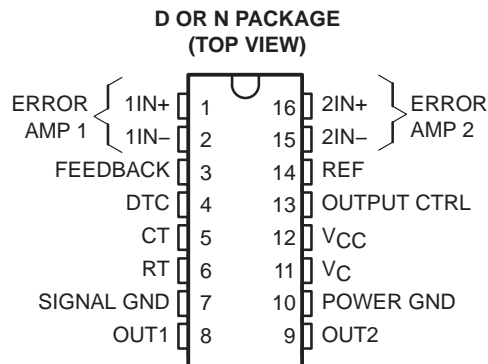


- Complete PWM Power-Control Function
- Totem-Pole Outputs for 200-mA Sink or Source Current
- Output Control Selects Parallel or Push-Pull Operation
- Internal Circuitry Prohibits Double Pulse at Either Output
- Variable Dead-Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply, Trimmed to 1% Tolerance
- On-Board Output Current-Limiting Protection
- Undervoltage Lockout for Low- $V_{CC}$  Conditions
- Separate Power and Signal Grounds



## description/ordering information

The TL598 incorporates all the functions required in the construction of pulse-width-modulated (PWM) controlled systems on a single chip. Designed primarily for power-supply control, the TL598 provides the systems engineer with the flexibility to tailor the power-supply control circuits to a specific application.

The TL598 contains two error amplifiers, an internal oscillator (externally adjustable), a dead-time control (DTC) comparator, a pulse-steering flip-flop, a 5-V precision reference, undervoltage lockout control, and output control circuits. Two totem-pole outputs provide exceptional rise- and fall-time performance for power FET control. The outputs share a common source supply and common power ground terminals, which allow system designers to eliminate errors caused by high current-induced voltage drops and common-mode noise.

The error amplifier has a common-mode voltage range of 0 V to  $V_{CC} - 2$  V. The DTC comparator has a fixed offset that prevents overlap of the outputs during push-pull operation. A synchronous multiple supply operation can be achieved by connecting RT to the reference output and providing a sawtooth input to CT.

The TL598 device provides an output control function to select either push-pull or parallel operation. Circuit architecture prevents either output from being pulsed twice during push-pull operation. The output frequency

for push-pull applications is one-half the oscillator frequency ( $f_o = \frac{1}{2 RT CT}$ ). For single-ended applications:

$$f_o = \frac{1}{RT CT}$$

## ORDERING INFORMATION

| T <sub>A</sub> | PACKAGE† |              | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|----------|--------------|-----------------------|------------------|
| 0°C to 70°C    | PDIP (N) | Tube of 25   | TL598CN               | TL598CN          |
|                | SOIC (D) | Tube of 40   | TL598CD               | TL598C           |
|                |          | Reel of 2500 | TL598CDR              |                  |

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).



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**TEXAS  
INSTRUMENTS**

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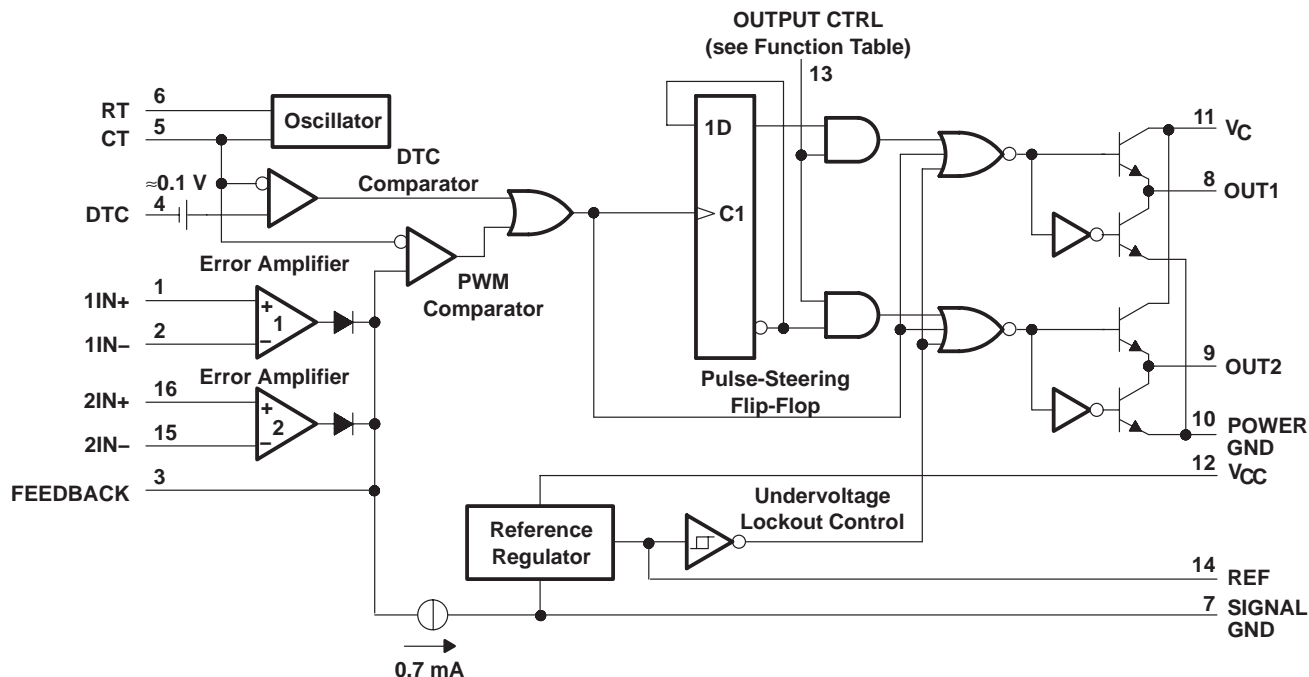
# TL598 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS053D – FEBRUARY 1988 – REVISED NOVEMBER 2003

FUNCTION TABLE

| INPUT/OUTPUT CTRL  | OUTPUT FUNCTION                 |
|--------------------|---------------------------------|
| $V_I = \text{GND}$ | Single-ended or parallel output |
| $V_I = \text{REF}$ | Normal push-pull operation      |

## functional block diagram



## absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

|   |                  |
|---|------------------|
| Supply voltage, $V_{CC}$ (see Note 1)                                   | 41 V             |
| Amplifier input voltage, $V_I$  | $V_{CC} + 0.3$ V |
| Collector voltage   | 41 V             |
| Output current (each output), sink or source, $I_O$                     | 250 mA           |
| Package thermal impedance, $\theta_{JA}$ (see Notes 2 and 3): D package | 73°C/W           |
| N package   | 67°C/W           |
| Operating virtual junction temperature, $T_J$                           | 150°C            |
| Storage temperature range, $T_{stg}$                                    | -65°C to 150°C   |

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
1. All voltage values, except differential voltages, are with respect to the signal ground terminal.
  2. Maximum power dissipation is a function of  $T_J(\text{max})$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can impact reliability.
  3. The package thermal impedance is calculated in accordance with JESD 51-7.



**recommended operating conditions**

|  | MIN     | MAX                | UNIT |
|--|---------|--------------------|------|
| V <sub>CC</sub> Supply voltage                               | 7       | 40                 | V    |
| V <sub>I</sub> Amplifier input voltage                       | 0       | V <sub>CC</sub> -2 | V    |
| I <sub>O</sub> Collector voltage                             |         | 40                 | V    |
| I <sub>IL</sub> Output current (each output), sink or source |         | 200                | mA   |
| Current into feedback terminal                               |         | 0.3                | mA   |
| C <sub>T</sub> Timing capacitor                              | 0.00047 | 10                 | μF   |
| R <sub>T</sub> Timing resistor                               | 1.8     | 500                | kΩ   |
| f <sub>osc</sub> Oscillator frequency                        | 1       | 300                | kHz  |
| T <sub>A</sub> Operating free-air temperature                | 0       | 70                 | °C   |

**electrical characteristics over recommended operating free-air temperature range, V<sub>CC</sub> = 15 V (unless otherwise noted)**

**reference section (see Note 4)**

| PARAMETER                              | TEST CONDITIONS†               | MIN                         | TYP‡ | MAX | UNIT |    |
|--|--------------------------------|-----------------------------|------|-----|------|----|
| Output voltage (REF)                   | I <sub>O</sub> = 1 mA          | T <sub>A</sub> = 25°C       | 4.95 | 5   | 5.05 | V  |
|  |                                | T <sub>A</sub> = full range | 4.9  |     | 5.1  |    |
| Input regulation                       | V <sub>CC</sub> = 7 V to 40 V  |                             | 2    | 25  | mV   |    |
| Output regulation                      | I <sub>O</sub> = 1 mA to 10 mA | T <sub>A</sub> = 25°C       |      | 1   | 15   | mV |
|  |                                | T <sub>A</sub> = full range |      |     | 50   |    |
| Output voltage change with temperature | ΔT <sub>A</sub> = MIN to MAX   |                             | 2    | 10  | mV/V |    |
| Short-circuit output current§          | REF = 0 V                      | -10                         | -48  |     | mA   |    |

† Full range is 0°C to 70°C.

‡ All typical values, except for parameter changes with temperature, are at T<sub>A</sub> = 25°C.

§ Duration of the short circuit should not exceed one second.

NOTE 4: Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

**oscillator section, C<sub>T</sub> = 0.001 μF, R<sub>T</sub> = 12 kΩ (see Figure 1) (see Note 4)**

| PARAMETER                          | TEST CONDITIONS†  | MIN | TYP‡ | MAX | UNIT   |
|------------------------------------|---|-----|------|-----|--------|
| Frequency                          |   |     | 100  |     | kHz    |
| Standard deviation of frequency¶   | All values of V <sub>CC</sub> , C <sub>T</sub> , R <sub>T</sub> , T <sub>A</sub> constant |     | 100  |     | Hz/kHz |
| Frequency change with voltage      | V <sub>CC</sub> = 7 V to 40 V, T <sub>A</sub> = 25°C                                      |     | 1    | 10  | Hz/kHz |
| Frequency change with temperature# | ΔT <sub>A</sub> = full range  |     | 70   | 120 | Hz/kHz |
|                                    | ΔT <sub>A</sub> = full range, C <sub>T</sub> = 0.01 μF                                    |     | 50   | 80  |        |

† Full range is 0°C to 70°C.

‡ All typical values, except for parameter changes with temperature, are at T<sub>A</sub> = 25°C.

¶ Standard deviation is a measure of the statistical distribution about the mean, as derived from the formula:

$$\sigma = \sqrt{\frac{\sum_{n=1}^N (x_n - \bar{x})^2}{N - 1}}$$

# Effects of temperature on external R<sub>T</sub> and C<sub>T</sub> are not taken into account.

NOTE 4: Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

# TL598

## PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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electrical characteristics over recommended operating free-air temperature range,  $V_{CC} = 15\text{ V}$  (unless otherwise noted) (continued)

### error amplifier section (see Note 4)

| PARAMETER                        | TEST CONDITIONS  | MIN | TYP†            | MAX | UNIT          |
|----------------------------------|--|-----|-----------------|-----|---------------|
| Input offset voltage             | FEEDBACK = 2.5 V   |     | 2               | 10  | mV            |
| Input offset current             | FEEDBACK = 2.5 V   |     | 25              | 250 | nA            |
| Input bias current               | FEEDBACK = 2.5 V   |     | 0.2             | 1   | $\mu\text{A}$ |
| Common-mode input voltage range  | $V_{CC} = 7\text{ V to } 40\text{ V}$  |     | 0 to $V_{CC}-2$ |     | V             |
| Open-loop voltage amplification  | $\Delta V_O$ (FEEDBACK) = 3 V, $V_O$ (FEEDBACK) = 0.5 V to 3.5 V                   | 70  | 95              |     | dB            |
| Unity-gain bandwidth             |  |     | 800             |     | kHz           |
| Common-mode rejection ratio      | $V_{CC} = 40\text{ V}$ , $\Delta V_{IC} = 6.5\text{ V}$ , $T_A = 25^\circ\text{C}$ | 65  | 80              |     | dB            |
| Output sink current (FEEDBACK)   | FEEDBACK = 0.5 V   | 0.3 | 0.7             |     | mA            |
| Output source current (FEEDBACK) | FEEDBACK = 3.5 V   | -2  |                 |     | mA            |
| Phase margin at unity gain       | FEEDBACK = 0.5 V to 3.5 V, $R_L = 2\text{ k}\Omega$                                |     | 65°             |     |               |
| Supply-voltage rejection ratio   | FEEDBACK = 2.5 V, $\Delta V_{CC} = 33\text{ V}$ , $R_L = 2\text{ k}\Omega$         |     | 100             |     | dB            |

† All typical values, except for parameter changes with temperature, are at  $T_A = 25^\circ\text{C}$ .

NOTE 4. Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

electrical characteristics over recommended operating free-air temperature range,  $V_{CC} = 15\text{ V}$  (unless otherwise noted)

### undervoltage lockout section (see Note 4)

| PARAMETER         | TEST CONDITIONS‡                 | MIN | MAX | UNIT |
|-------------------|----------------------------------|-----|-----|------|
| Threshold voltage | $T_A = 25^\circ\text{C}$         | 4   | 6   | V    |
|                   | $\Delta T_A = \text{full range}$ | 3.5 | 6.9 |      |
| Hysteresis§       | $T_A = 25^\circ\text{C}$         | 100 |     | mV   |
|                   | $T_A = \text{full range}$        | 50  |     |      |

‡ Full range is  $0^\circ\text{C}$  to  $70^\circ\text{C}$ .

§ Hysteresis is the difference between the positive-going input threshold voltage and the negative-going input threshold voltage.

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

### output section (see Note 4)

| PARAMETER                    | TEST CONDITIONS                                 | MIN                    | MAX | UNIT          |
|------------------------------|---|------------------------|-----|---------------|
| High-level output voltage    | $V_{CC} = 15\text{ V}$ ,<br>$V_C = 15\text{ V}$ | $I_O = -200\text{ mA}$ | 12  | V             |
|                              |   | $I_O = -20\text{ mA}$  | 13  |               |
| Low-level output voltage     | $V_{CC} = 15\text{ V}$ ,<br>$V_C = 15\text{ V}$ | $I_O = 200\text{ mA}$  | 2   | V             |
|                              |   | $I_O = 20\text{ mA}$   | 0.4 |               |
| Output-control input current | $V_I = V_{\text{ref}}$<br>$V_I = 0.4\text{ V}$  |                        | 3.5 | mA            |
|                              |   |                        | 100 | $\mu\text{A}$ |

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.



**electrical characteristics over recommended operating free-air temperature range,  $V_{CC} = 15\text{ V}$  (unless otherwise noted) (continued)**

**dead-time control section (see Figure 1) (see Note 4)**

| PARAMETER                       | TEST CONDITIONS              | MIN  | TYP† | MAX | UNIT          |
|---------------------------------|------------------------------|------|------|-----|---------------|
| Input bias current (DTC)        | $V_I = 0$ to $5.25\text{ V}$ |      | -2   | -10 | $\mu\text{A}$ |
| Maximum duty cycle, each output | DTC = $0\text{ V}$           | 0.45 |      |     |               |
| Input threshold voltage (DTC)   | Zero duty cycle              |      | 3    | 3.3 | V             |
|                                 | Maximum duty cycle           | 0    |      |     |               |

† All typical values, except for parameter changes with temperature, are at  $T_A = 25^\circ\text{C}$ .

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

**pwm comparator section (see Note 4)**

| PARAMETER                          | TEST CONDITIONS                        | MIN | TYP† | MAX | UNIT |
|------------------------------------|--|-----|------|-----|------|
| Input threshold voltage (FEEDBACK) | DTC = $0\text{ V}$                     |     | 3.75 | 4.5 | V    |
| Input sink current (FEEDBACK)      | $V_{(\text{FEEDBACK})} = 0.5\text{ V}$ | 0.3 | 0.7  |     | mA   |

† All typical values, except for parameter changes with temperature, are at  $T_A = 25^\circ\text{C}$ .

NOTE Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

**total device (see Figure 1) (see Note 4)**

| PARAMETER              | TEST CONDITIONS  | MIN                    | TYP† | MAX | UNIT |
|------------------------|--|------------------------|------|-----|------|
| Standby supply current | RT = $V_{\text{ref}}$ ,<br>All other inputs and outputs open | $V_{CC} = 15\text{ V}$ | 15   | 21  | mA   |
|                        |  | $V_{CC} = 40\text{ V}$ | 20   | 26  |      |
| Average supply current | DTC = $2\text{ V}$   |                        | 15   |     | mA   |

† All typical values, except for parameter changes with temperature, are at  $T_A = 25^\circ\text{C}$ .

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

**switching characteristics,  $T_A = 25^\circ\text{C}$  (see Note 4)**

| PARAMETER                | TEST CONDITIONS                         | MIN | TYP | MAX | UNIT |
|--------------------------|---|-----|-----|-----|------|
| Output-voltage rise time | CL = $1500\text{ pF}$ ,<br>See Figure 2 |     | 60  | 150 | ns   |
| Output-voltage fall time |   |     |     |     |      |

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

# TL598 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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## PARAMETER MEASUREMENT INFORMATION

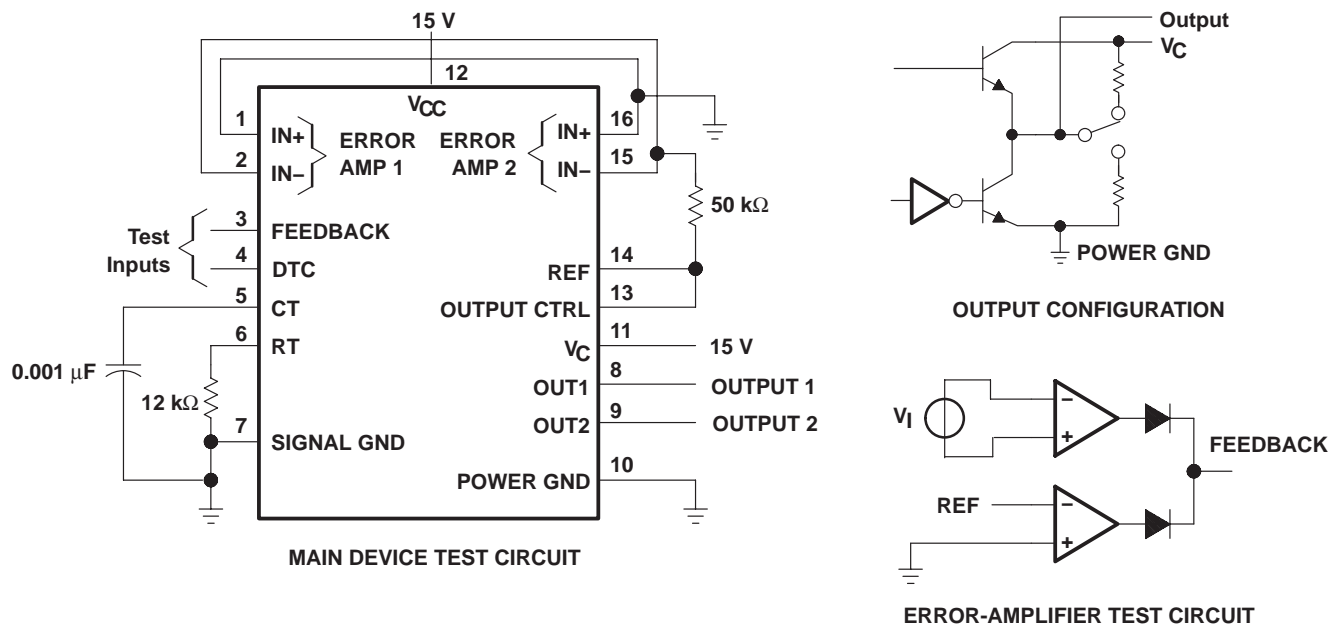


Figure 1. Test Circuits

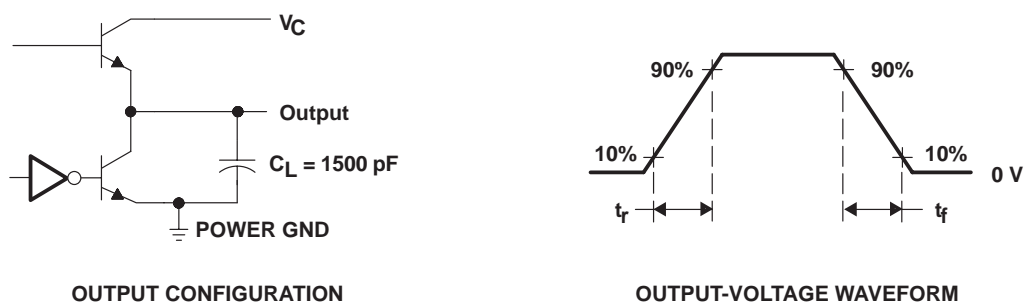
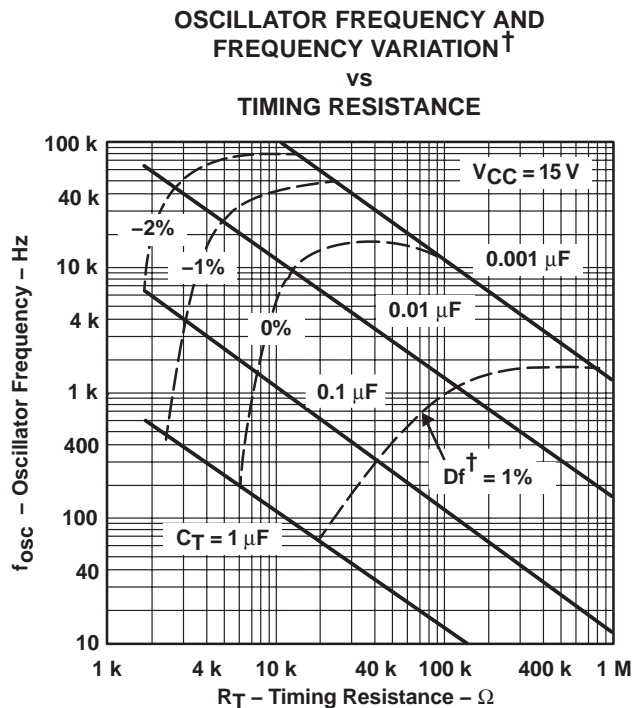


Figure 2. Switching Output Configuration and Voltage Waveform

TYPICAL CHARACTERISTICS



<sup>†</sup> Frequency variation ( $\Delta f$ ) is the change in predicted oscillator frequency that occurs over the full temperature range.

Figure 3

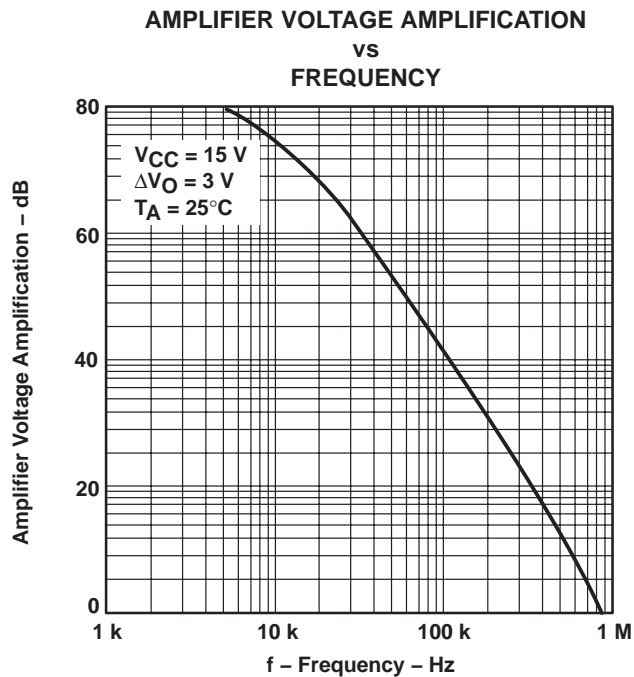


Figure 4

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.



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

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



- 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

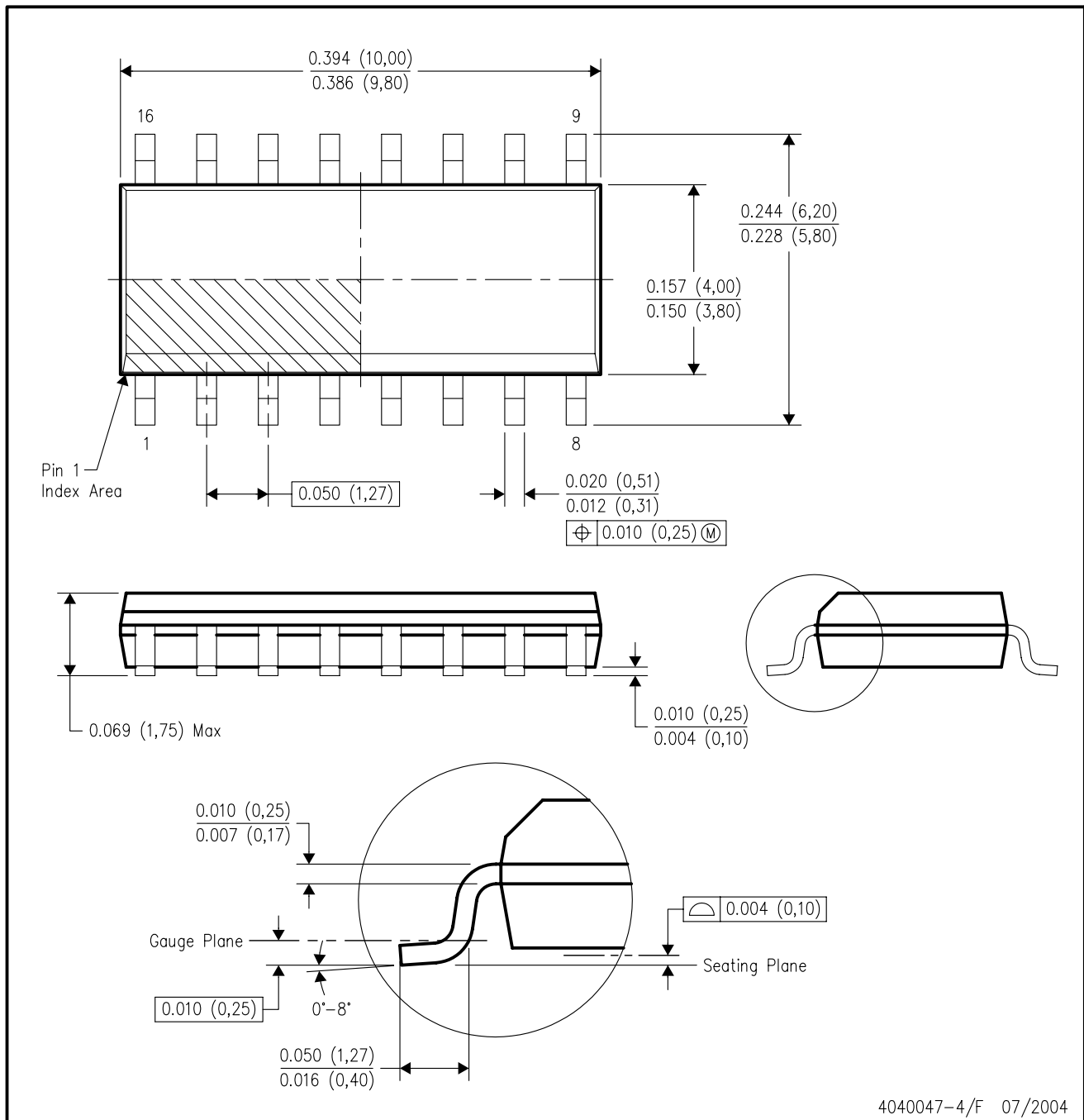
16 PINS SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - 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.

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 dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - D. Falls within JEDEC MS-012 variation AC.

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