{V_{outsc} + \Delta V_{OUT} - 2.5}{R_1} = I_{SC} + \Delta I.$$

Since the current through R<sub>2</sub> doesn't change, the ΔI current must flow through the capacitor C and enter in the error amplifier.

This current is mirrored inside the L6560, and compared with a precise internal reference of 40μA. Whenever such 40μA limit is exceeded, the OVP protection is triggered (Dynamic OVP), and the external power transistor is switched off, until the overvoltage situation disappears. However if the overvoltage persists, before that the transient condition of dynamic circuit exhausts, an internal comparator (Static OVP) latches the OVP condition keeping the external power switch turned off (see fig. 1).

The OVP value is therefore set by the equation  $OVP = \Delta V_{out} = R_1 \cdot 40\mu A$ .

Typical values for R<sub>1</sub>, R<sub>2</sub> and C are reported in the application circuit. The overvoltage can be set independently from the average output voltage. The precision in setting the overvoltage threshold is 7% of the overvoltage value (for instance ΔV = 60V ± 4.2V).

Figure 1.

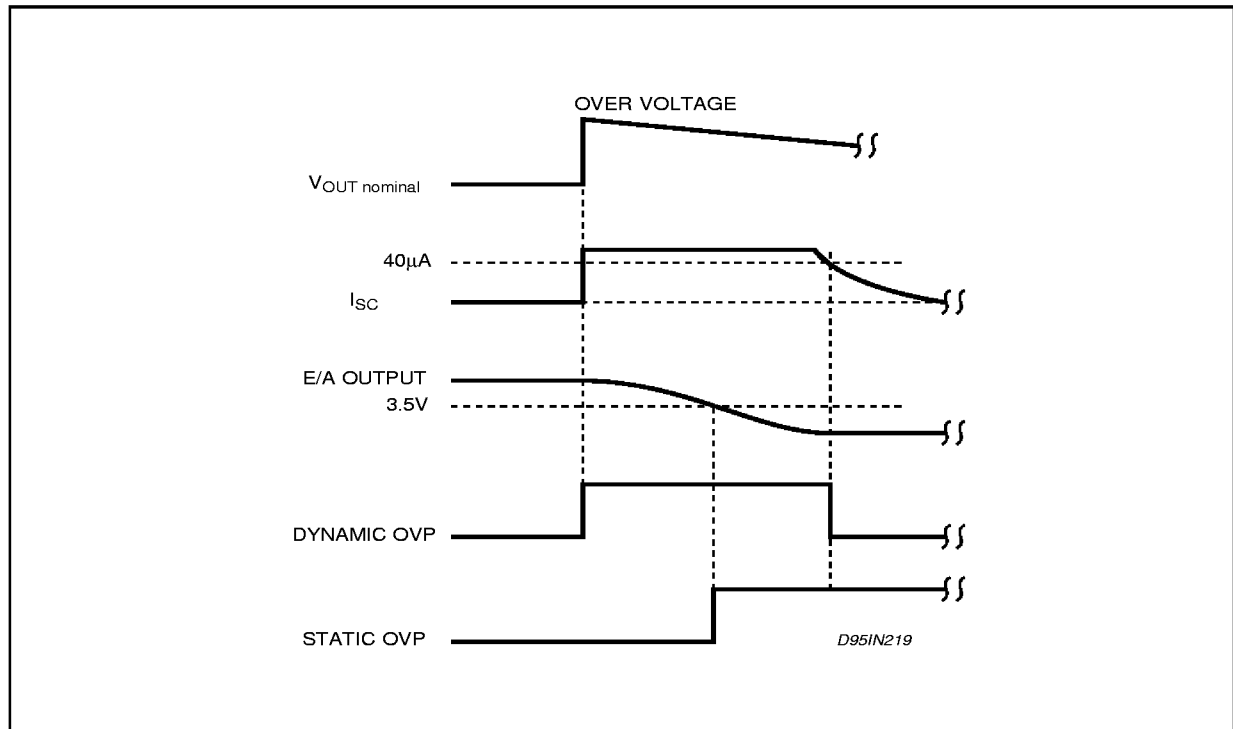
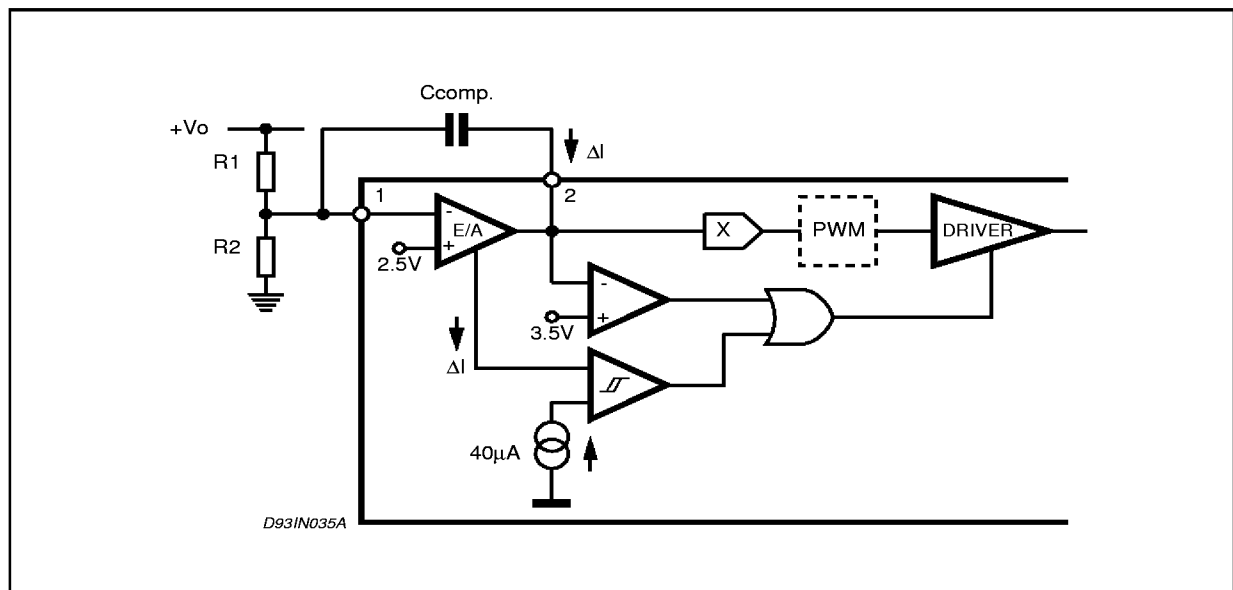
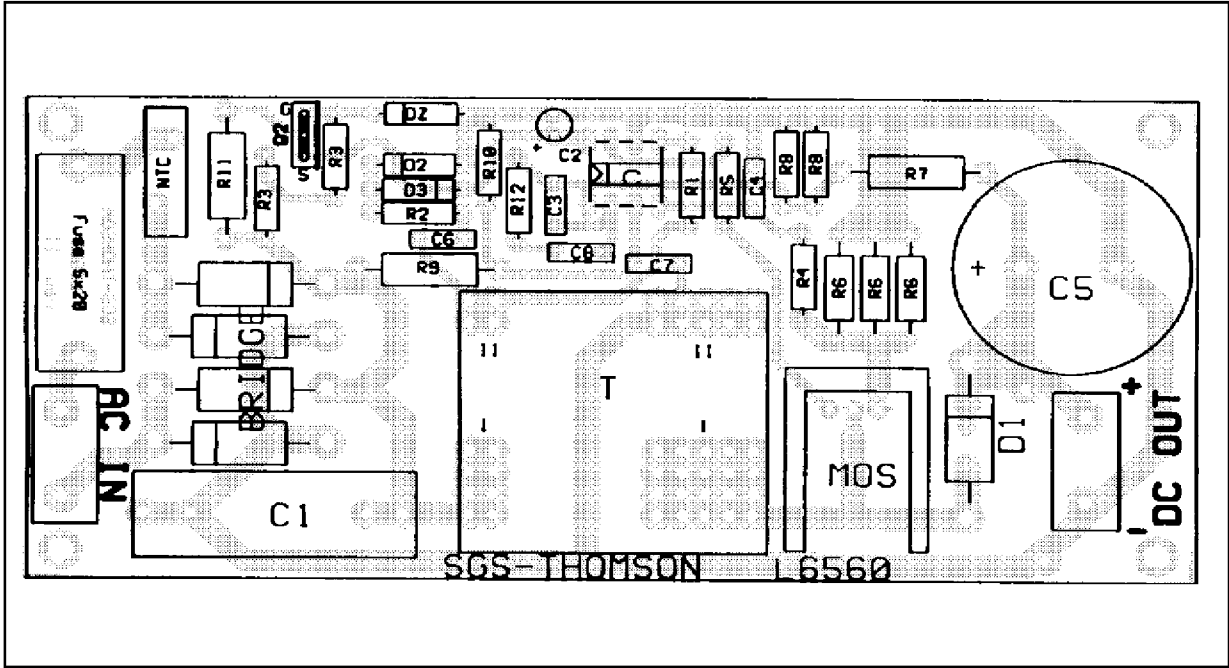


Figure 2: Overvoltage Protection Circuit

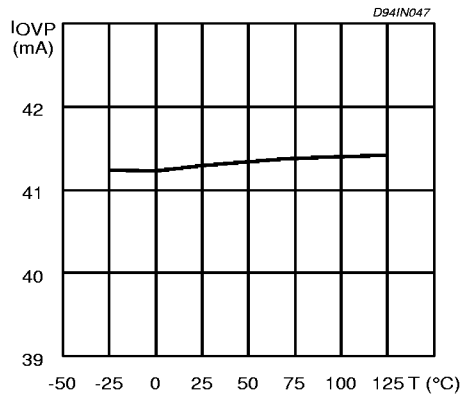




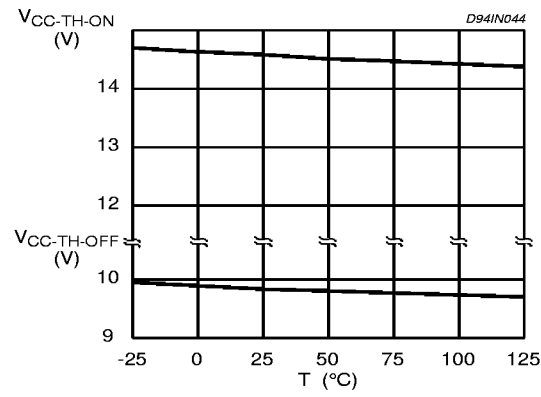
**Figure 5:** P.C. Board and Component Layout of the Figg. 3 and 4 (1:1.25 scale)



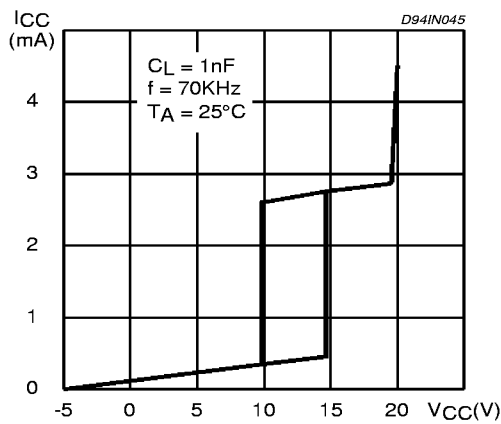
**Figure 6:** OVP Current Threshold vs. Temperature



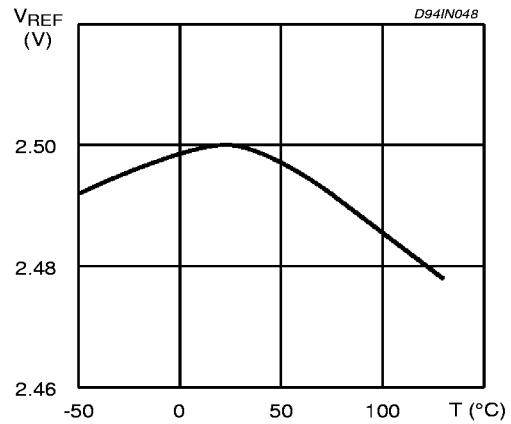
**Figure 7:** Undervoltage Lockout Threshold vs. Temperature



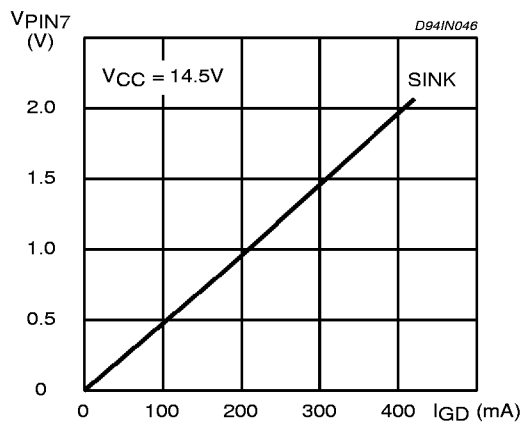
**Figure 8:** Supply Current vs. Supply Voltage



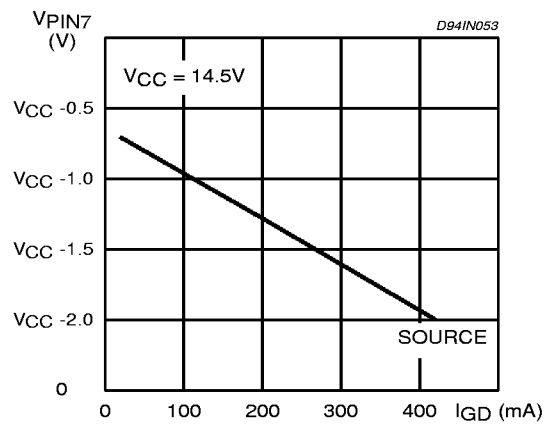
**Figure 9:** Voltage Feedback Input Threshold vs. Temperature



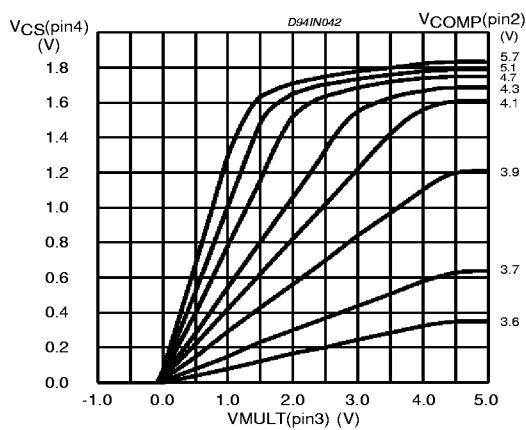
**Figure 10:** Output Saturation Voltage vs. Sink Current



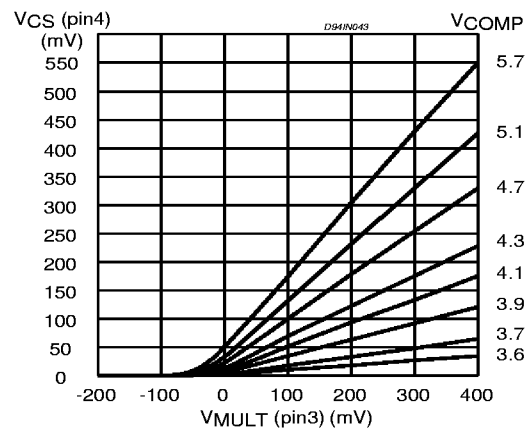
**Figure 11:** Output Saturation Voltage vs. Source Current



**Figure 12:** Multiplier Characteristics Family



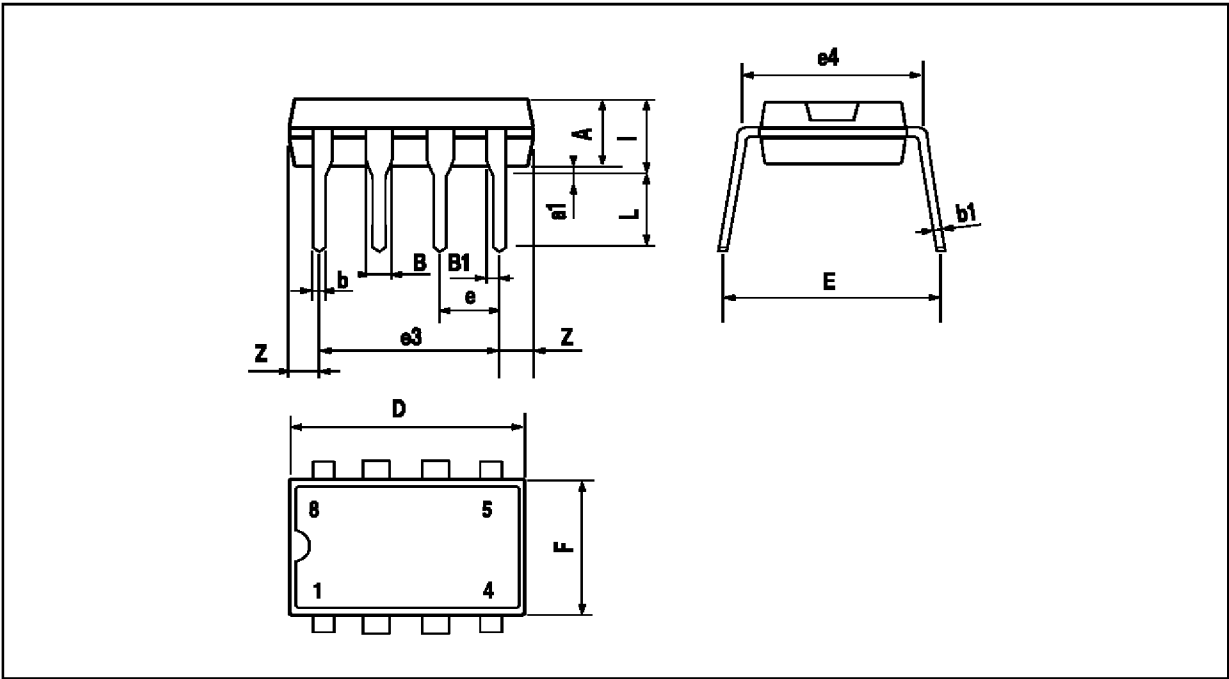
**Figure 13:** Multiplier Characteristics Family





MINIDIP PACKAGE MECHANICAL DATA

| 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 |



SO8 PACKAGE MECHANICAL DATA

| DIM | mm         |      |      | Inch  |       |       |
|-----|------------|------|------|-------|-------|-------|
|     | Min.       | Typ. | Max. | Min.  | Typ.  | Max.  |
| A   |            |      | 1.75 |       |       | 0.069 |
| a1  | 0.1        |      | 0.25 | 0.004 |       | 0.010 |
| a2  |            |      | 1.65 |       |       | 0.065 |
| a3  | 0.65       |      | 0.85 | 0.026 |       | 0.033 |
| b   | 0.35       |      | 0.48 | 0.014 |       | 0.019 |
| b1  | 0.19       |      | 0.25 | 0.007 |       | 0.010 |
| C   | 0.25       |      | 0.5  | 0.010 |       | 0.020 |
| c1  | 45° (typ.) |      |      |       |       |       |
| D   | 4.8        |      | 5.0  | 0.189 |       | 0.197 |
| E   | 5.8        |      | 6.2  | 0.228 |       | 0.244 |
| e   |            | 1.27 |      |       | 0.050 |       |
| e3  |            | 3.81 |      |       | 0.150 |       |
| F   | 3.8        |      | 4.0  | 0.150 |       | 0.157 |
| L   | 0.4        |      | 1.27 | 0.016 |       | 0.050 |
| M   |            |      | 0.6  |       |       | 0.024 |
| S   | 8° (max.)  |      |      |       |       |       |

