

## Power Supply Supervisory Circuit

### FEATURES

- Includes Over-Voltage, Under-Voltage, and Current Sensing Circuits
- Internal 1% Accurate Reference
- Programmable Time Delays
- SCR “Crowbar” Drive of 300 mA
- Remote Activation Capability
- Optional Over-Voltage Latch
- Uncommitted Comparator Inputs for Low Voltage Sensing (UC1544 Series Only)

### DESCRIPTION

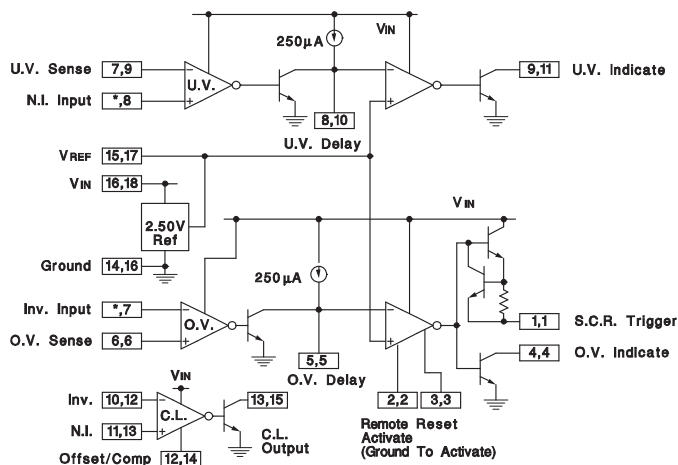
The monolithic integrated circuits contain all the functions necessary to monitor and control the output of a sophisticated power supply system. Over-voltage (O.V.) sensing with provision to trigger an external SCR “crowbar” shutdown; an undervoltage (U.V.) circuit which can be used to monitor either the output or to sample the input line voltage; and a third op amp/comparator usable for current sensing (C.L.) are all included in this device, together with an independent, accurate reference generator.

Both over- and under-voltage sensing circuits can be externally programmed for minimum time duration of fault before triggering. All functions contain open collector outputs which can be used independently or wire-or’ed together, and although the SCR trigger is directly connected only to the over-voltage sensing circuit, it may be optionally activated by any of the other outputs, or from an external signal. The O.V. circuit also includes an optional latch and external reset capability.

The UC1544/2544/3544 devices have the added versatility of completely uncommitted inputs to the voltage sensing comparators so that levels less than 2.5 V may be monitored by dividing down the internal reference voltage. The current sense circuit may be used with external compensation as a linear amplifier or as a highgain comparator. Although nominally set for zero input offset, a fixed threshold may be added with an external resistor. Instead of current limiting, this circuit may also be used as an additional voltage monitor.

The reference generator circuit is internally trimmed to eliminate the need for external potentiometers and the entire circuit may be powered directly from either the output being monitored or from a separate bias voltage.

### BLOCK DIAGRAM



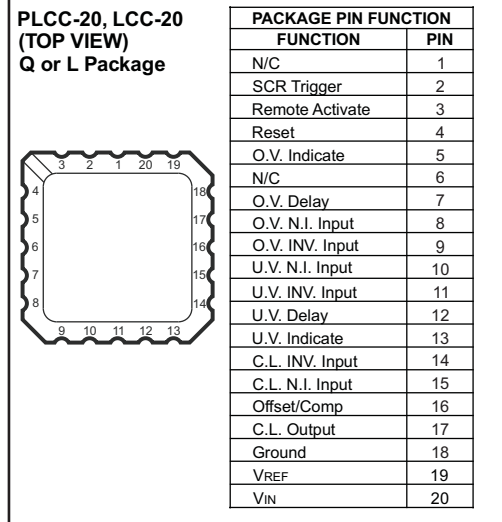
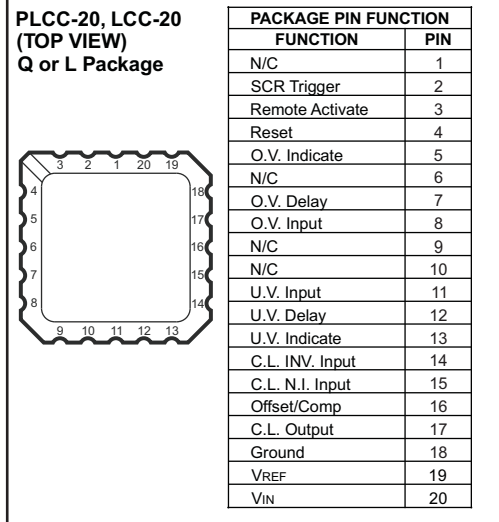
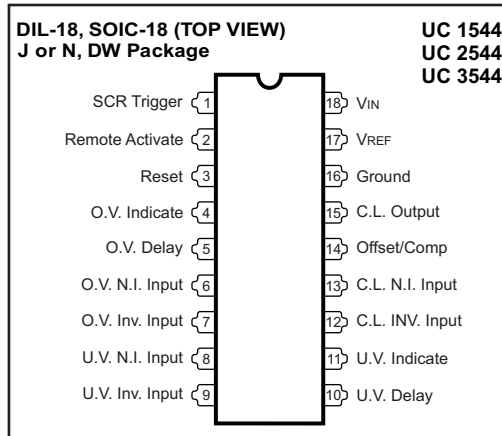
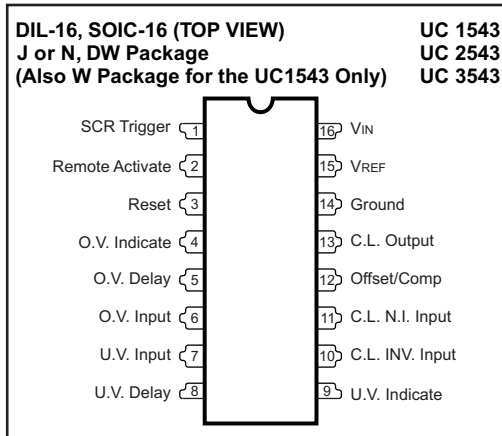
### NOTE:

For each terminal, first number refers to 1543 series, second to 1544 series.  
\*On 1543 series, this function is internally connected to VREF.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

## Connection Diagrams



## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

over operating free-air temperature range (unless otherwise noted)

|           |  | VALUE          | UNIT |
|-----------|--|----------------|------|
| $V_{IN}$  | Input supply voltage                   | 40             | V    |
|           | Sense inputs, voltage range            | 0 to $V_{IN}$  |      |
|           | SCR trigger current <sup>(2)</sup>     | -600           | mA   |
|           | Indicator output voltage               | 40             | V    |
|           | Indicator output sink current          | 50             | mA   |
|           | Power dissipation (package limitation) | 1000           | mW   |
| $T_J$     | Operating temperature range            | UC1543, UC1544 | °C   |
|           |  | UC2543, UC2544 |      |
|           |  | UC3543, UC3544 |      |
| $T_{stg}$ | Storage temperature range              | -65 to 150     |      |

(1) Currents are positive-into, negative-out of the specified terminal.

(2) At higher input voltages, a dissipation limiting resistor,  $R_G$ , is required.

## ELECTRICAL CHARACTERISTICS

Unless otherwise stated, these specifications apply for  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C}$  for the UC1543 and UC1544;  $-25^\circ\text{C}$  to  $85^\circ\text{C}$  for the UC2543 and UC2544; and  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the UC3543 and UC3544. Electrical tests are performed with  $V_{IN} = 10\text{ V}$  and 2-k $\Omega$  pull-up resistors on all indicator outputs. All electrical specifications for the UC1544, UC2544, and UC3544 devices are tested with the inverting over-voltage input and the non-inverting under-voltage input externally connected to the 2.5 V reference.  $T_A = T_J$ .

| PARAMETER                  |  | TEST CONDITIONS   | UC1543/UC1544/UC2543/<br>UC2544 |      |      | UC3543/UC3544 |      |      | UNIT                  |
|----------------------------|--|---|---------------------------------|------|------|---------------|------|------|-----------------------|
|                            |  |   | MIN                             | TYP  | MAX  | MIN           | TYP  | MAX  |                       |
| $V_{IN}$                   | Input voltage range  | $T_J = 25^\circ\text{C}$ to $T_{MAX}$   | 4.5                             |      | 40   | 4.5           |      | 40   | V                     |
|                            |  | $T_{MIN}$ to $T_{MAX}$  | 4.7                             |      | 40   | 4.7           |      | 40   |                       |
| $I_{CC}$                   | Supply current   | $V_{IN} = 40\text{ V}$ , output open,<br>$T_J = 25^\circ\text{C}$               |                                 | 7    | 10   |               | 7    | 10   | mA                    |
|                            |  | $T_{MIN} \leq T_J \leq T_{MAX}$   |                                 |      | 15   |               |      | 15   |                       |
| <b>Reference Section</b>   |  |   |                                 |      |      |               |      |      |                       |
| $V_{OUT}$                  | Output voltage   | $T_J = 25^\circ\text{C}$  | 2.48                            | 2.5  | 2.52 | 2.45          | 2.50 | 2.55 | V                     |
|                            |  | Over temperature range  | 2.45                            |      | 2.55 | 2.40          |      | 2.60 |                       |
|                            | Line regulation  | $V_{IN} = 5$ to $30\text{ V}$   |                                 | 1    | 5    |               | 1    | 5    | mV                    |
|                            | Load regulation  | $I_{REF} = 0$ to $10\text{ mA}$   |                                 | 1    | 10   |               | 1    | 10   |                       |
|                            | Short circuit current  | $V_{REF} = 0$   | -10                             | -20  | -40  | -12           | -20  | -40  | mA                    |
|                            | Temperature stability  |   |                                 | 50   |      |               | 50   |      | ppm/ $^\circ\text{C}$ |
| <b>SCR Trigger Section</b> |  |   |                                 |      |      |               |      |      |                       |
|                            | Peak output current  | $V_{IN} = 5\text{ V}$ , $R_G = 0$ , $V_O = 0$                                   | -100                            | -300 | -600 | -100          | -300 | -600 | mA                    |
|                            | Peak output voltage  | $V_{IN} = 15\text{ V}$ , $I_O = -100\text{ mA}$                                 | 12                              | 13   |      | 12            | 13   |      | V                     |
|                            | Output OFF voltage   | $V_{IN} = 40\text{ V}$  |                                 | 0    | 0.1  |               | 0    | 0.1  |                       |
|                            | Remote activate current  | R/A Pin = GND   |                                 | -0.4 | -0.8 |               | -0.4 | -0.8 | mA                    |
|                            | Remote activate voltage  | R/A Pin Open  |                                 | 2    | 6    |               | 2    | 6    | V                     |
|                            | Reset current  | Reset = GND, R/A = GND  |                                 | -0.4 | -0.8 |               | -0.4 | -0.8 | mA                    |
|                            | Reset voltage  | Reset open, R/A = GND   |                                 | 2    | 6    |               | 2    | 6    | V                     |
|                            | Output current rise time   | $R_L = 50$ , $T_J = 25^\circ\text{C}$ , $C_D = 0$                               |                                 | 400  |      |               | 400  |      | mA/ $\mu\text{s}$     |
|                            | Prop. delay from R/A   | $R_L = 50$ , $T_J = 25^\circ\text{C}$ , $C_D = 0$                               |                                 | 300  |      |               | 300  |      | ns                    |
|                            | Prop. delay from O/V input   | $R_L = 50$ , $T_J = 25^\circ\text{C}$ , $C_D = 0$                               |                                 | 500  |      |               | 500  |      |                       |
| <b>Comparator Section</b>  |  |   |                                 |      |      |               |      |      |                       |
|                            | Input threshold (Input voltage rising on O.V. and falling on U.V.) | $T_J = 25^\circ\text{C}$  | 2.45                            | 2.50 | 2.55 | 2.40          | 2.50 | 2.60 | V                     |
|                            |  | Over temperature range  | 2.40                            |      | 2.60 | 2.35          |      | 2.65 |                       |
|                            | Input hysteresis   |   |                                 | 25   |      |               | 25   |      | mV                    |
|                            | Input bias current   | Sense input = 0 V   |                                 | -0.3 | -1.0 |               | -0.3 | -1.0 | $\mu\text{A}$         |
|                            | Delay saturation   |   |                                 | 0.2  | 0.5  |               | 0.2  | 0.5  | V                     |
|                            | Delay high level   |   |                                 | 6    | 7    |               | 6    | 7    |                       |
|                            | Delay charging current   | $V_O = 0$   | -200                            | -250 | -300 | -200          | -250 | -300 | $\mu\text{A}$         |
|                            | Indicate saturation  | $I_L = 10\text{ mA}$  |                                 | 0.2  | 0.5  |               | 0.2  | 0.5  | V                     |
|                            | Indicate leakage   | $V_{IND} = 40\text{ V}$   |                                 | 0.01 | 1.0  |               | 0.01 | 1.0  | $\mu\text{A}$         |
|                            | Propagation delay  | Input over drive = 200 mV,<br>$T_J = 25^\circ\text{C}$ , $C_D = 0$              |                                 | 400  |      |               | 400  |      | ns                    |
|                            |  | Input over drive = 200 mV,<br>$T_J = 25^\circ\text{C}$ , $C_D = 1\ \mu\text{F}$ |                                 | 10   |      |               | 10   |      | ms                    |

**ELECTRICAL CHARACTERISTICS (continued)**

Unless otherwise stated, these specifications apply for  $T_A = -55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  for the UC1543 and UC1544;  $-25^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  for the UC2543 and UC2544; and  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$  for the UC3543 and UC3544. Electrical tests are performed with  $V_{IN} = 10\text{ V}$  and 2-k $\Omega$  pull-up resistors on all indicator outputs. All electrical specifications for the UC1544, UC2544, and UC3544 devices are tested with the inverting over-voltage input and the non-inverting under-voltage input externally connected to the 2.5 V reference.  $T_A = T_J$ .

| Current Limit Section  |   |    |      |         |    |      |         |               |
|------------------------|---|----|------|---------|----|------|---------|---------------|
| Input voltage range    |   | 0  |      | VIN -3V | 0  |      | VIN -3V | V             |
| Input Bias Current     | Offset pin open, $V_{CM} = 0$   |    | -0.3 | -1.0    |    | -0.3 | -1.0    | $\mu\text{A}$ |
| Input offset voltage   | Offset pin open, $V_{CM} = 0$   | 0  | 10   |         | 0  | 10   |         | mV            |
|                        | 10k from offset pin to GND  | 80 | 100  | 120     | 80 | 100  | 120     |               |
| CMRR                   | $0 \leq V_{CM} \leq 12\text{ V}$ , $V_{IN} = 15\text{ V}$   | 60 | 70   |         | 60 | 70   |         | dB            |
| AVOL                   | Offset pin open, $V_{CM} = 0$<br>$V_i$ ,<br>$R_L = 10\text{ k}\Omega$ to $15\text{ k}\Omega$ ,<br>$V_{OUT} = 1$ to $6\text{ V}$ | 72 | 80   |         | 72 | 80   |         |               |
| Output saturation      | $I_L = 10\text{ mA}$  |    | 0.2  | 0.5     |    | 0.2  | 0.5     | V             |
| Output leakage         | $V_{IND} = 40\text{ V}$   |    | 0.01 | 1.0     |    | 0.01 | 1.0     | $\mu\text{A}$ |
| Small signal bandwidth | $A_V = 0\text{ dB}$ , $T_J = 25^{\circ}\text{C}$  |    | 5    |         |    | 5    |         | MHz           |
| Propagation delay      | $V_{OVERDRIVE} = 100\text{ mV}$ ,<br>$T_J = 25^{\circ}\text{C}$   |    | 200  |         |    | 200  |         | ns            |

**TYPICAL CHARACTERISTICS**

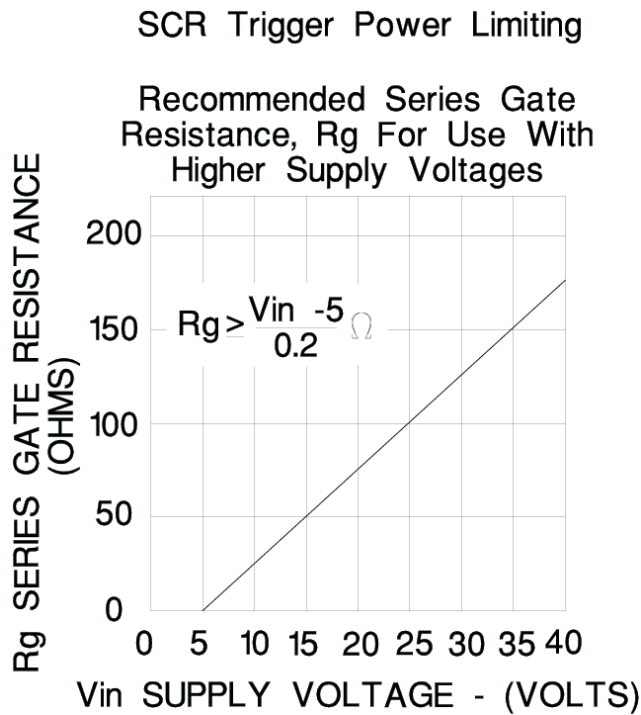


Figure 1.

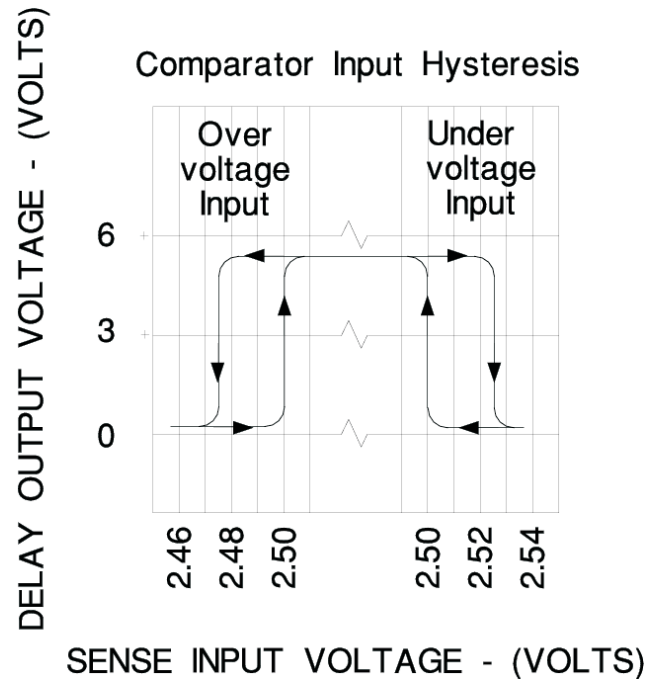


Figure 2.

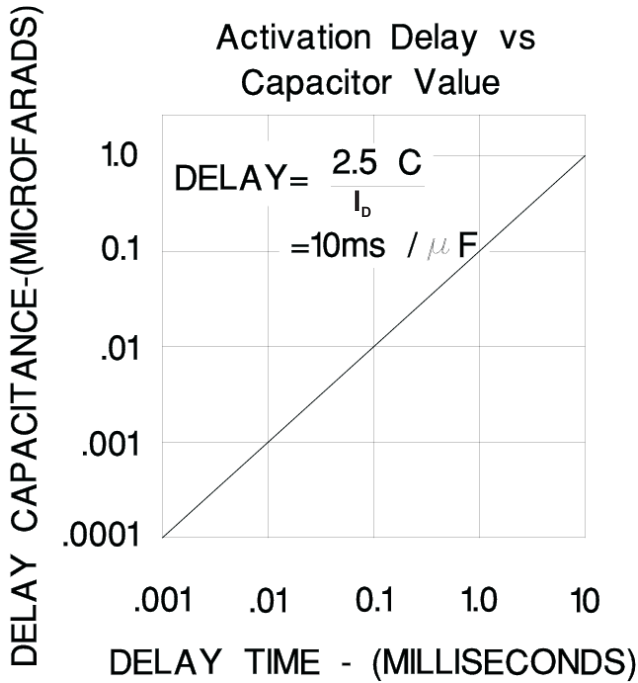


Figure 3.

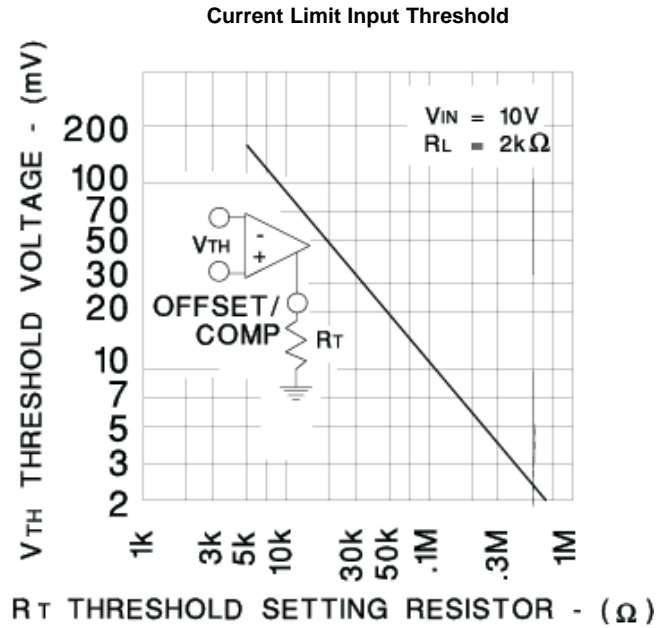


Figure 4.

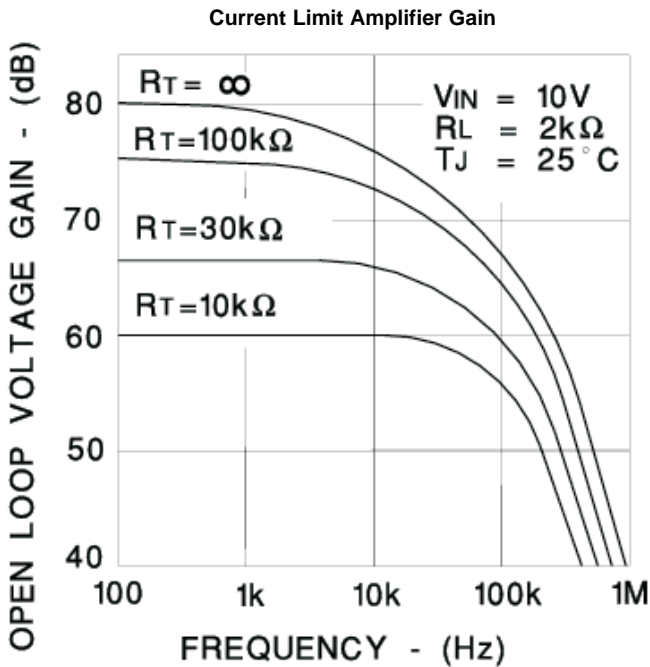


Figure 5.

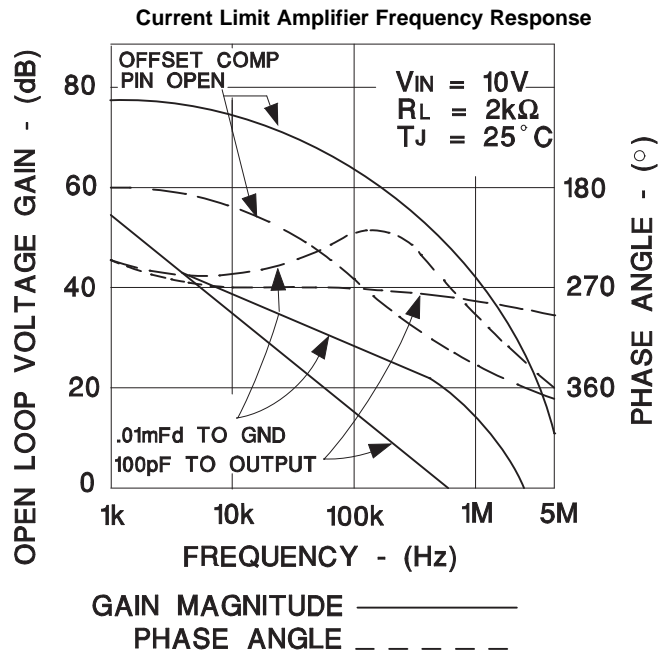


Figure 6.

### APPLICATION INFORMATION

The values for the external components are determined as follows:

$$V_{TH} = \frac{1000}{R1}$$

Current limit input threshold,

$C_S$  is determined by the current loop dynamics

$$I_P \cong \frac{V_{TH}}{R_{SC}} + \frac{V_O}{R_{SC}} \left( \frac{R2}{R2 + R3} \right)$$

Peak current to load,

$$I_{SC} = \frac{V_{TH}}{R_{SC}}$$

Short circuit current,

$$V_{O(low)} = \frac{2.5(R4 + R5 + R6)}{R5 + R6}$$

Low output voltage limit,

$$V_{O(high)} = \frac{2.5(R4 + R5 + R6)}{R6}$$

High output voltage limit,

Voltage sensing delay,  $t_D = 10,000C_d$

$$R_G > \frac{V_{IN} - 5}{0.2}$$

SCR trigger power limiting resistor,

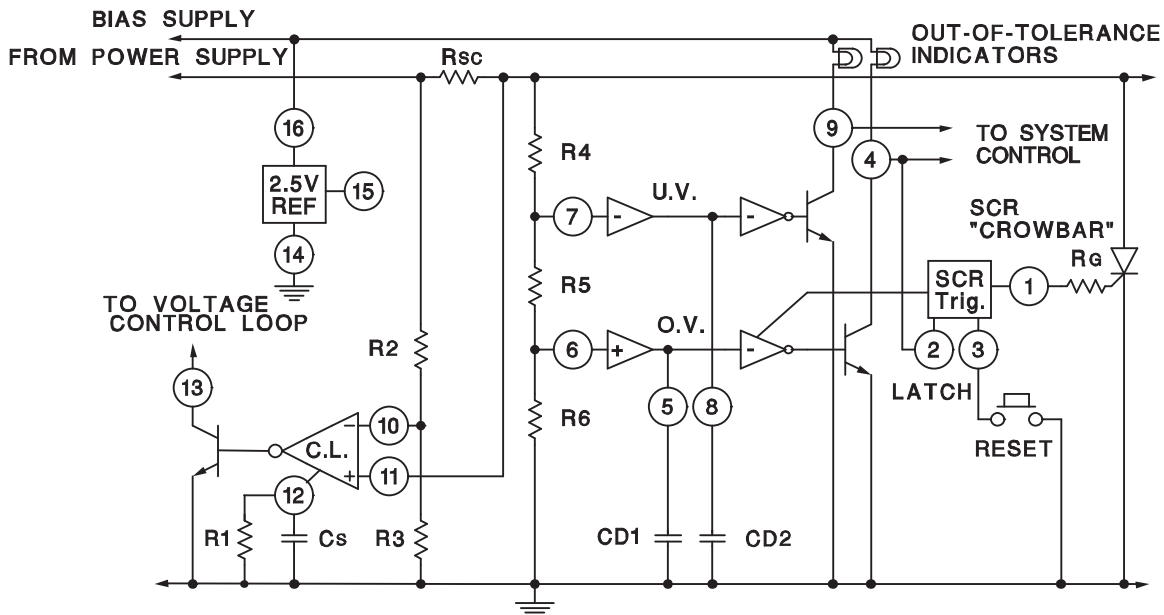


Figure 7. Typical Application

APPLICATION INFORMATION (continued)

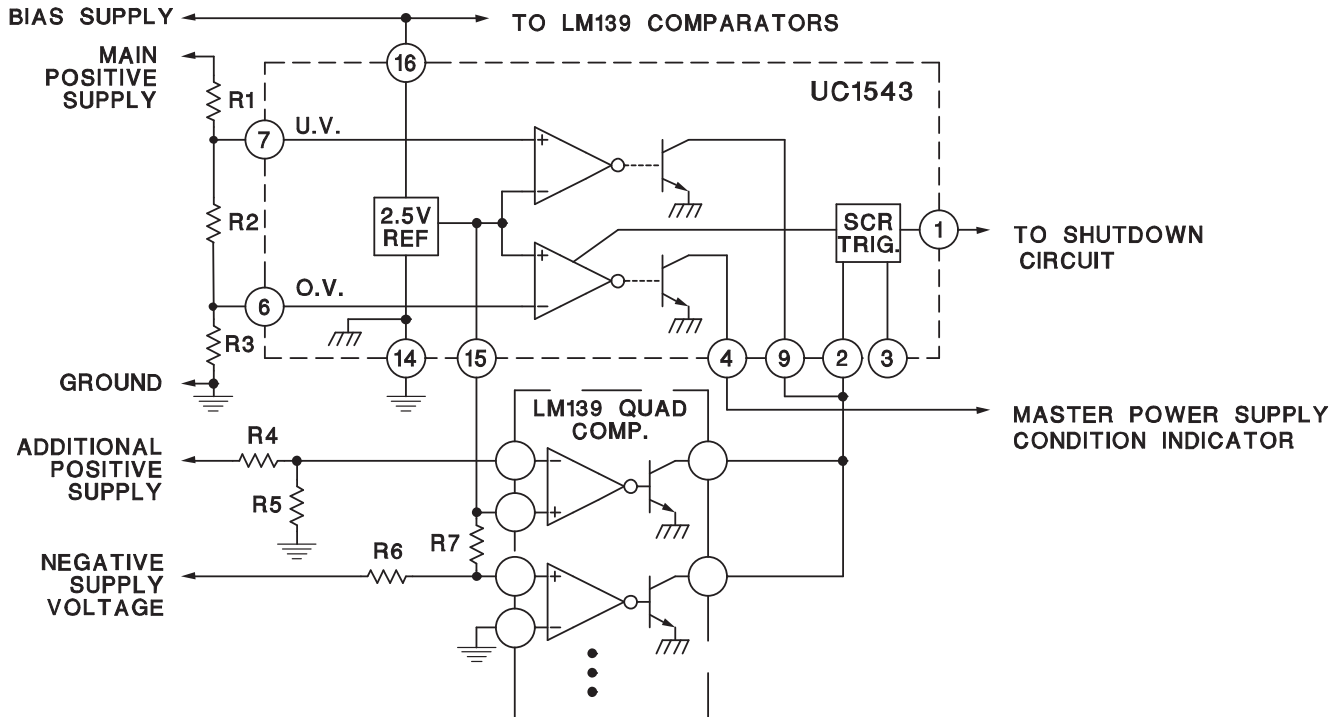


Figure 8. Sensing Multiple Supply Voltages

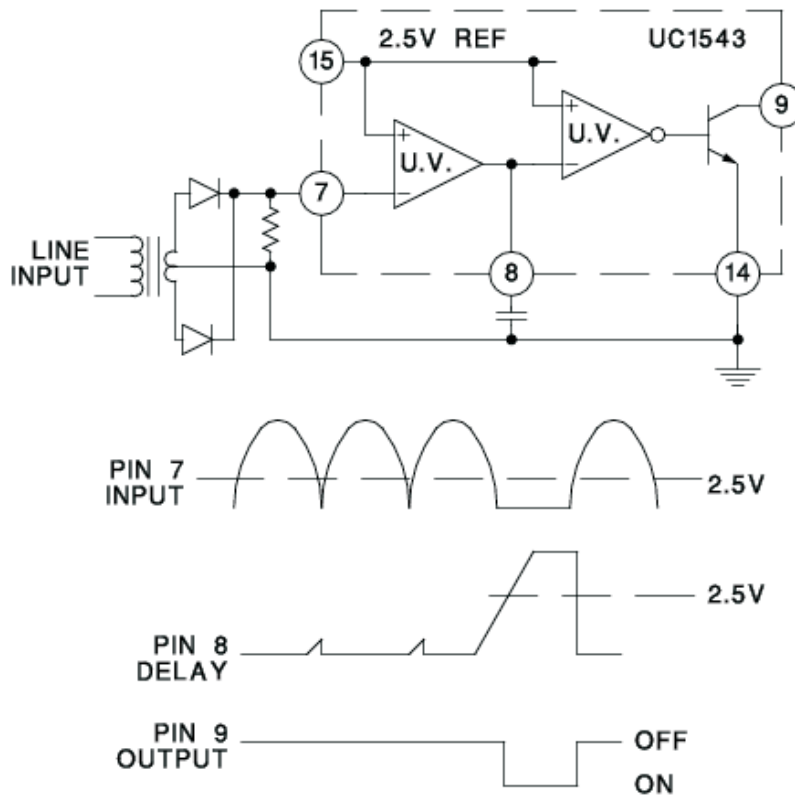


Figure 9. Input Line Monitor

APPLICATION INFORMATION (continued)

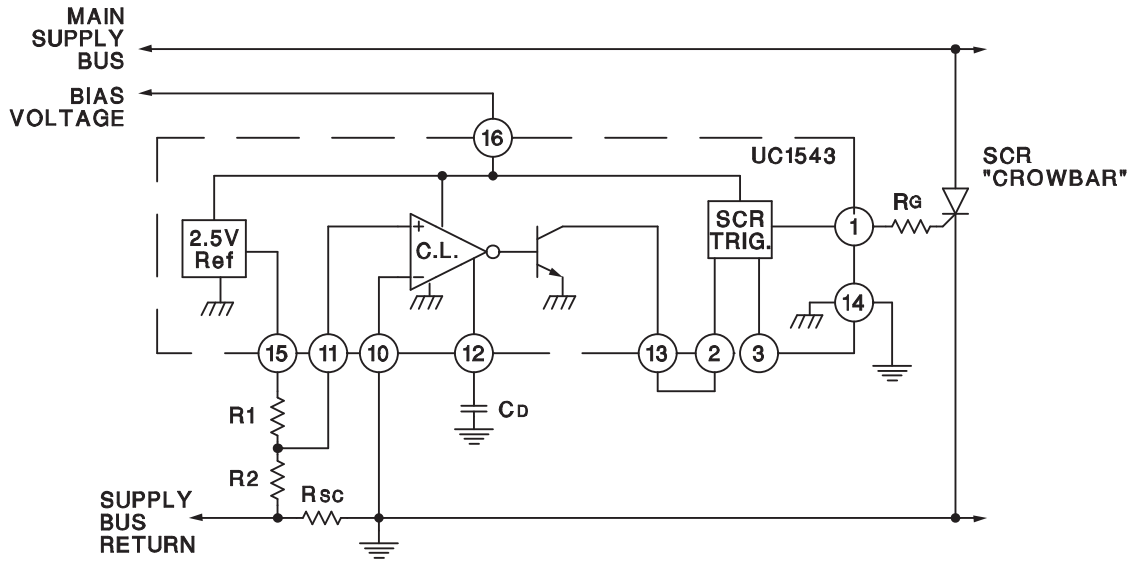


Figure 10. Overcurrent Shutdown



**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| 5962-8774001EA   | ACTIVE                | CDIP         | J               | 16   | 1           | TBD                     | A42              | N / A for Pkg Type           |
| 5962-8774001FA   | ACTIVE                | CFP          | W               | 16   | 25          | TBD                     | A42              | N / A for Pkg Type           |
| 5962-8774002VA   | OBSOLETE              | CDIP         | J               | 18   |             | TBD                     | Call TI          | Call TI                      |
| UC1543J          | ACTIVE                | CDIP         | J               | 16   | 1           | TBD                     | A42              | N / A for Pkg Type           |
| UC1543J/80265    | ACTIVE                | CDIP         | J               | 16   | 1           | TBD                     | A42              | N / A for Pkg Type           |
| UC1543J883B      | ACTIVE                | CDIP         | J               | 16   | 1           | TBD                     | A42              | N / A for Pkg Type           |
| UC1543L          | ACTIVE                | LCCC         | FK              | 20   | 1           | TBD                     | POST-PLATE       | N / A for Pkg Type           |
| UC1543L883B      | ACTIVE                | LCCC         | FK              | 20   | 1           | TBD                     | POST-PLATE       | N / A for Pkg Type           |
| UC1543W883B      | ACTIVE                | CFP          | W               | 16   | 25          | TBD                     | A42              | N / A for Pkg Type           |
| UC1544J          | OBSOLETE              | CDIP         | J               | 18   |             | TBD                     | Call TI          | Call TI                      |
| UC1544J883B      | OBSOLETE              | CDIP         | J               | 18   |             | TBD                     | Call TI          | Call TI                      |
| UC1544L          | OBSOLETE              | LCCC         | FK              | 20   |             | TBD                     | Call TI          | Call TI                      |
| UC1544L883B      | OBSOLETE              | LCCC         | FK              | 20   |             | TBD                     | Call TI          | Call TI                      |
| UC2543DW         | NRND                  | SOIC         | DW              | 16   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC2543DWG4       | NRND                  | SOIC         | DW              | 16   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC2543J          | ACTIVE                | CDIP         | J               | 16   | 1           | TBD                     | A42              | N / A for Pkg Type           |
| UC2543N          | NRND                  | PDIP         | N               | 16   | 25          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC2543NG4        | NRND                  | PDIP         | N               | 16   | 25          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC2544DW         | NRND                  | SOIC         | DW              | 18   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC2544DWG4       | NRND                  | SOIC         | DW              | 18   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC2544J          | OBSOLETE              | CDIP         | J               | 18   |             | TBD                     | Call TI          | Call TI                      |
| UC2544N          | NRND                  | PDIP         | N               | 18   | 20          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC2544NG4        | NRND                  | PDIP         | N               | 18   | 20          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC3543DW         | NRND                  | SOIC         | DW              | 16   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC3543DWG4       | NRND                  | SOIC         | DW              | 16   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC3543J          | ACTIVE                | CDIP         | J               | 16   | 1           | TBD                     | A42              | N / A for Pkg Type           |
| UC3543N          | NRND                  | PDIP         | N               | 16   | 25          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC3543NG4        | NRND                  | PDIP         | N               | 16   | 25          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC3544J          | OBSOLETE              | CDIP         | J               | 18   |             | TBD                     | Call TI          | Call TI                      |
| UC3544N          | NRND                  | PDIP         | N               | 18   | 20          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC3544NG4        | NRND                  | PDIP         | N               | 18   | 20          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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J (R-GDIP-T\*\*)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



| DIM \ PINS ** | 14                     | 16                     | 18                     | 20                     |
|---------------|------------------------|------------------------|------------------------|------------------------|
| A             | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC |
| B MAX         | 0.785<br>(19,94)       | .840<br>(21,34)        | 0.960<br>(24,38)       | 1.060<br>(26,92)       |
| B MIN         | —                      | —                      | —                      | —                      |
| C MAX         | 0.300<br>(7,62)        | 0.300<br>(7,62)        | 0.310<br>(7,87)        | 0.300<br>(7,62)        |
| C MIN         | 0.245<br>(6,22)        | 0.245<br>(6,22)        | 0.220<br>(5,59)        | 0.245<br>(6,22)        |



4040083/F 03/03

- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - This package is hermetically sealed with a ceramic lid using glass frit.
  - Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
  - Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

W (R-GDFP-F16)

CERAMIC DUAL FLATPACK



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package can be hermetically sealed with a ceramic lid using glass frit.
  - D. Index point is provided on cap for terminal identification only.
  - E. Falls within MIL STD 1835 GDFP1-F16 and JEDEC MO-092AC

FK (S-CQCC-N\*\*)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



4040140/D 10/96

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package can be hermetically sealed with a metal lid.
  - D. The terminals are gold plated.
  - E. Falls within JEDEC MS-004

N (R-PDIP-T\*\*)

PLASTIC DUAL-IN-LINE PACKAGE

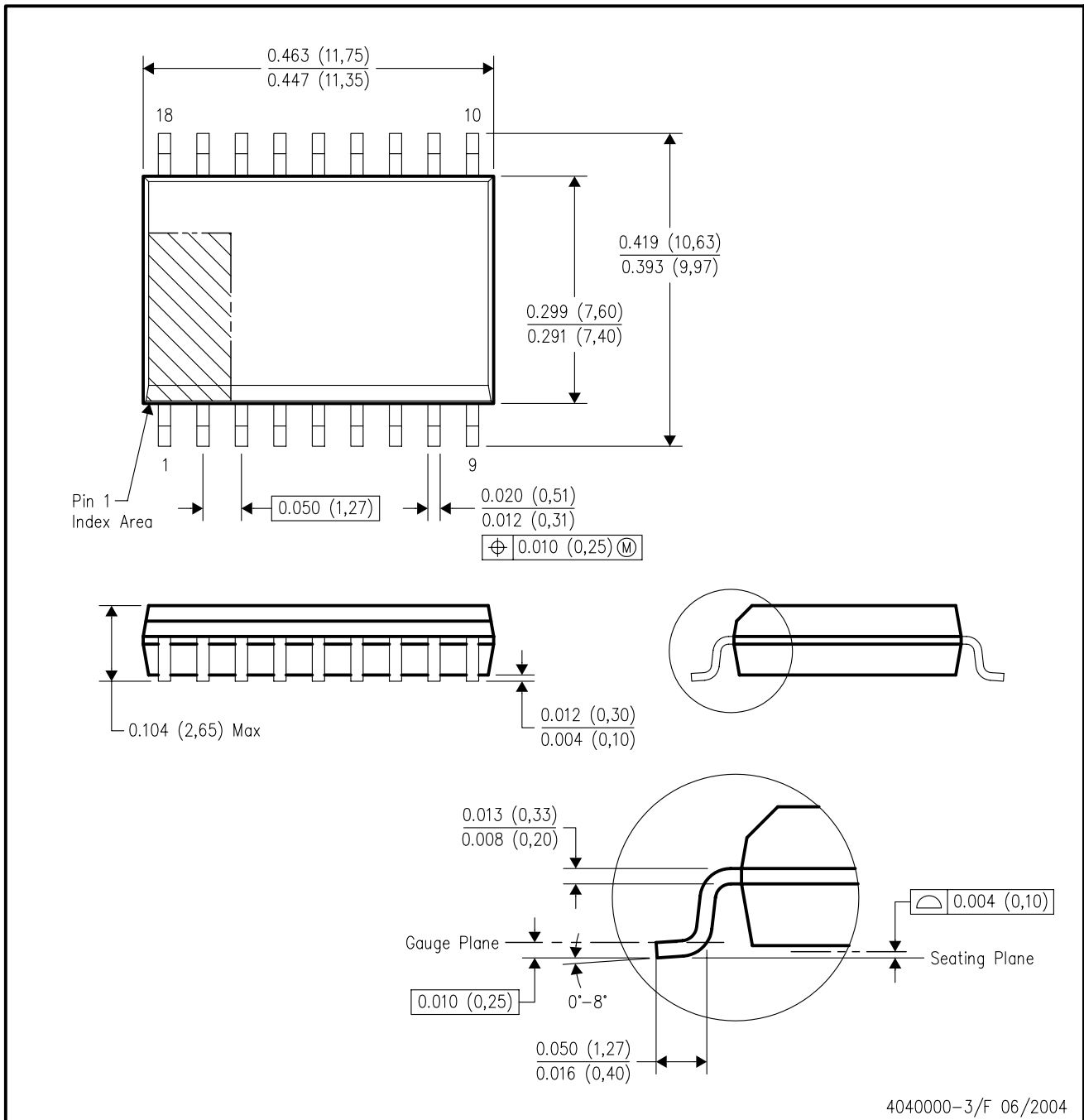
16 PINS SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
  - D The 20 pin end lead shoulder width is a vendor option, either half or full width.

DW (R-PDSO-G18)

PLASTIC SMALL-OUTLINE PACKAGE

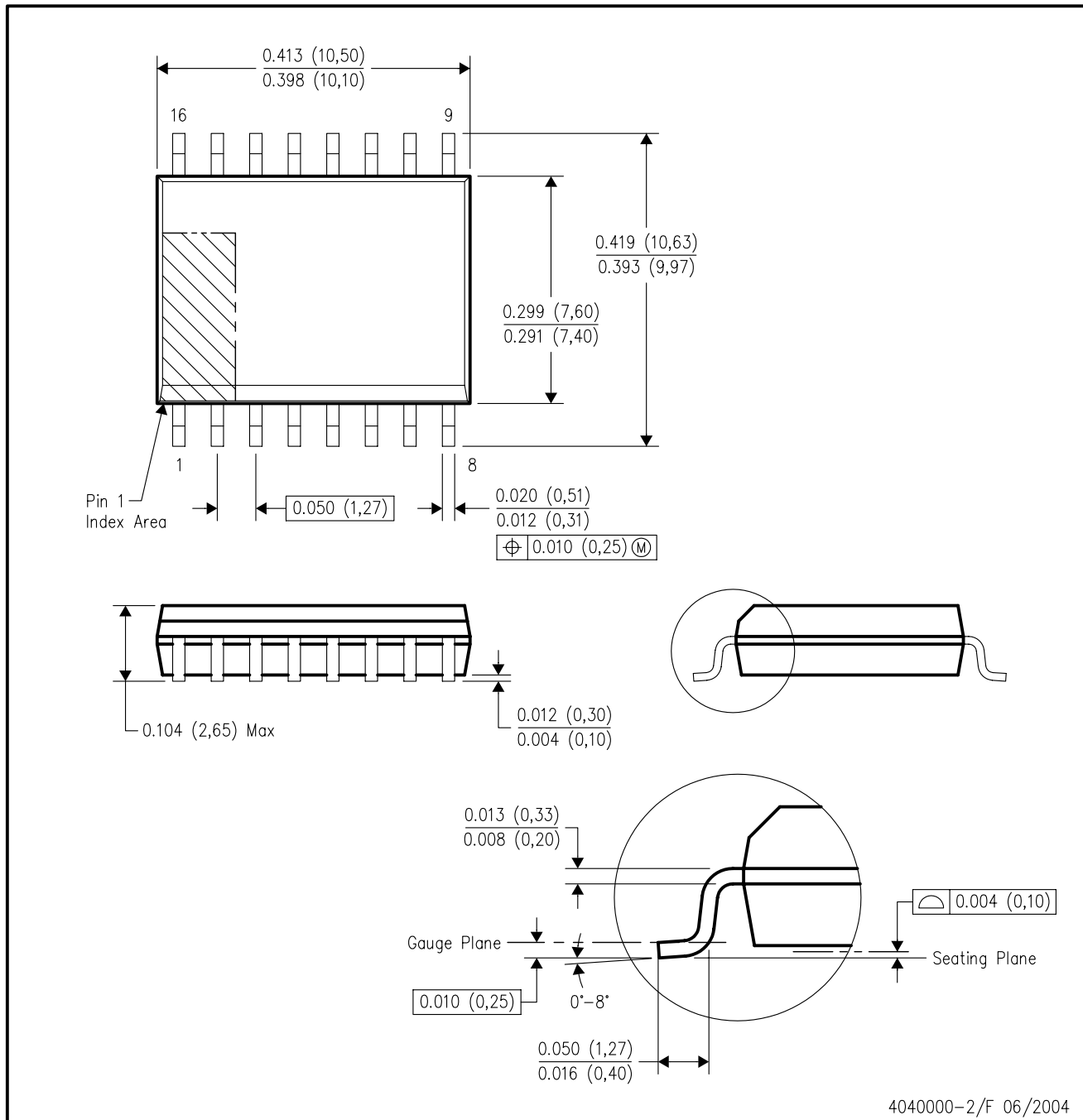


4040000-3/F 06/2004

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - D. Falls within JEDEC MS-013 variation AB.

DW (R-PDSO-G16)

PLASTIC SMALL-OUTLINE PACKAGE



4040000-2/F 06/2004

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - D. Falls within JEDEC MS-013 variation AA.



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| Interface                   | <a href="http://interface.ti.com">interface.ti.com</a>             | Energy                     | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
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