



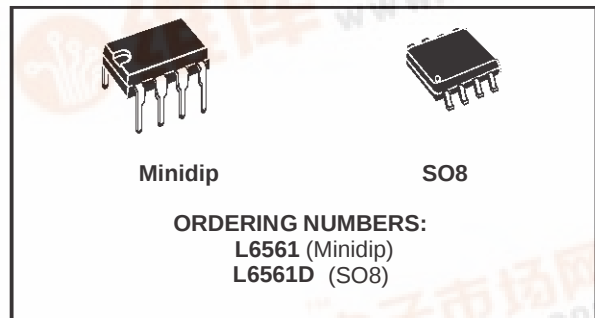
**L6561**

## POWER FACTOR CORRECTOR

- VERY PRECISE ADJUSTABLE OUTPUT OVERVOLTAGE PROTECTION
- MICRO POWER START-UP CURRENT (50 $\mu$ A TYP.)
- VERY LOW OPERATING SUPPLY CURRENT (4mA TYP.)
- INTERNAL START-UP TIMER
- CURRENT SENSE FILTER ON CHIP
- DISABLE FUNCTION
- 1% PRECISION (@  $T_j = 25^\circ\text{C}$ ) INTERNAL REFERENCE VOLTAGE
- TRANSITION MODE OPERATION
- TOTEM POLE OUTPUT CURRENT:  $\pm 400\text{mA}$
- DIP8/SO8 PACKAGES

### DESCRIPTION

L6561 is the improved version of the L6560 standard Power Factor Corrector. Fully compatible with the standard version, it has a superior performant multiplier making the device capable of working in wide input voltage range applications (from 85V to 265V) with an excellent THD. Furthermore the start up current has been reduced at few tens of  $\mu\text{A}$  and a disable function has been implemented on the ZCD pin, guaranteeing lower current consumption in stand by mode.

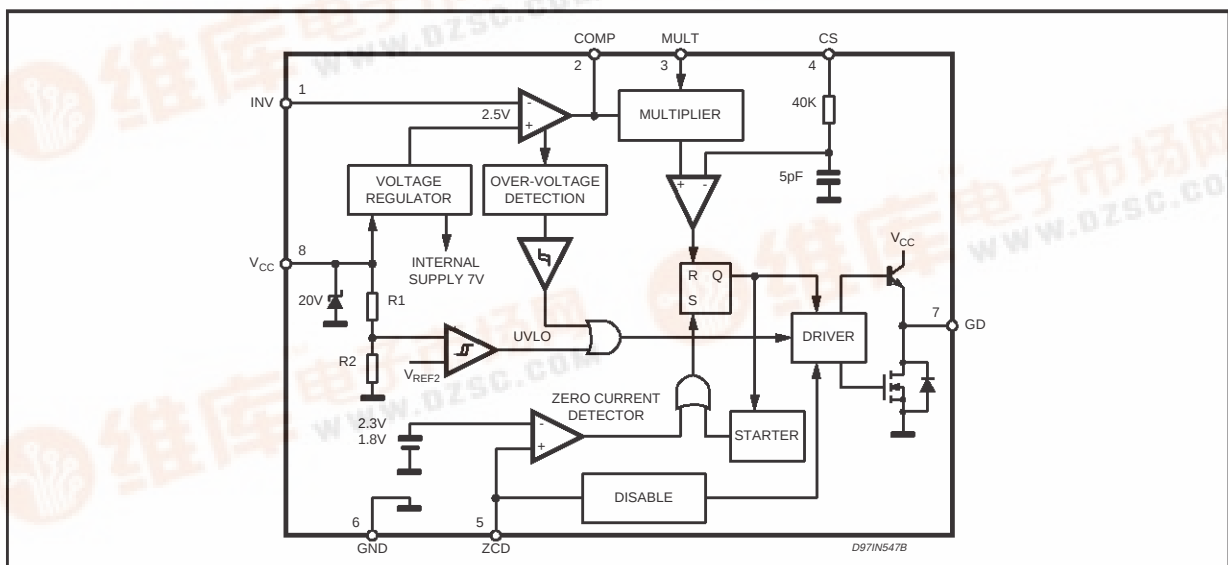


Realised in mixed BCD technology, the chip gives the following benefits:

- **micro power start up current**
- **1% precision internal reference voltage** ( $T_j = 25^\circ\text{C}$ )
- **Soft Output Over Voltage Protection**
- **no need for external low pass filter on the current sense**
- **very low operating quiescent current minimises power dissipation**

The totem pole output stage is capable of driving a Power MOS or IGBT with source and sink currents of  $\pm 400\text{mA}$ . The device is operating in transition mode and it is optimised for Electronic Lamp Ballast application, AC-DC adaptors and SMPS.

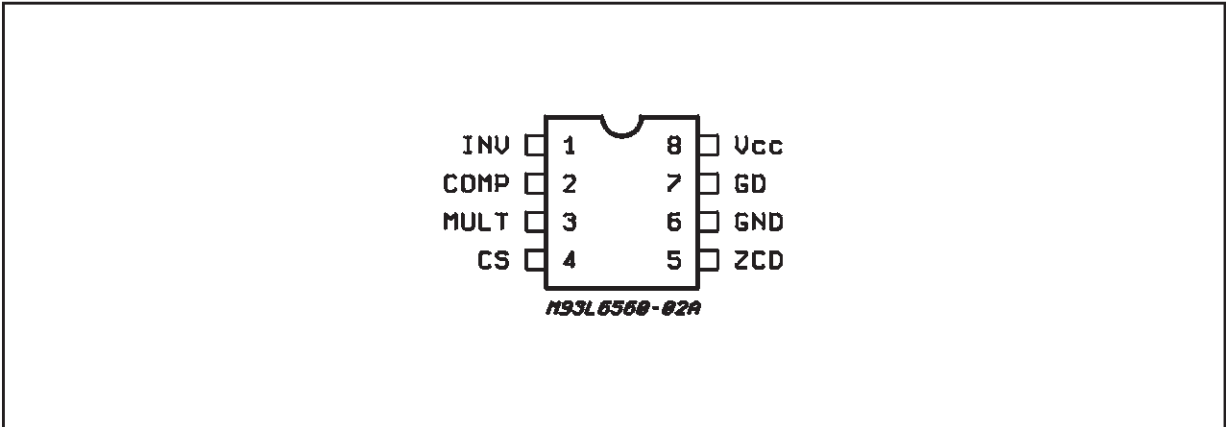
### BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

| Symbol            | Pin     | Parameter                                                                     | Value                     | Unit               |
|-------------------|---------|-------------------------------------------------------------------------------|---------------------------|--------------------|
| $I_{VCC}$         | 8       | $I_{CC} + I_Z$                                                                | 30                        | mA                 |
| $I_{GD}$          | 7       | Output Totem Pole Peak Current (2 $\mu$ s)                                    | $\pm 700$                 | 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                                                         | 50 (source)<br>-10 (sink) | mA<br>mA           |
| $P_{tot}$         |         | Power Dissipation @ $T_{amb} = 50\text{ }^{\circ}\text{C}$ (Minidip)<br>(SO8) | 1<br>0.65                 | W                  |
| $T_j$             |         | Junction Temperature Operating Range                                          | -25 to 150                | $^{\circ}\text{C}$ |
| $T_{stg}$         |         | Storage Temperature                                                           | -55 to 150                | $^{\circ}\text{C}$ |

PIN CONNECTION



THERMAL DATA

| Symbol          | Parameter                           | SO 8 | MINIDIP | Unit                 |
|-----------------|-------------------------------------|------|---------|----------------------|
| $R_{th\ j-amb}$ | Thermal Resistance Junction-ambient | 150  | 100     | $^{\circ}\text{C/W}$ |

PIN FUNCTIONS

| N. | Name | Function                                                                                                                                                                 |
|----|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | INV  | Inverting input of the error amplifier. A resistive divider is connected between the output regulated voltage and this point, to provide 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. If it is connected to GND, the device is disabled.                                                                                         |
| 6  | GND  | Current return for driver and control circuits.                                                                                                                          |
| 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** ( $V_{CC} = 14.5V$ ;  $T_{amb} = -25^{\circ}C$  to  $125^{\circ}C$ ; 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  |                | 11   | 12   | 13   | V    |
| $V_{CC\ OFF}$ | 8   | Turn-off Threshold |                | 8.7  | 9.5  | 10.3 | V    |
| Hys           | 8   | Hysteresis         |                | 2.2  | 2.5  | 2.8  | V    |

**SUPPLY CURRENT SECTION**

| Symbol        | Pin | Parameter                | Test Condition                              | Min. | Typ. | Max. | Unit    |
|---------------|-----|--------------------------|---------------------------------------------|------|------|------|---------|
| $I_{START-U}$ | 8   | Start-up Current         | before turn-on ( $V_{CC} = 11V$ )           | 20   | 50   | 90   | $\mu A$ |
| $I_q$         | 8   | Quiescent Current        |                                             |      | 2.6  | 4    | mA      |
| $I_{CC}$      |     | Operating Supply Current | $C_L = 1nF @ 70KHz$                         |      | 4    | 5.5  | mA      |
|               |     |                          | in OVP condition $V_{pin1} = 2.7V$          |      | 1.4  | 2.1  | mA      |
| $I_q$         |     | Quiescent Current        | $V_{PIN5} \leq 150mV, V_{CC} > V_{CC\ off}$ |      | 1.4  | 2.1  | mA      |
|               |     |                          | $V_{PIN5} \leq 150mV, V_{CC} < V_{CC\ off}$ | 20   | 50   | 90   | $\mu A$ |
| $V_Z$         | 8   | Zener Voltage            | $I_{CC} = 25mA$                             | 18   | 20   | 22   | V       |

**ERROR AMPLIFIER SECTION**

| Symbol     | Pin | Parameter                        | Test Condition                  | Min.  | Typ. | Max.  | Unit    |
|------------|-----|----------------------------------|---------------------------------|-------|------|-------|---------|
| $V_{INV}$  | 1   | Voltage Feedback Input Threshold | $T_{amb} = 25^{\circ}C$         | 2.465 | 2.5  | 2.535 | V       |
|            |     |                                  | $12V < V_{CC} < 18V$            | 2.44  |      | 2.56  |         |
|            |     | Line Regulation                  | $V_{CC} = 12$ to $18V$          |       | 2    | 5     | mV      |
| $I_{INV}$  | 1   | Input Bias Current               |                                 |       | -0.1 | -1    | $\mu A$ |
| $G_V$      |     | Voltage Gain                     | Open loop                       | 60    | 80   |       | dB      |
| GB         |     | Gain Bandwidth                   |                                 |       | 1    |       | MHz     |
| $I_{COMP}$ | 2   | Source Current                   | $V_{COMP} = 4V, V_{INV} = 2.4V$ | -2    | -4   | -8    | mA      |
|            |     | Sink Current                     | $V_{COMP} = 4V, V_{INV} = 2.6V$ | 2.5   | 4.5  |       | mA      |
| $V_{COMP}$ | 2   | Upper Clamp Voltage              | $I_{SOURCE} = 0.5mA$            |       | 5.8  |       | V       |
|            |     | Lower Clamp Voltage              | $I_{Sink} = 0.5mA$              |       | 2.25 |       | V       |

**MULTIPLIER SECTION**

| Symbol                                  | Pin | Parameter                | Test Condition                                                                           | Min.   | Typ.     | Max. | Unit |
|-----------------------------------------|-----|--------------------------|------------------------------------------------------------------------------------------|--------|----------|------|------|
| $V_{MULT}$                              | 3   | Linear Operating Voltage |                                                                                          | 0 to 3 | 0 to 3.5 |      | V    |
| $\frac{\Delta V_{CS}}{\Delta V_{mult}}$ |     | Output Max. Slope        | $V_{MULT} = \text{from } 0V \text{ to } 0.5V$<br>$V_{COMP} = \text{Upper Clamp Voltage}$ | 1.65   | 1.9      |      |      |
| K                                       |     | Gain                     | $V_{MULT} = 1V, V_{COMP} = 4V$                                                           | 0.45   | 0.6      | 0.75 | 1/V  |

**CURRENT SENSE COMPARATOR**

| Symbol      | Pin | Parameter                     | Test Condition                                               | Min. | Typ.  | Max. | Unit    |
|-------------|-----|-------------------------------|--------------------------------------------------------------|------|-------|------|---------|
| $V_{CS}$    | 4   | Current Sense Reference Clamp | $V_{MULT} = 2.5V$<br>$V_{COMP} = \text{Upper Clamp Voltage}$ | 1.6  | 1.7   | 1.8  | V       |
| $I_{CS}$    | 4   | Input Bias Current            | $V_{OS} = 0$                                                 |      | -0.05 | -1   | $\mu A$ |
| $t_d (H-L)$ | 4   | Delay to Output               |                                                              |      | 200   | 450  | ns      |
|             | 4   | Current Sense Offset          |                                                              |      | 0     | 15   | mV      |

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

| Symbol           | Pin | Parameter                              | Test Condition                                                             | Min. | Typ. | Max. | Unit |
|------------------|-----|----------------------------------------|----------------------------------------------------------------------------|------|------|------|------|
| V <sub>ZCD</sub> | 5   | Input Threshold Voltage<br>Rising Edge | (1)                                                                        |      | 2.1  |      | V    |
|                  |     | Hysteresis                             | (1)                                                                        | 0.3  | 0.5  | 0.7  | V    |
| V <sub>ZCD</sub> | 5   | Upper Clamp Voltage                    | I <sub>ZCD</sub> = 20μA                                                    | 4.5  | 5.1  | 5.9  | V    |
| V <sub>ZCD</sub> | 5   | Upper Clamp Voltage                    | I <sub>ZCD</sub> = 3mA                                                     | 4.7  | 5.2  | 6.1  | V    |
| V <sub>ZCD</sub> | 5   | Lower Clamp Voltage                    | I <sub>ZCD</sub> = -3mA                                                    | 0.3  | 0.65 | 1    | V    |
| I <sub>ZCD</sub> | 5   | Sink Bias Current                      | 1V ≤ V <sub>ZCD</sub> ≤ 4.5V                                               |      | 2    |      | μA   |
| I <sub>ZCD</sub> | 5   | Source Current Capability              |                                                                            | -3   |      | -10  | mA   |
| I <sub>ZCD</sub> | 5   | Sink Current Capability                |                                                                            | 3    |      | 10   | mA   |
| V <sub>DIS</sub> | 5   | Disable threshold                      |                                                                            | 150  | 200  | 250  | mV   |
| I <sub>ZCD</sub> | 5   | Restart Current After Disable          | V <sub>ZCD</sub> < V <sub>DIS</sub> ; V <sub>CC</sub> > V <sub>CCOFF</sub> | -100 | -200 | -300 | μA   |

**OUTPUT SECTION**

|                     |   |                              |                                             |   |     |     |    |
|---------------------|---|------------------------------|---------------------------------------------|---|-----|-----|----|
| 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     | C <sub>L</sub> = 1nF                        |   | 40  | 100 | ns |
| t <sub>f</sub>      | 7 | Output Voltage Fall Time     | C <sub>L</sub> = 1nF                        |   | 40  | 100 | ns |
| I <sub>GD off</sub> | 7 | I <sub>GD</sub> Sink Current | V <sub>CC</sub> = 3.5V V <sub>GD</sub> = 1V | 5 | 10  | -   | mA |

**OUTPUT OVERVOLTAGE SECTION**

|                  |   |                        |  |     |      |     |    |
|------------------|---|------------------------|--|-----|------|-----|----|
| I <sub>OVP</sub> | 2 | OVP Triggering Current |  | 35  | 40   | 45  | μA |
|                  |   | Static OVP Threshold   |  | 2.1 | 2.25 | 2.4 | V  |

**RESTART TIMER**

|                    |  |             |  |    |     |     |    |
|--------------------|--|-------------|--|----|-----|-----|----|
| t <sub>START</sub> |  | Start Timer |  | 70 | 150 | 400 | μs |
|--------------------|--|-------------|--|----|-----|-----|----|

(1) Parameter guaranteed by design, not tested in production.

**OVER VOLTAGE PROTECTION OVP**

The output voltage is expected to be kept by the operation of the PFC circuit close to its nominal value. This 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 L6561 at 2.5V.

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

$$I_{R1sc} = \frac{V_{out} - 2.5}{R_1} = I_{R2} = \frac{2.5V}{R_2}$$

and, if the external compensation network is made only with a capacitor C<sub>comp</sub>, the current through C<sub>comp</sub> equals zero.

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

$$I_{R1} = \frac{V_{outsc} + \Delta V_{OUT} - 2.5}{R_1} = I_{R1sc} + \Delta I_{R1}$$

Since the current through R<sub>2</sub> does not change, ΔI<sub>R1</sub> must flow through the capacitor C<sub>comp</sub> and enter the error amplifier.

This current is monitored inside the L6561 and when reaches about 37μA the output voltage of the multiplier is forced to decrease, thus reducing the energy drawn from the mains. If the current exceeds 40μA, the OVP protection is triggered (Dynamic OVP), and the external power transistor is switched off until the current falls approximately below 10μA.

However, if the overvoltage persists, an internal comparator (Static OVP) confirms the OVP condition keeping the external power switch turned off (see fig. 1).

Finally, the overvoltage that triggers the OVP function is:

$$\Delta V_{out} = R_1 \cdot 40\mu A.$$

Typical values for R<sub>1</sub>, R<sub>2</sub> and C are shown in the application circuits. 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  $\Delta V = 60V \pm 4.2V$ ).

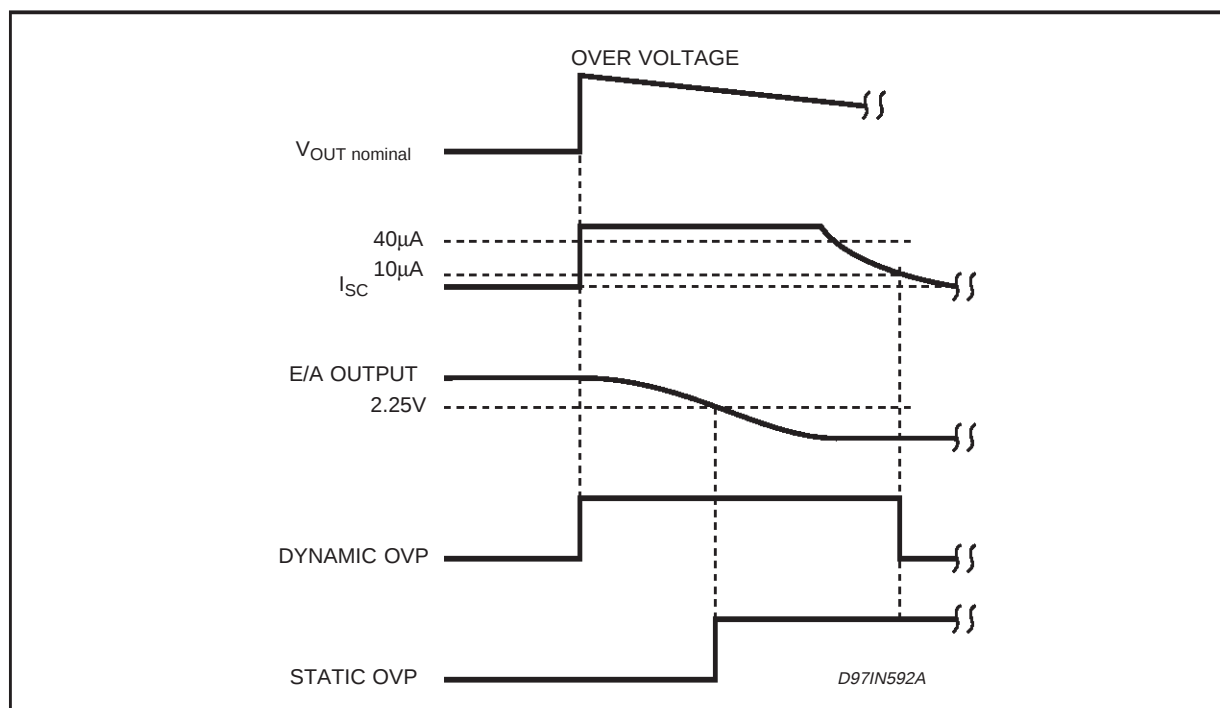
## Disable function

The zero current detector (ZCD) pin can be used

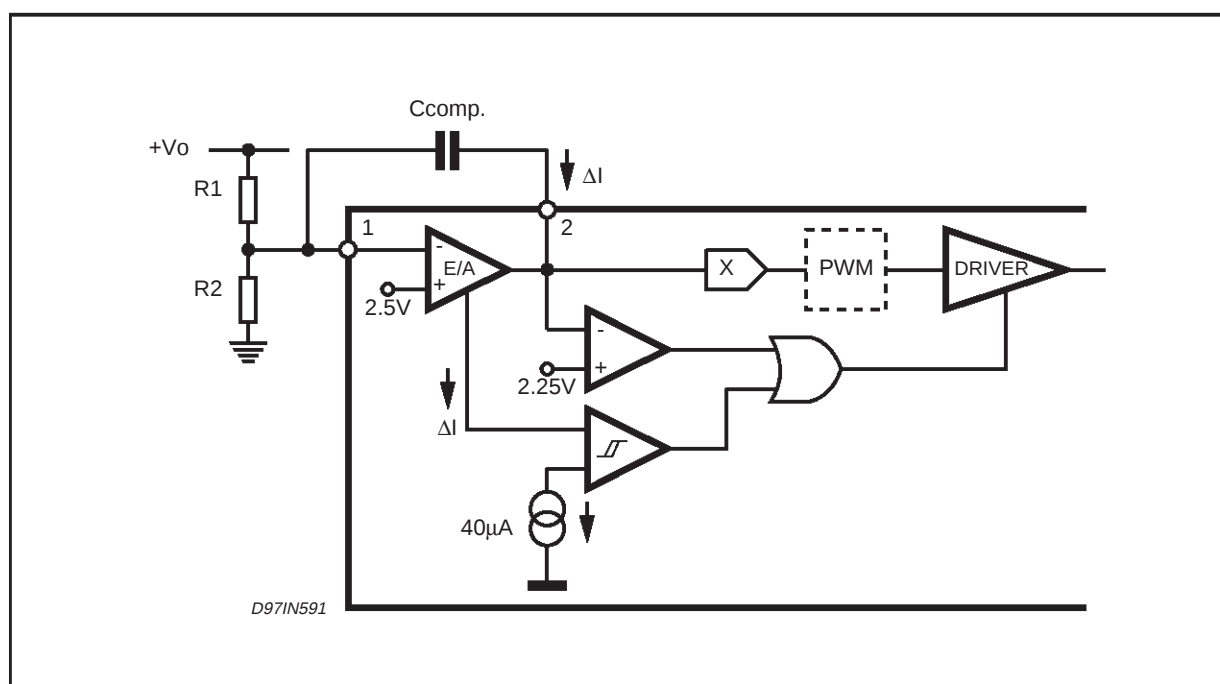
for device disabling as well. By grounding the ZCD voltage the device is disabled reducing the supply current consumption at 1.4mA typical (@ 14.5V supply voltage).

Releasing the ZCD pin the internal start-up timer will restart the device.

**Figure 1.**



### Figure 2. Overvoltage Protection Circuit



## L6561

Figure 3. Typical Application Circuit (80W, 110VAC)

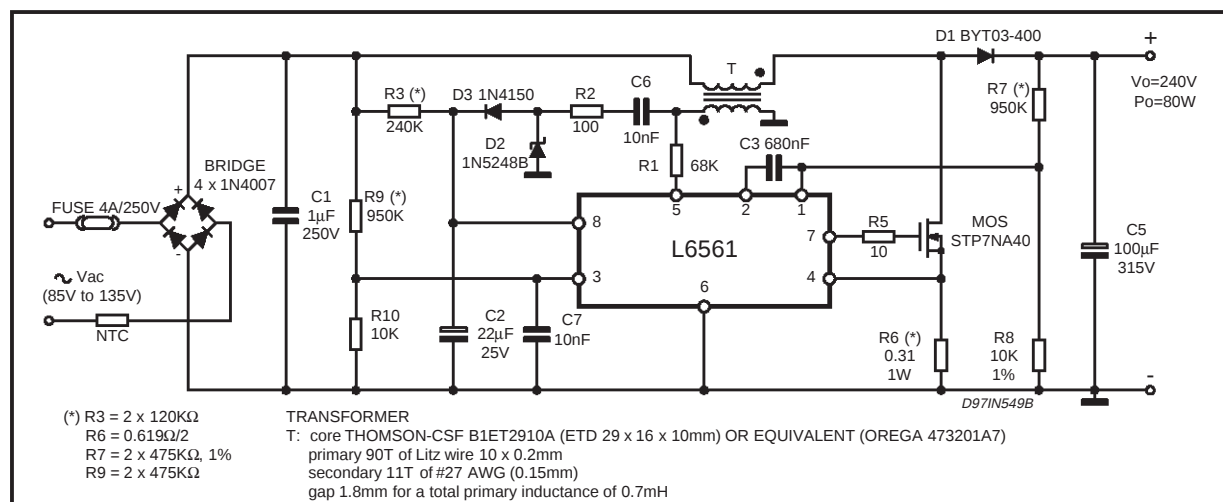


Figure 4. Typical Application Circuit (120W, 220VAC)

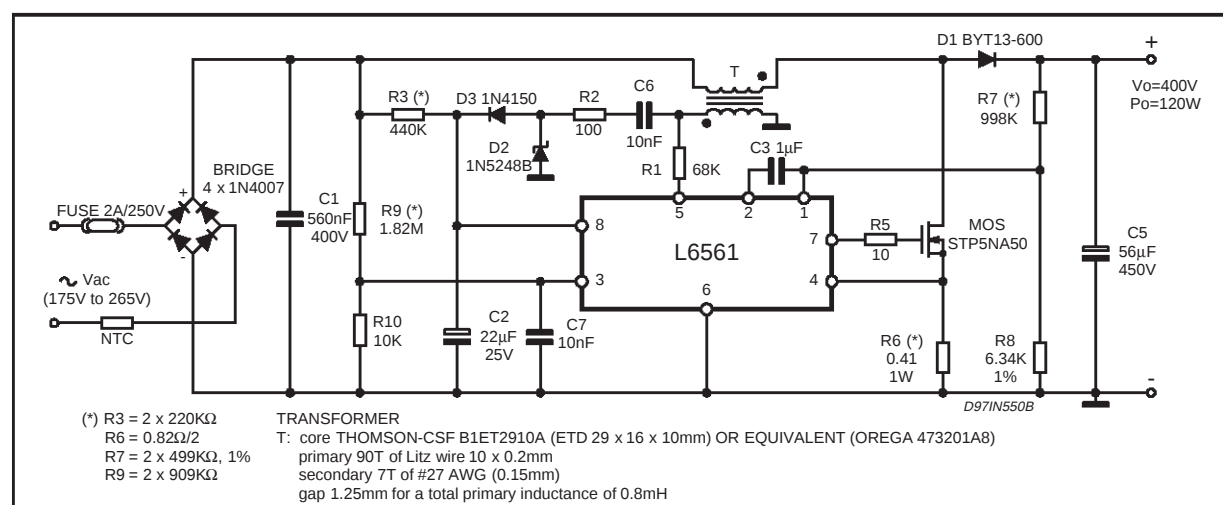


Figure 5. Wide-Range Application (80W)

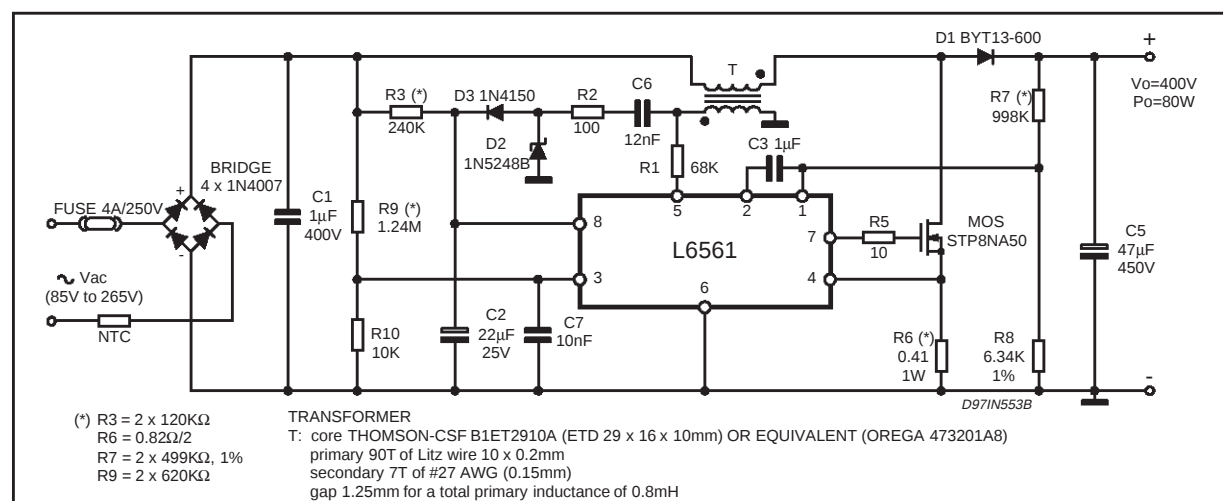


Figure 6. P.C. Board and Components Layout of the Figg. 3, 4 and 5 (1:1.25 scale)

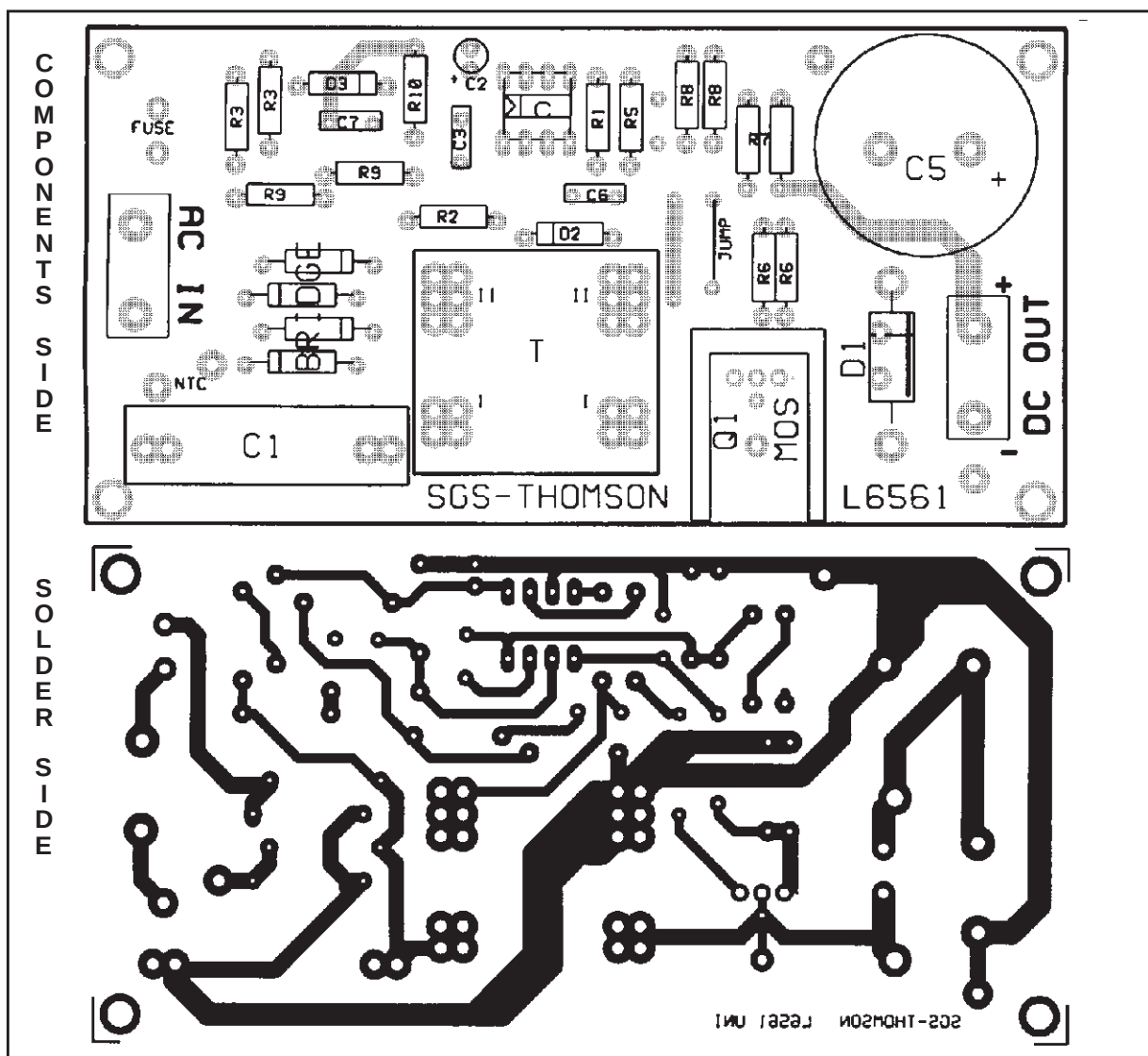


Figure 7. OVP Current Threshold vs. Temperature

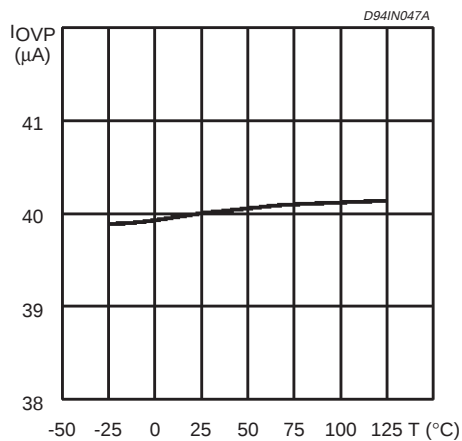


Figure 8. Undervoltage Lockout Threshold vs. Temperature

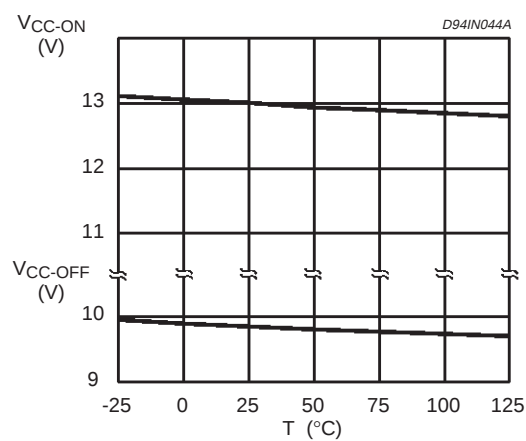


Figure 9. Supply Current vs. Supply Voltage

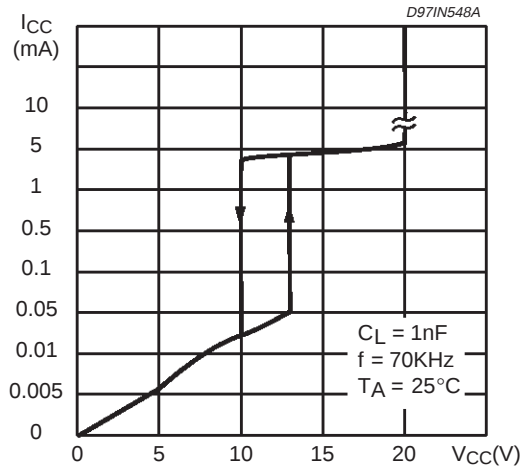


Figure 10. Voltage Feedback Input Threshold vs. Temperature

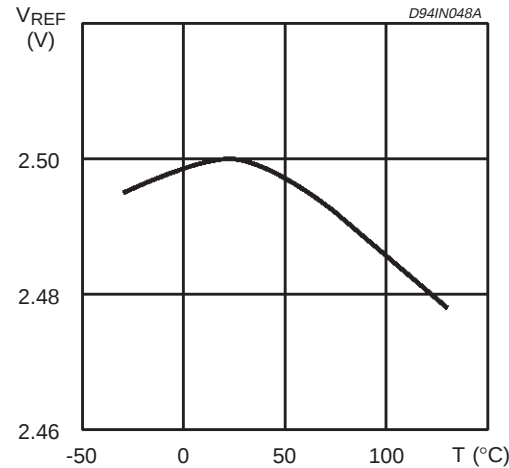


Figure 11. Output Saturation Voltage vs. Sink Current

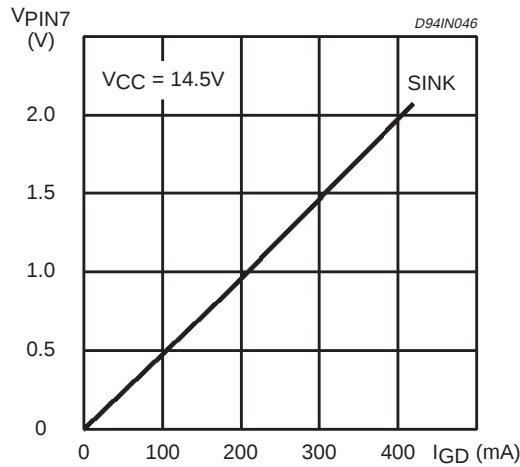


Figure 12. Output Saturation Voltage vs. Source Current

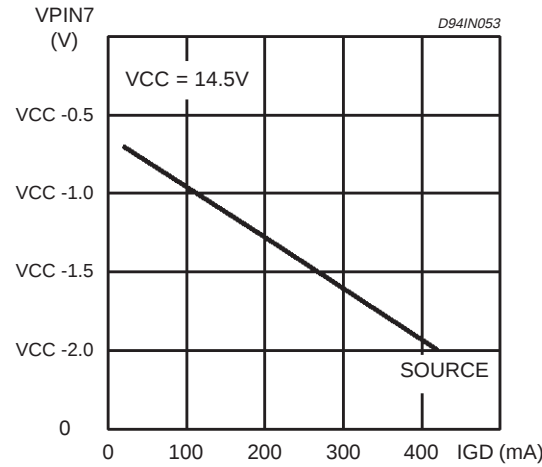
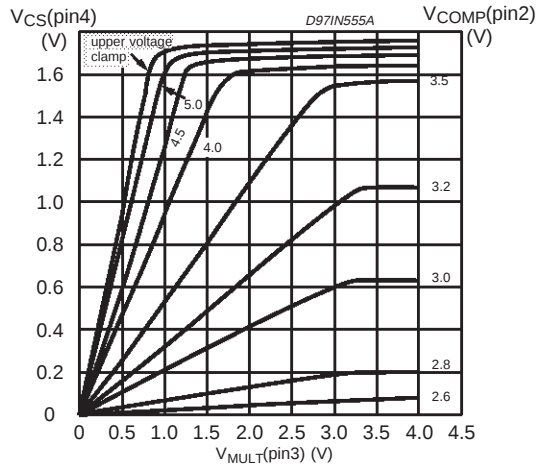
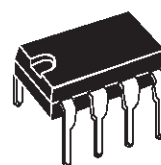


Figure 13. Multiplier Characteristics Family

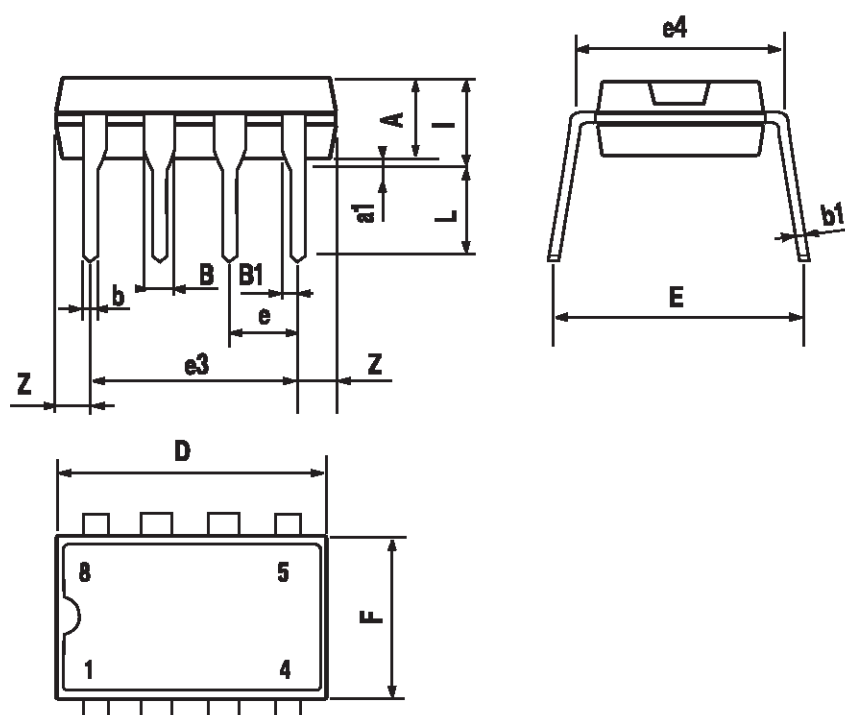


| DIM. | mm    |      |       | inch  |       |       |
|------|-------|------|-------|-------|-------|-------|
|      | MIN.  | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    |       | 3.32 |       |       | 0.131 |       |
| a1   | 0.51  |      |       | 0.020 |       |       |
| B    | 1.15  |      | 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



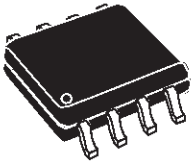
**Minidip**



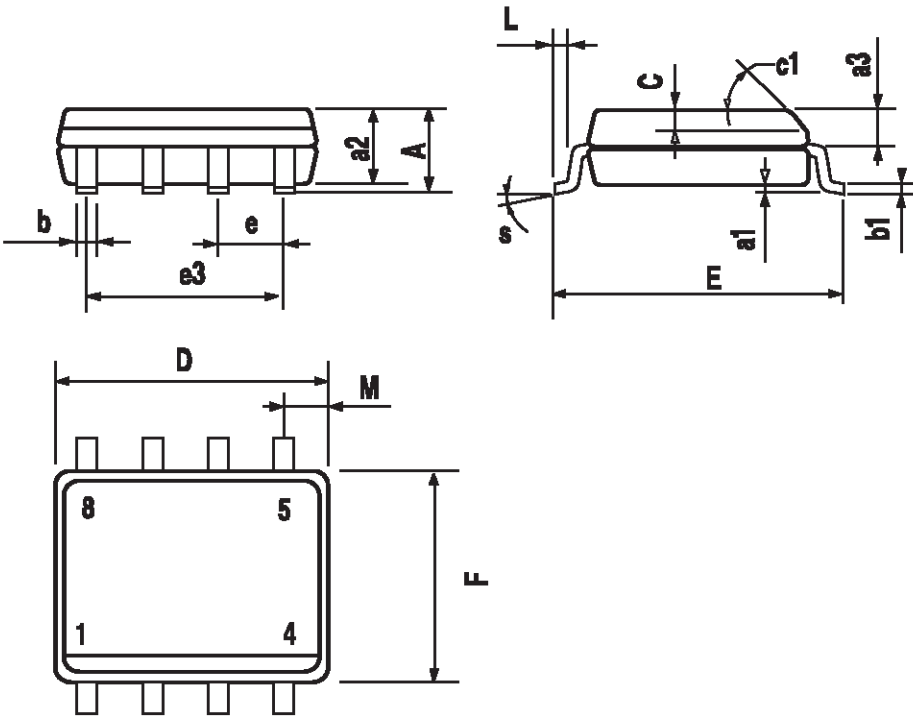
| DIM.  | mm         |      |      | inch  |       |       |
|-------|------------|------|------|-------|-------|-------|
|       | MIN.       | TYP. | MAX. | MIN.  | TYP.  | MAX.  |
| A     |            |      | 1.75 |       |       | 0.069 |
| a1    | 0.1        |      | 0.25 | 0.004 |       | 0.010 |
| 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 (1) | 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 (1) | 3.8        |      | 4.0  | 0.15  |       | 0.157 |
| L     | 0.4        |      | 1.27 | 0.016 |       | 0.050 |
| M     |            |      | 0.6  |       |       | 0.024 |
| S     | 8° (max.)  |      |      |       |       |       |

(1) D and F do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm (.006inch).

OUTLINE AND  
MECHANICAL DATA



SO8



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