

## ADVANCED REGULATING PULSE WIDTH MODULATORS

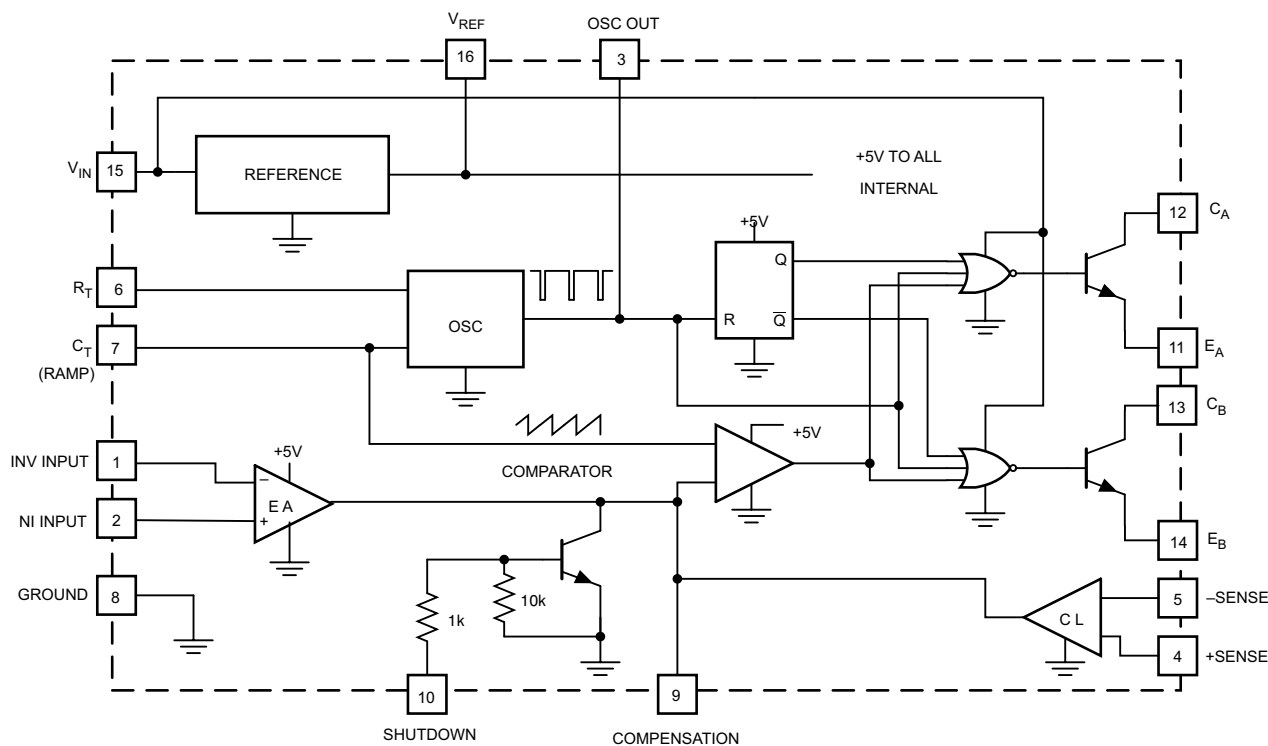
### FEATURES

- Complete PWM Power Control Circuitry
- Uncommitted Outputs for Single-Ended or Push-Pull Applications
- Low Standby Current . . . 8 mA Typical
- Interchangeable With SG1524, SG2524 and SG3524, Respectively

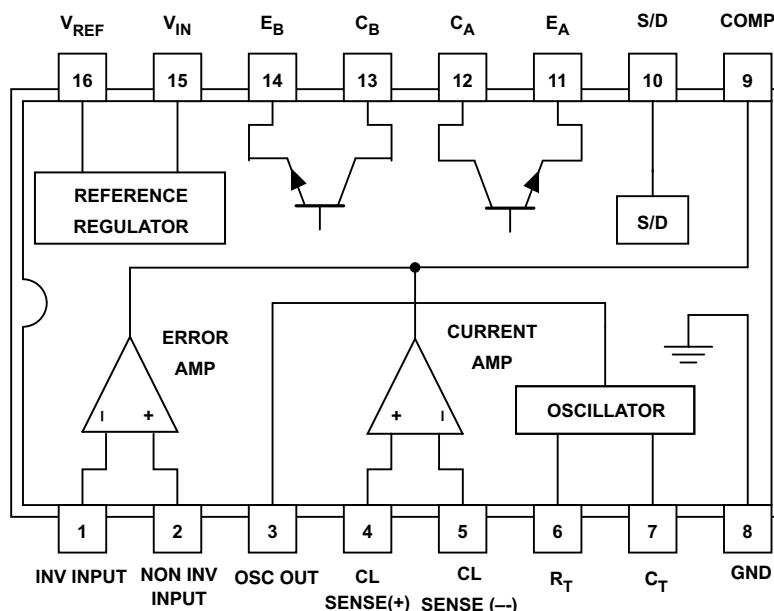
### DESCRIPTION

The UC1524, UC2524 and UC3524 incorporate on a single monolithic chip all the functions required for the construction of regulating power supplies, inverters or switching regulators. They can also be used as the control element for high-power-output applications. The UC1524 family was designed for switching regulators of either polarity, transformer-coupled dc-to-dc converters, transformerless voltage doublers and polarity converter applications employing fixed-frequency, pulse-width modulation techniques. The dual alternating outputs allow either single-ended or push-pull applications. Each device includes an on-chip reference, error amplifier, programmable oscillator, pulse-steering flip-flop, two uncommitted output transistors, a high-gain comparator, and current-limiting and shut-down circuitry. The UC1524 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The UC2524 and UC3524 are designed for operation from  $-25^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ , respectively.

### BLOCK DIAGRAM



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 DIAGRAM****ABSOLUTE MAXIMUM RATINGS**

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

|                                      |                                  | UNIT            |
|--------------------------------------|----------------------------------|-----------------|
| $V_{CC}$                             | Supply voltage <sup>(1)(2)</sup> | 40 V            |
|                                      | Collector output current         | 100 mA          |
|                                      | Reference output current         | 50 mA           |
|                                      | Current through $C_T$ terminal   | –50 mA          |
| Power dissipation                    | $T_A = 25^\circ\text{C}^{(3)}$   | 1000 mW         |
|                                      | $T_C = 25^\circ\text{C}^{(3)}$   | 2000 mW         |
| Operating junction temperature range |                                  | –55°C to 150°C  |
| Storage temperature range            |                                  | –65°C to +150°C |

(1) All voltage values are with respect to the ground terminal, pin 8.

(2) The reference regulator may be bypassed for operation from a fixed 5 V supply by connecting the  $V_{CC}$  and reference output pins both to the supply voltage. In this configuration the maximum supply voltage is 6 V.

(3) Consult packaging section of data book for thermal limitations and considerations of package.

**RECOMMENDED OPERATING CONDITIONS**

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

|                                     |                                | MIN   | NOM | MAX | UNIT          |
|-------------------------------------|--------------------------------|-------|-----|-----|---------------|
| $V_{CC}$                            | Supply voltage                 | 8     |     | 40  | V             |
|                                     | Reference output current       | 0     |     | 20  | mA            |
|                                     | Current through $C_T$ terminal | –0.03 |     | –2  | mA            |
| $R_T$                               | Timing resistor                | 1.8   |     | 100 | k $\Omega$    |
| $C_T$                               | Timing capacitor               | 0.001 |     | 0.1 | $\mu\text{F}$ |
| Operating ambient temperature range | UC1524                         | –55   |     | 125 | °C            |
|                                     | UC2524                         | –25   |     | 85  |               |
|                                     | UC3524                         | 0     |     | 70  |               |

## ELECTRICAL CHARACTERISTICS

these specifications apply for  $T_A = -55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  for the UC1524,  $-25^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  for the UC2524, and  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$  for the UC3524,  $V_{IN} = 20\text{ V}$ , and  $f = 20\text{ kHz}$ ,  $T_A = T_J$ , over operating free-air temperature range (unless otherwise noted)

| PARAMETER                    | TEST CONDITIONS                                                             | UC1524/UC2524 |      |     | UC3524 |      |     | UNIT  |
|------------------------------|-----------------------------------------------------------------------------|---------------|------|-----|--------|------|-----|-------|
|                              |                                                                             | MIN           | TYP  | MAX | MIN    | TYP  | MAX |       |
| REFERENCE SECTION            |                                                                             |               |      |     |        |      |     |       |
| Output voltage               |                                                                             | 4.8           | 5.0  | 5.2 | 4.6    | 5.0  | 5.4 | V     |
| Line regulation              | V <sub>IN</sub> = 8 V to 40 V                                               |               | 10   | 20  |        | 10   | 30  | mV    |
| Load regulation              | I <sub>L</sub> = 0 mA to 20 mA                                              |               | 20   | 50  |        | 20   | 50  | mV    |
| Ripple rejection             | f = 120 Hz, T <sub>J</sub> = 25°C                                           |               | 66   |     |        | 66   |     | dB    |
| Short circuit current limit  | V <sub>REF</sub> = 0, T <sub>J</sub> = 25°C                                 |               | 100  |     |        | 100  |     | mA    |
| Temperature stability        | Over operating temperature range                                            |               | 0.3% | 1%  |        | 0.3% | 1%  |       |
| Long term stability          | T <sub>J</sub> = 125°C, t = 1000 Hrs                                        |               | 20   |     |        | 20   |     | mV    |
| OSCILLATOR SECTION           |                                                                             |               |      |     |        |      |     |       |
| Maximum frequency            | C <sub>T</sub> = 1 nF, R <sub>T</sub> = 2 kΩ                                |               | 300  |     |        | 300  |     | kHz   |
| Initial accuracy             | R <sub>T</sub> and C <sub>T</sub> constant                                  |               | 5%   |     |        | 5%   |     |       |
| Voltage stability            | V <sub>IN</sub> = 8 V to 40 V, T <sub>J</sub> = 25°C                        |               |      | 1%  |        |      | 1%  |       |
| Temperature stability        | Over operating temperature range                                            |               |      | 5%  |        |      | 5%  |       |
| Output amplitude             | Pin 3, T <sub>J</sub> = 25°C                                                |               | 3.5  |     |        | 3.5  |     | V     |
| Output pulse width           | C <sub>T</sub> = 0.01 mfd, T <sub>J</sub> = 25°C                            |               | 0.5  |     |        | 0.5  |     | μs    |
| ERROR AMPLIFIER SECTION      |                                                                             |               |      |     |        |      |     |       |
| Input offset voltage         | V <sub>CM</sub> = 2.5 V                                                     |               | 0.5  | 5   |        | 2    | 10  | mV    |
| Input bias current           | V <sub>CM</sub> = 2.5 V                                                     |               | 2    | 10  |        | 2    | 10  | μA    |
| Open loop voltage gain       |                                                                             | 72            | 80   |     | 60     | 80   |     | dB    |
| Common mode voltage          | T <sub>J</sub> = 25°C                                                       | 1.8           |      | 3.4 | 1.8    |      | 3.4 | V     |
| Common mode rejection ratio  | T <sub>J</sub> = 25°C                                                       |               | 70   |     |        | 70   |     | dB    |
| Small signal bandwidth       | A <sub>V</sub> = 0 dB, T <sub>J</sub> = 25°C                                |               | 3    |     |        | 3    |     | MHz   |
| Output voltage               | T <sub>J</sub> = 25°C                                                       | 0.5           |      | 3.8 | 0.5    |      | 3.8 | V     |
| COMPARATOR SECTION           |                                                                             |               |      |     |        |      |     |       |
| Duty-cycle                   | % Each output on                                                            | 0%            |      | 45% | 0%     |      | 45% |       |
| Input threshold              | Zero duty-cycle                                                             |               | 1    |     |        | 1    |     | V     |
|                              | Maximum duty-cycle                                                          |               | 3.5  |     |        | 3.5  |     |       |
| Input bias current           |                                                                             |               | 1    |     |        | 1    |     | μA    |
| CURRENT LIMITING SECTION     |                                                                             |               |      |     |        |      |     |       |
| Sense voltage                | Pin 9 = 2 V with error amplifier set for maximum out, T <sub>J</sub> = 25°C | 190           | 200  | 210 | 180    | 200  | 220 | mV    |
| Sense voltage T.C.           |                                                                             |               | 0.2  |     |        | 0.2  |     | mV/°C |
| Common mode voltage          | T <sub>J</sub> = −55°C to 85°C for the −1 V to 1 V limit                    | −1            |      | 1   | −1     |      | 1   | V     |
|                              | T <sub>J</sub> = 25°C                                                       | −0.3          |      | 1   |        |      |     |       |
| OUTPUT SECTION (EACH OUTPUT) |                                                                             |               |      |     |        |      |     |       |
| Collector-emitter voltage    |                                                                             | 40            |      |     | 40     |      |     | V     |
| Collector leakage current    | V <sub>CE</sub> = 40 V                                                      |               | 0.1  | 50  |        | 0.1  | 50  | μ A   |
| Saturation voltage           | I <sub>C</sub> = 50 mA                                                      |               | 1    | 2   |        | 1    | 2   | V     |
| Emitter output voltage       | V <sub>IN</sub> = 20 V                                                      | 17            | 18   |     | 17     | 18   |     | V     |
| Rise Time                    | R <sub>C</sub> = 2 kΩ, T <sub>J</sub> = 25°C                                |               | 0.2  |     |        | 0.2  |     | μs    |
| Fall Time                    | R <sub>C</sub> = 2 kΩ, T <sub>J</sub> = 25°C                                |               | 0.1  |     |        | 0.1  |     | μs    |
| Total standby current (Note) | V <sub>IN</sub> = 40 V                                                      |               | 8    | 10  |        | 8    | 10  | mA    |

## PRINCIPLES OF OPERATION

The UC1524 is a fixed-frequency pulse-width-modulation voltage regulator control circuit. The regulator operates at a frequency that is programmed by one timing resistor ( $R_T$ ), and one timing capacitor ( $C_T$ ).  $R_T$  establishes a constant charging current for  $C_T$ . This results in a linear voltage ramp at  $C_T$ , which is fed to the comparator providing linear control of the output pulse width by the error amplifier. The UC1524 contains an on-board 5 V regulator that serves as a reference as well as powering the UC1524's internal control circuitry and is also useful in supplying external support functions. This reference voltage is lowered externally by a resistor divider to provide a reference within the common-mode range of the error amplifier or an external reference may be used. The power supply output is sensed by a second resistor divider network to generate a feedback signal to the error amplifier. The amplifier output voltage is then compared to the linear voltage ramp at  $C_T$ . The resulting modulated pulse out of the high-gain comparator is then steered to the appropriate output pass transistor ( $Q_1$  or  $Q_2$ ) by the pulse-steering

flip-flop, which is synchronously toggled by the oscillator output. The oscillator output pulse also serves as a blanking pulse to assure both outputs are never on simultaneously during the transition times. The width of the blanking pulse is controlled by the value of  $C_T$ . The outputs may be applied in a push-pull configuration in which their frequency is half that of the base oscillator. Note that for buck regulator topologies, the two outputs can be wire-ORed for an effective 0-90% duty cycle range. With this connection, the output frequency is the same as the oscillator frequency. The output of the error amplifier shares a common input to the comparator with the current limiting and shutdown circuitry and can be overridden by signals from either of these inputs. This common point is also available externally and may be employed to control the gain of, or to compensate, the error amplifier or to provide additional control to the regulator.

## TYPICAL CHARACTERISTICS

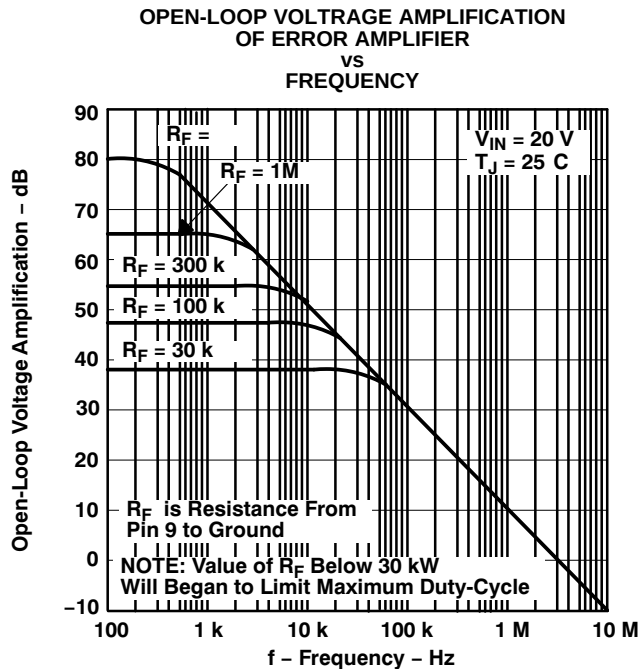


Figure 1.

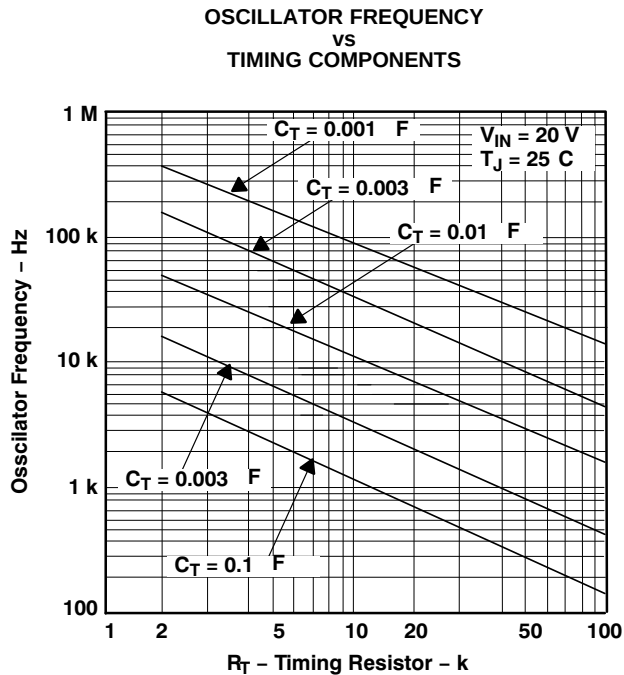


Figure 2.

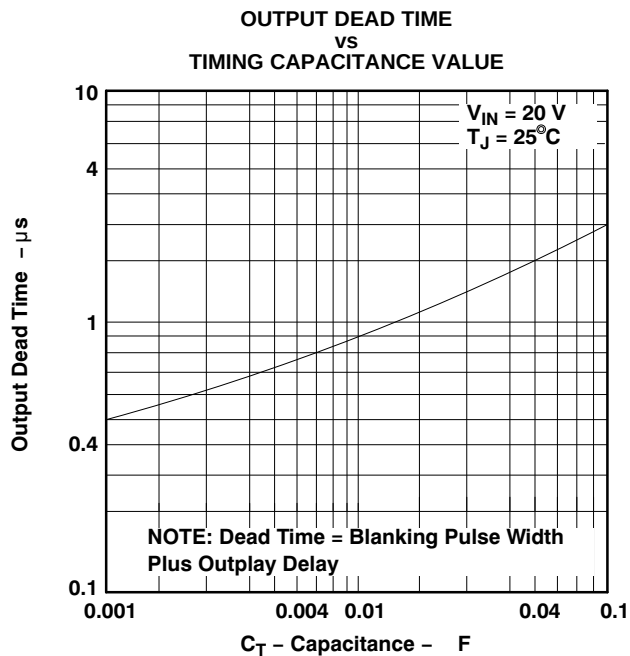


Figure 3.

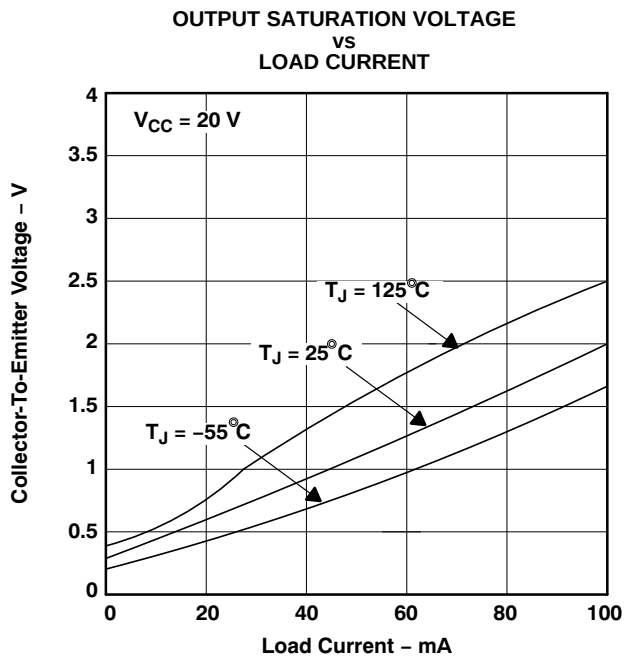


Figure 4.

## APPLICATION INFORMATION

### OSCILLATOR

The oscillator controls the frequency of the UC1524 and is programmed by  $R_T$  and  $C_T$  according to the approximate formula:

$$f = \frac{1.18}{R_T C_T} \quad (1)$$

where

$R_T$  is in  $k\Omega$

$C_T$  is in  $\mu F$

$f$  is in kHz

Practical values of  $C_T$  fall between 1 nF and 100 nF. Practical values of  $R_T$  fall between 1.8  $k\Omega$  and 100  $k\Omega$ . This results in a frequency range typically from 120 Hz to 500 kHz.

### BLANKING

The output pulse of the oscillator is used as a blanking pulse at the output. This pulse width is controlled by the value of  $C_T$ . If small values of  $C_T$  are required for frequency control, the oscillator output pulse width may still be increased by applying a shunt capacitance of up to 100 pF from pin 3 to ground. If still greater dead-time is required, it should be accomplished by limiting the maximum duty cycle by clamping the output of the error amplifier. This can easily be done with the circuit in Figure 5.

### SYNCHRONOUS OPERATIONS

When an external clock is desired, a clock pulse of approximately 3 V can be applied directly to the oscillator output terminal. The impedance to ground at this point is approximately 2  $k\Omega$ . In this configuration  $R_T$   $C_T$  must be selected for a clock period slightly greater than that of the external clock.

If two or more UC1524 regulators are to operate synchronously, all oscillator output terminals should be tied together, all  $C_T$  terminals connected to single timing capacitor, and the timing resistor connected to a single  $R_T$  terminal.

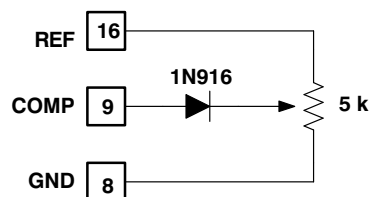


Figure 5. Error Amplifier Clamp

The other  $R_T$  terminals can be left open or shorted to  $V_{REF}$ . Minimum lead lengths should be used between the  $C_T$  terminals.

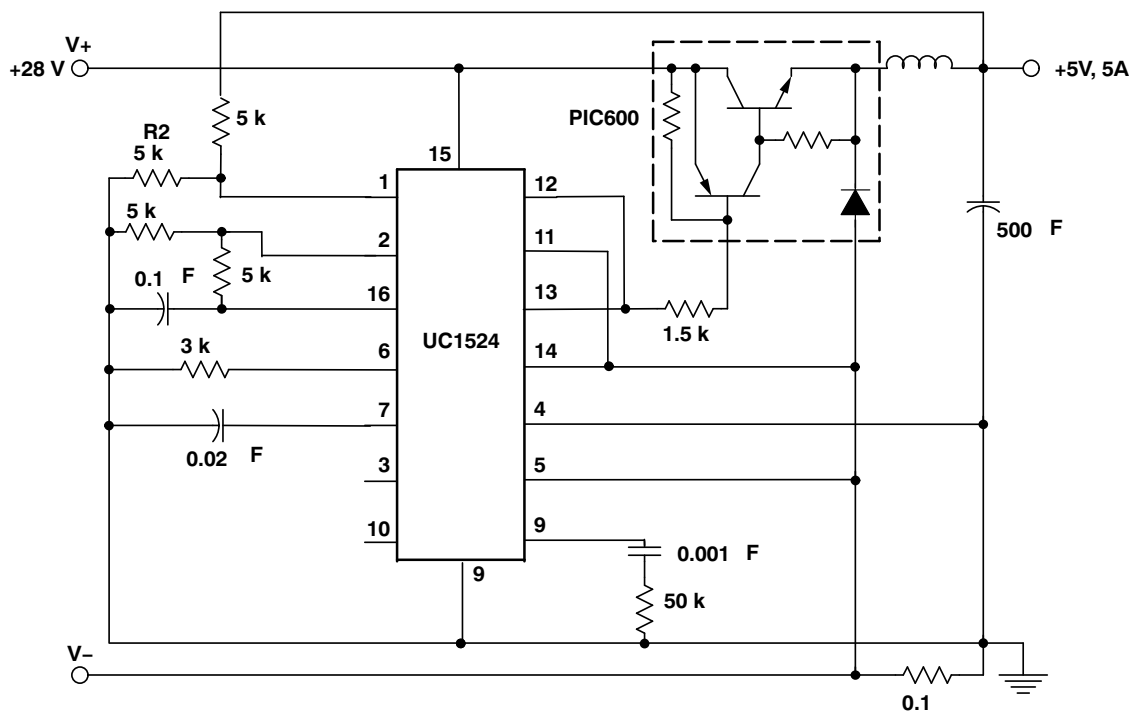


Figure 6. Single-Ended LC Switching Regulator Circuit

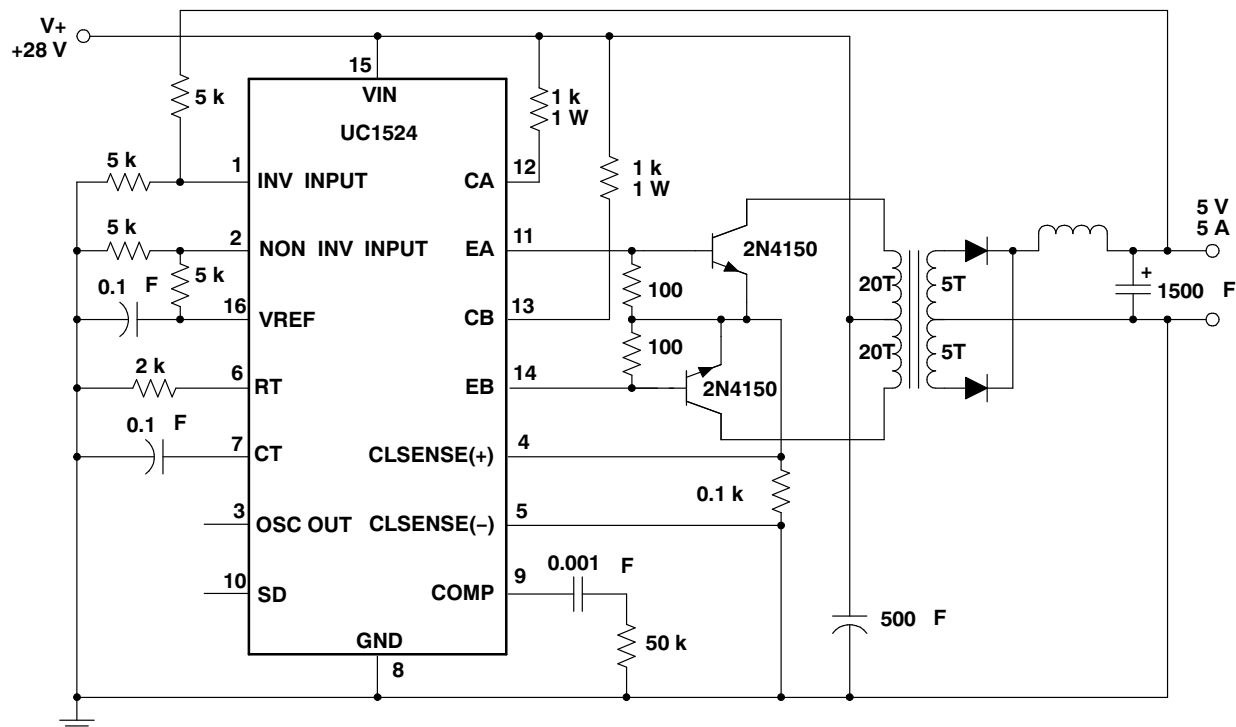


Figure 7. Push-Pull Transformer Coupled Circuit

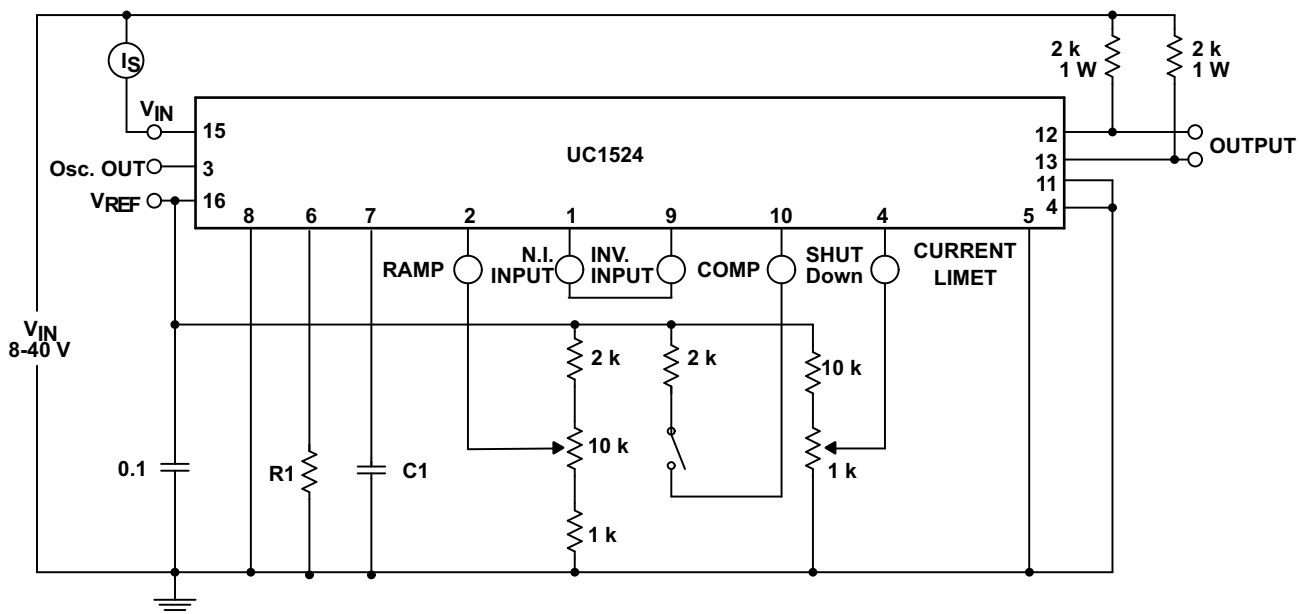


Figure 8. Open Loop Test Circuit

**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> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| UC1524J          | OBSOLETE              | CDIP         | J               | 16   |             | TBD                     | Call TI          | Call TI                      |
| UC1524J/80937    | OBSOLETE              | CDIP         | J               | 16   |             | TBD                     | Call TI          | Call TI                      |
| UC1524J883B      | OBSOLETE              | CDIP         | J               | 16   |             | TBD                     | Call TI          | Call TI                      |
| UC2524DW         | ACTIVE                | SOIC         | DW              | 16   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC2524DWG4       | ACTIVE                | SOIC         | DW              | 16   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC2524DWTR       | ACTIVE                | SOIC         | DW              | 16   | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC2524DWTRG4     | ACTIVE                | SOIC         | DW              | 16   | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC2524J          | OBSOLETE              | CDIP         | J               | 16   |             | TBD                     | Call TI          | Call TI                      |
| UC2524N          | ACTIVE                | PDIP         | N               | 16   | 25          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC2524NG4        | ACTIVE                | PDIP         | N               | 16   | 25          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC3524D          | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS & no Sb/Br) | Call TI          | Level-2-260C-1 YEAR          |
| UC3524DG4        | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS & no Sb/Br) | Call TI          | Level-2-260C-1 YEAR          |
| UC3524DTR        | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS & no Sb/Br) | Call TI          | Level-2-260C-1 YEAR          |
| UC3524DTRG4      | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS & no Sb/Br) | Call TI          | Level-2-260C-1 YEAR          |
| UC3524DW         | ACTIVE                | SOIC         | DW              | 16   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC3524DWG4       | ACTIVE                | SOIC         | DW              | 16   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC3524DWTR       | ACTIVE                | SOIC         | DW              | 16   | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC3524DWTRG4     | ACTIVE                | SOIC         | DW              | 16   | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR          |
| UC3524J          | OBSOLETE              | CDIP         | J               | 16   |             | TBD                     | Call TI          | Call TI                      |
| UC3524N          | ACTIVE                | PDIP         | N               | 16   | 25          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| UC3524NG4        | ACTIVE                | PDIP         | N               | 16   | 25          | 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.

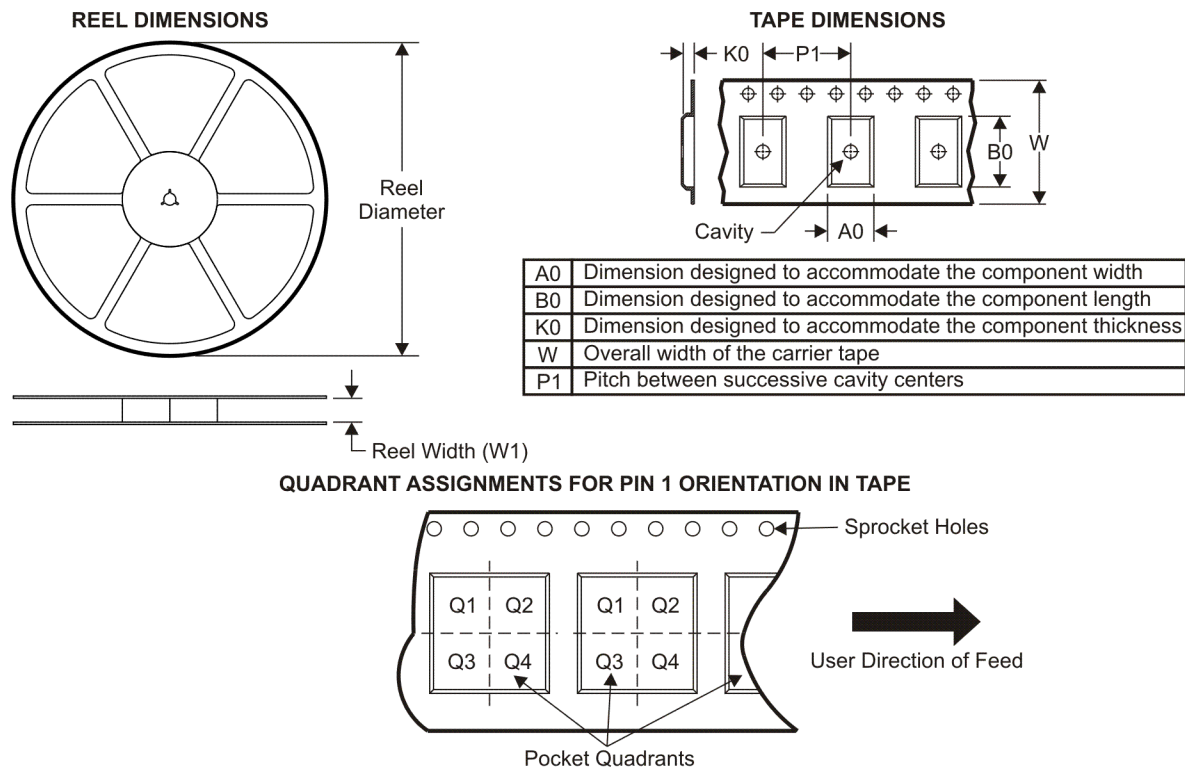
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<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.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

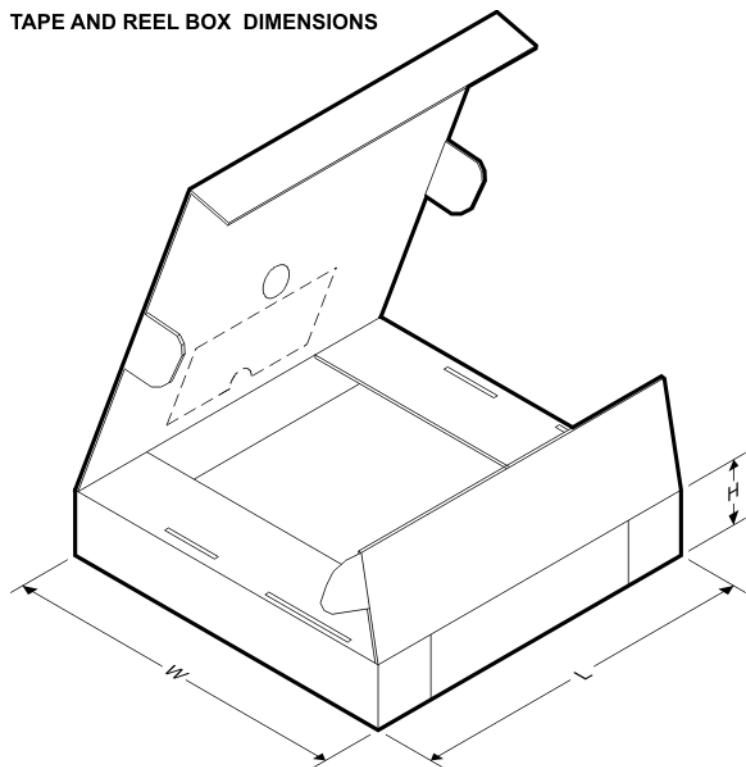
**TAPE AND REEL INFORMATION**



\*All dimensions are nominal

| Device     | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| UC2524DWTR | SOIC         | DW              | 16   | 2000 | 330.0              | 16.4               | 10.85   | 10.8    | 2.7     | 12.0    | 16.0   | Q1            |
| UC3524DTR  | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |
| UC3524DWTR | SOIC         | DW              | 16   | 2000 | 330.0              | 16.4               | 10.85   | 10.8    | 2.7     | 12.0    | 16.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



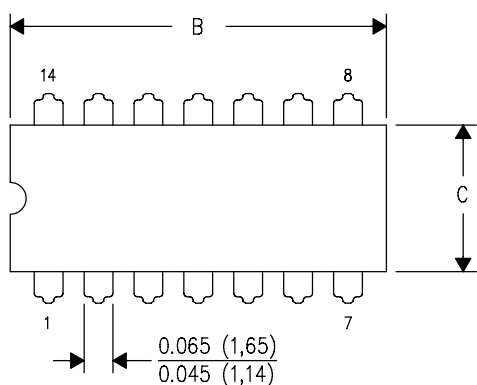
\*All dimensions are nominal

| Device     | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|------------|--------------|-----------------|------|------|-------------|------------|-------------|
| UC2524DWTR | SOIC         | DW              | 16   | 2000 | 346.0       | 346.0      | 33.0        |
| UC3524DTR  | SOIC         | D               | 16   | 2500 | 346.0       | 346.0      | 33.0        |
| UC3524DWTR | SOIC         | DW              | 16   | 2000 | 346.0       | 346.0      | 33.0        |

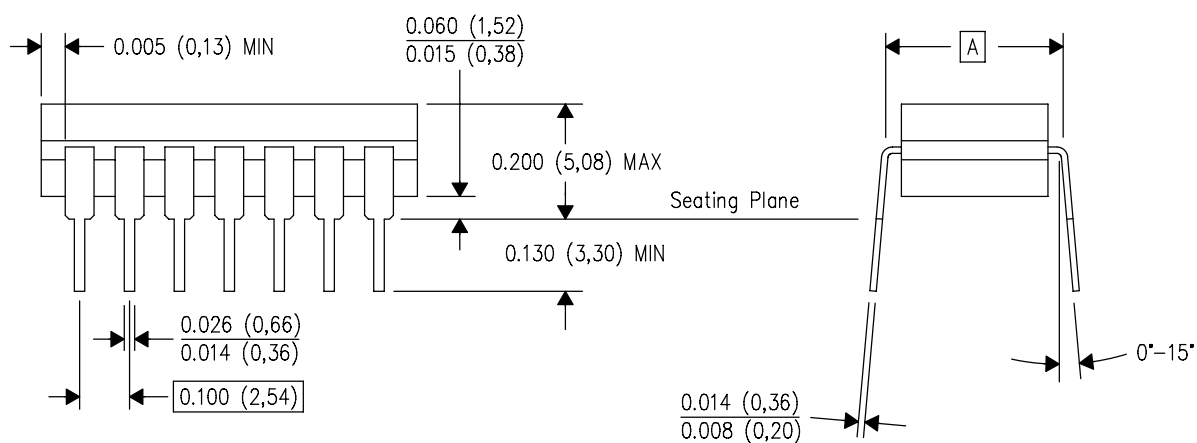
J (R-GDIP-T\*\*)

14 LEADS SHOWN

# CERAMIC DUAL IN-LINE PACKAGE



| PINS **<br>DIM | 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)        |

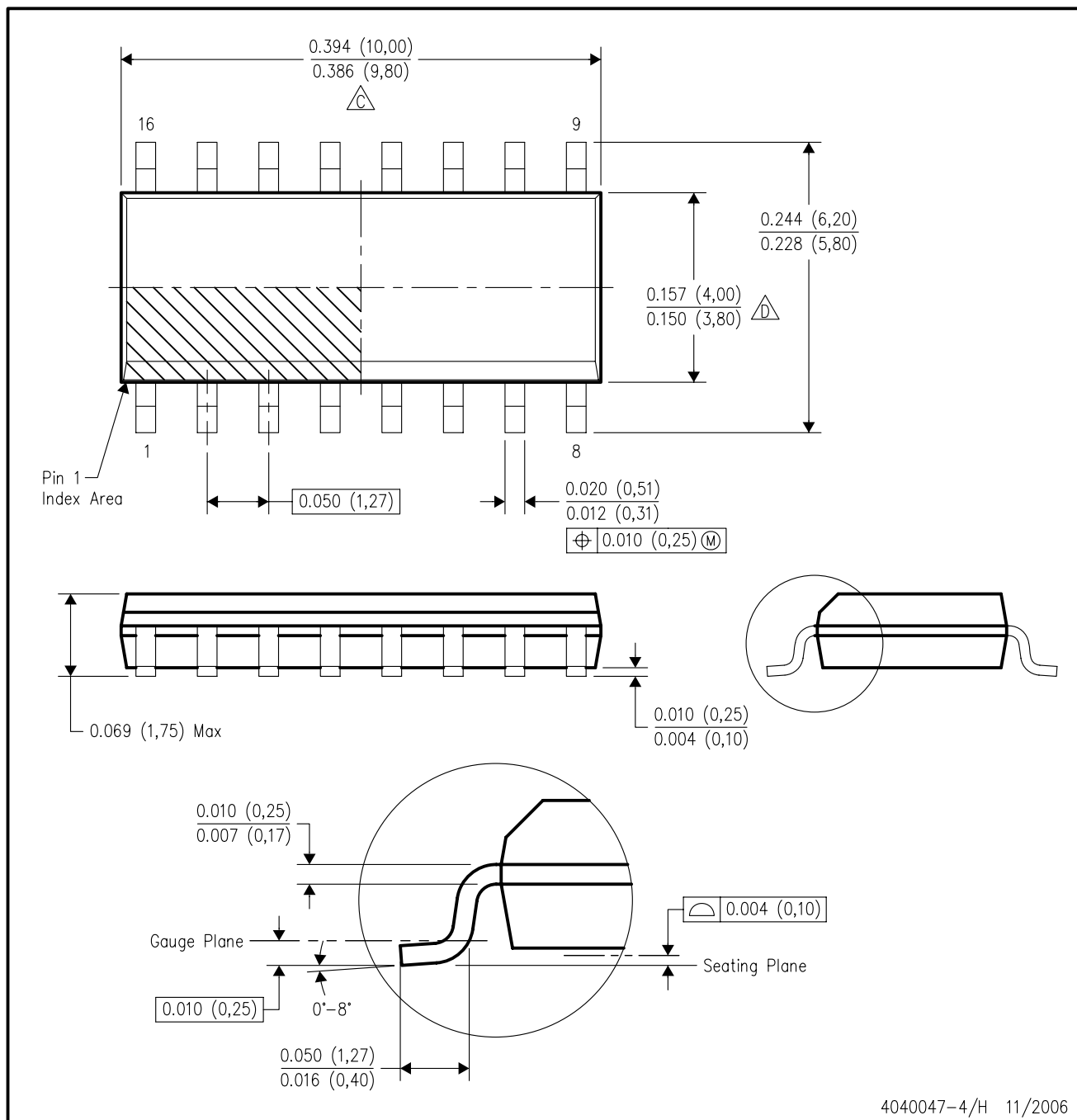


4040083/F 03/03

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

## D (R-PDSO-G16)

## PLASTIC SMALL-OUTLINE PACKAGE

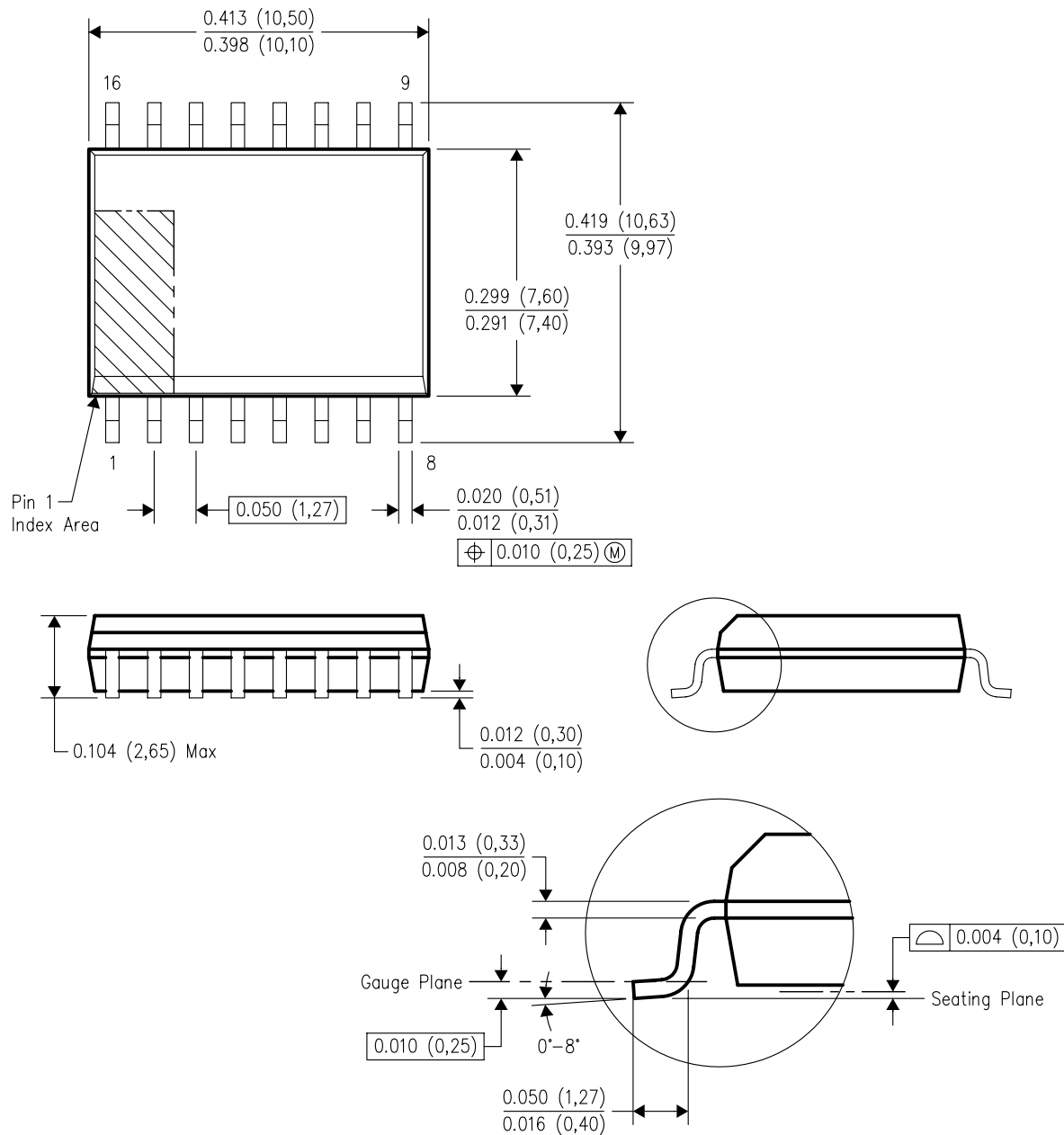


## NOTES:

- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
- D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
- E. Reference JEDEC MS-012 variation AC.

DW (R-PDSO-G16)

# PLASTIC SMALL-OUTLINE PACKAGE



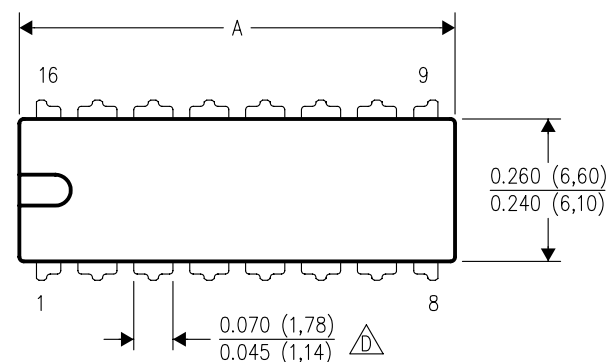
4040000-2/F 06/2004

- 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.

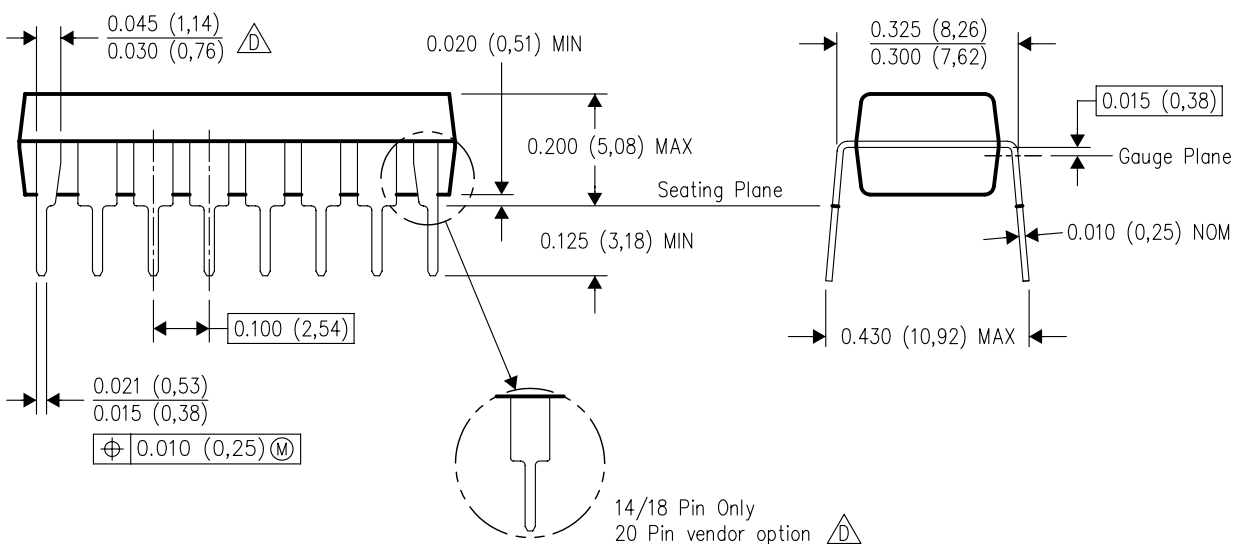
N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE



| PINS **<br>DIM      | 14               | 16               | 18               | 20               |
|---------------------|------------------|------------------|------------------|------------------|
| A MAX               | 0.775<br>(19,69) | 0.775<br>(19,69) | 0.920<br>(23,37) | 1.060<br>(26,92) |
| A MIN               | 0.745<br>(18,92) | 0.745<br>(18,92) | 0.850<br>(21,59) | 0.940<br>(23,88) |
| MS-001<br>VARIATION | AA               | BB               | AC               | AD               |



4040049/E 12/2002

NOTES:

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

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

|                             |                                                                    |
|-----------------------------|--------------------------------------------------------------------|
| Amplifiers                  | <a href="http://amplifier.ti.com">amplifier.ti.com</a>             |
| Data Converters             | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>     |
| DSP                         | <a href="http://dsp.ti.com">dsp.ti.com</a>                         |
| Clocks and Timers           | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>           |
| Interface                   | <a href="http://interface.ti.com">interface.ti.com</a>             |
| Logic                       | <a href="http://logic.ti.com">logic.ti.com</a>                     |
| Power Mgmt                  | <a href="http://power.ti.com">power.ti.com</a>                     |
| Microcontrollers            | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a> |
| RFID                        | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>               |
| RF/IF and ZigBee® Solutions | <a href="http://www.ti.com/lprf">www.ti.com/lprf</a>               |

### Applications

|                    |                                                                          |
|--------------------|--------------------------------------------------------------------------|
| Audio              | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                   |
| Automotive         | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>         |
| Broadband          | <a href="http://www.ti.com/broadband">www.ti.com/broadband</a>           |
| Digital Control    | <a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a> |
| Medical            | <a href="http://www.ti.com/medical">www.ti.com/medical</a>               |
| Military           | <a href="http://www.ti.com/military">www.ti.com/military</a>             |
| Optical Networking | <a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a> |
| Security           | <a href="http://www.ti.com/security">www.ti.com/security</a>             |
| Telephony          | <a href="http://www.ti.com/telephony">www.ti.com/telephony</a>           |
| Video & Imaging    | <a href="http://www.ti.com/video">www.ti.com/video</a>                   |
| Wireless           | <a href="http://www.ti.com/wireless">www.ti.com/wireless</a>             |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2008, Texas Instruments Incorporated