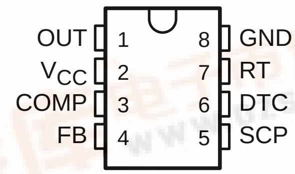
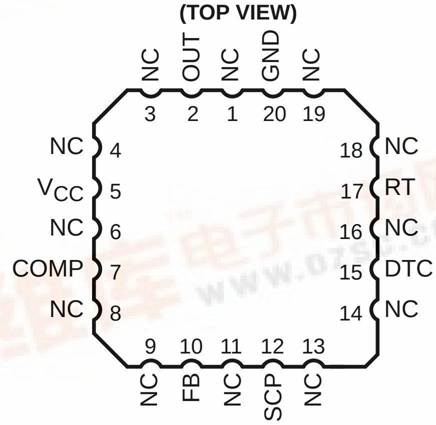
- Complete PWM Power Control
- 3.6-V to 40-V Operation
- Internal Undervoltage-Lockout Circuit
- Internal Short-Circuit Protection
- Oscillator Frequency . . . 20 kHz to 500 kHz
- Variable Dead Time Provides Control Over Total Range
- ±3% Tolerance on Reference Voltage (TL5001A)
- Available in Q-Temp Automotive
  - HighRel Automotive Applications
  - Configuration Control / Print Support
  - Qualification to Automotive Standards

D, JG OR P PACKAGE
(TOP VIEW)




FK PACKAGE
(TOP VIEW)




## description

The TL5001 and TL5001A incorporate on a single monolithic chip all the functions required for a pulse-width-modulation (PWM) control circuit. Designed primarily for power-supply control, the TL5001/A contains an error amplifier, a regulator, an oscillator, a PWM comparator with a dead-time-control input, undervoltage lockout (UVLO), short-circuit protection (SCP), and an open-collector output transistor. The TL5001A has a typical reference voltage tolerance of ±3% compared to ±5% for the TL5001.

The error-amplifier common-mode voltage ranges from 0 V to 1.5 V. The noninverting input of the error amplifier is connected to a 1-V reference. Dead-time control (DTC) can be set to provide 0% to 100% dead time by connecting an external resistor between DTC and GND. The oscillator frequency is set by terminating RT with an external resistor to GND. During low $V_{CC}$ conditions, the UVLO circuit turns the output off until $V_{CC}$ recovers to its normal operating range.

The TL5001C and TL5001AC are characterized for operation from –20°C to 85°C. The TL5001I and TL5001AI are characterized for operation from –40°C to 85°C. The TL5001Q and TL5001AQ are characterized for operation from –40°C to 125°C. The TL5001M and TL5001AM are characterized for operation from –55°C to 125°C.

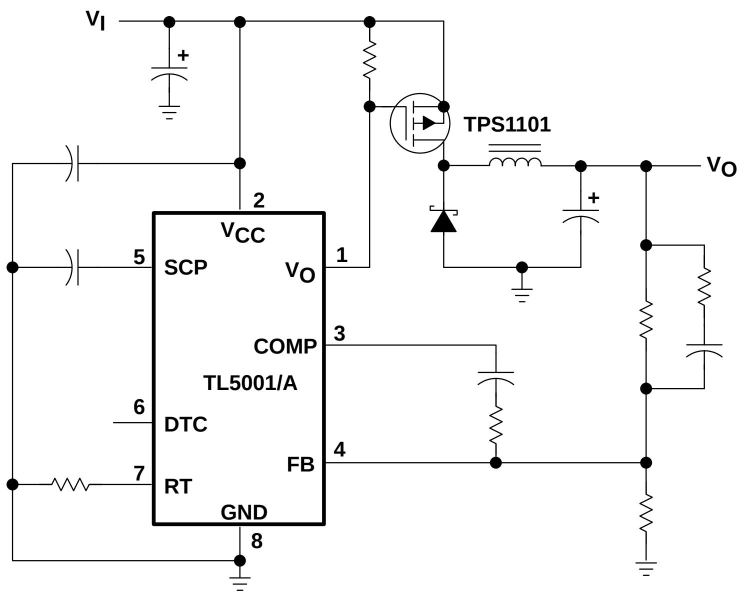
AVAILABLE OPTIONS

| $T_A$ | PACKAGED DEVICES | | | |
|---|---|---|---|---|
| | SMALL OUTLINE (D) | PLASTIC DIP (P) | CERAMIC DIP (JG) | CHIP CARRIER (FK) |
| –20°C to 85°C | TL5001CD | TL5001CP | — | — |
| | TL5001ACD | TL5001ACP | — | — |
| –40°C to 85°C | TL5001ID | TL5001IP | — | — |
| | TL5001AID | TL5001AIP | — | — |
| –40°C to 125°C | TL5001QD | — | — | — |
| | TL5001AQD | — | — | — |
| –55°C to 125°C | — | — | TL5001MJG | TL5001MFK |
| | — | — | TL5001AMJG | TL5001AMFK |

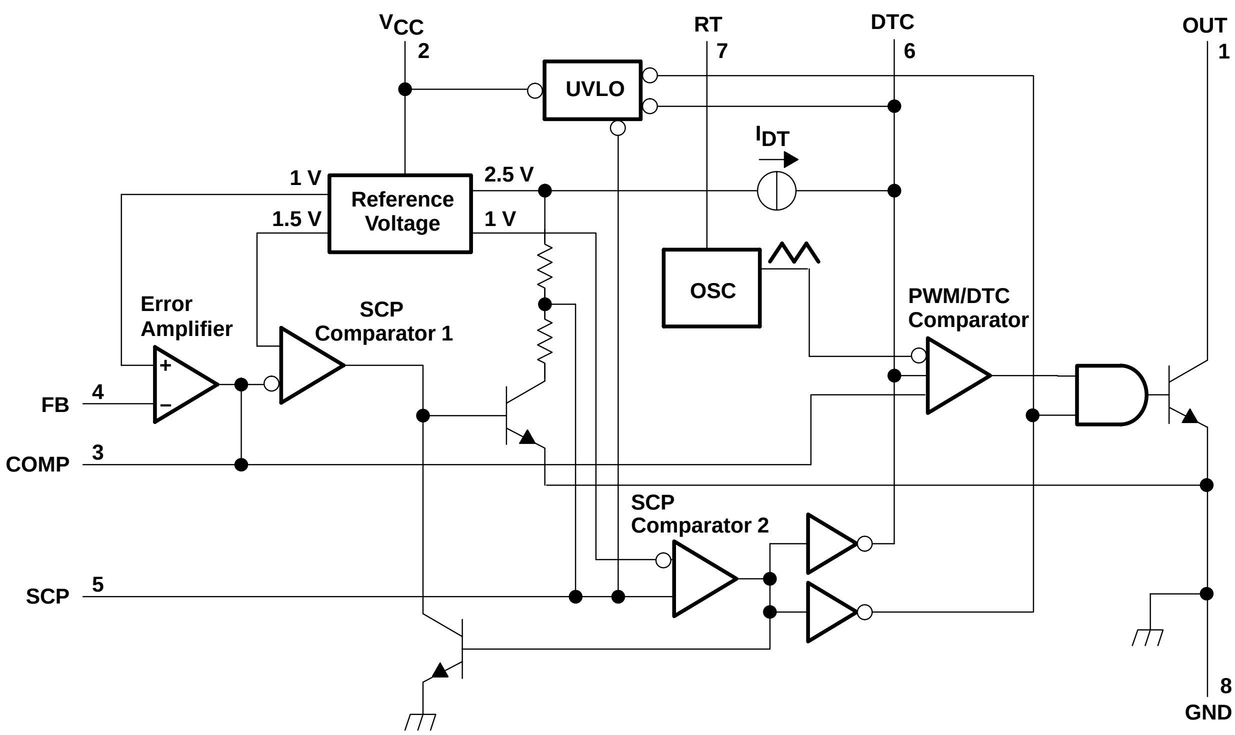
The D package is available taped and reeled. Add the suffix R to the device type (e.g., TL5001CDR).

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.

## schematic for typical application




## functional block diagram



## detailed description

### voltage reference

A 2.5-V regulator operating from $V_{CC}$ is used to power the internal circuitry of the TL5001 and TL5001A and as a reference for the error amplifier and SCP circuits. A resistive divider provides a 1-V reference for the error amplifier noninverting input which typically is within 2% of nominal over the operating temperature range.

### error amplifier

The error amplifier compares a sample of the dc-to-dc converter output voltage to the 1-V reference and generates an error signal for the PWM comparator. The dc-to-dc converter output voltage is set by selecting the error-amplifier gain (see Figure 1), using the following expression:

$$V_O = (1 + R1/R2)\ (1\ V)$$

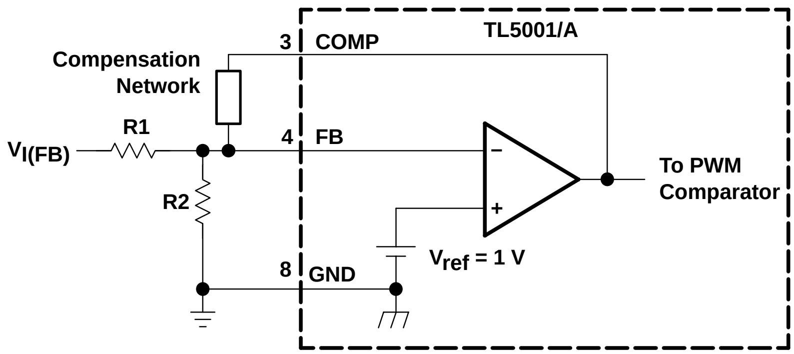



**Figure 1. Error-Amplifier Gain Setting**

The error-amplifier output is brought out as COMP for use in compensating the dc-to-dc converter control loop for stability. Because the amplifier can only source 45 µA, the total dc load resistance should be 100 kΩ or more.

### oscillator/PWM

The oscillator frequency ($f_{osc}$) can be set between 20 kHz and 500 kHz by connecting a resistor between RT and GND. Acceptable resistor values range from 15 kΩ to 250 kΩ. The oscillator frequency can be determined by using the graph shown in Figure 5.

The oscillator output is a triangular wave with a minimum value of approximately 0.7 V and a maximum value of approximately 1.3 V. The PWM comparator compares the error-amplifier output voltage and the DTC input voltage to the triangular wave and turns the output transistor off whenever the triangular wave is greater than the lesser of the two inputs.

### dead-time control (DTC)

DTC provides a means of limiting the output-switch duty cycle to a value less than 100%, which is critical for boost and flyback converters. A current source generates a reference current ($I_{DT}$) at DTC that is nominally equal to the current at the oscillator timing terminal, RT. Connecting a resistor between DTC and GND generates a dead-time reference voltage ($V_{DT}$), which the PWM/DTC comparator compares to the oscillator triangle wave as described in the previous section. Nominally, the maximum duty cycle is 0% when $V_{DT}$ is 0.7 V or less and 100% when $V_{DT}$ is 1.3 V or greater. Because the triangle wave amplitude is a function of frequency and the source impedance of RT is relatively high (1250 Ω), choosing $R_{DT}$ for a specific maximum duty cycle, D, is accomplished using the following equation and the voltage limits for the frequency in question as found in Figure 11 ($V_{osc}$max and $V_{osc}$min are the maximum and minimum oscillator levels):

### dead-time control (DTC) (continued)

$$R_{DT} = \left(R_t + 1250\right)\left[D\left(V_{osc}max - V_{osc}min\right) + V_{osc}min\right]$$

Where

$R_{DT}$ and $R_t$ are in ohms, D in decimal

Soft start can be implemented by paralleling the DTC resistor with a capacitor ($C_{DT}$) as shown in Figure 2. During soft start, the voltage at DTC is derived by the following equation:

$$V_{DT} \approx I_{DT}R_{DT}\left(1 - e^{\left(-t/R_{DT}C_{DT}\right)}\right)$$

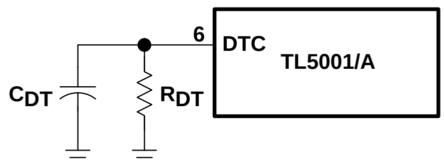



**Figure 2. Soft-Start Circuit**

If the dc-to-dc converter must be in regulation within a specified period of time, the time constant, $R_{DT}C_{DT}$, should be $t_0/3$ to $t_0/5$. The TL5001/A remains off until $V_{DT} \approx 0.7$ V, the minimum ramp value. $C_{DT}$ is discharged every time UVLO or SCP becomes active.

### undervoltage-lockout (UVLO) protection

The undervoltage-lockout circuit turns the output transistor off and resets the SCP latch whenever the supply voltage drops too low (approximately 3 V at 25°C) for proper operation. A hysteresis voltage of 200 mV eliminates false triggering on noise and chattering.

### short-circuit protection (SCP)

The TL5001/A includes short-circuit protection (see Figure 3), which turns the power switch off to prevent damage when the converter output is shorted. When activated, the SCP prevents the switch from being turned on until the internal latching circuit is reset. The circuit is reset by reducing the input voltage until UVLO becomes active or until the SCP terminal is pulled to ground externally.

When a short circuit occurs, the error-amplifier output at COMP rises to increase the power-switch duty cycle in an attempt to maintain the output voltage. SCP comparator 1 starts an RC timing circuit when COMP exceeds 1.5 V. If the short is removed and the error-amplifier output drops below 1.5 V before time out, normal converter operation continues. If the fault is still present at the end of the time-out period, the timer sets the latching circuit and turns off the TL5001/A output transistor.

### short-circuit protection (SCP) (continued)

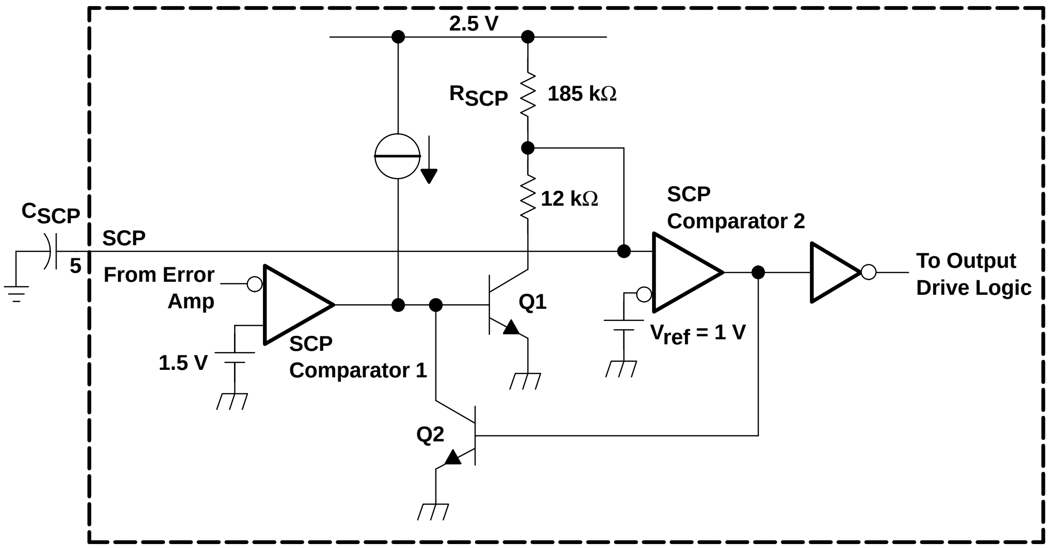



**Figure 3. SCP Circuit**

The timer operates by charging an external capacitor ($C_{SCP}$), connected between the SCP terminal and ground, towards 2.5 V through a 185-kΩ resistor ($R_{SCP}$). The circuit begins charging from an initial voltage of approximately 185 mV and times out when the capacitor voltage reaches 1 V. The output of SCP comparator 2 then goes high, turns on Q2, and latches the timer circuit. The expression for setting the SCP time period is derived from the following equation:

$$V_{SCP} = (2.5 - 0.185)\left(1 - e^{-t/\tau}\right) + 0.185$$

Where

$\tau = R_{SCP}C_{SCP}$

The end of the time-out period, $t_{SCP}$, occurs when $V_{SCP}$ = 1 V. Solving for $C_{SCP}$ yields:

$$C_{SCP} = 12.46 \times t_{SCP}$$

Where

t is in seconds, C in μF.

$t_{SCP}$ must be much longer (generally 10 to 15 times) than the converter start-up period or the converter will not start.

### output transistor

The output of the TL5001/A is an open-collector transistor with a maximum collector current rating of 21 mA and a voltage rating of 51 V. The output is turned on under the following conditions: the oscillator triangle wave is lower than both the DTC voltage and the error-amplifier output voltage, the UVLO circuit is inactive, and the short-circuit protection circuit is inactive.

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

Supply voltage, $V_{CC}$ (see Note 1) . . . . . 41 V
Amplifier input voltage, $V_{I(FB)}$ . . . . . 20 V
Output voltage, $V_O$, OUT . . . . . 51 V
Output current, $I_O$, OUT . . . . . 21 mA
Output peak current, $I_{O(peak)}$, OUT . . . . . 100 mA
Continuous total power dissipation . . . . . See Dissipation Rating Table
Operating ambient temperature range, $T_A$: TL5001C, TL5001AC . . . . . –20°C to 85°C
TL5001I, TL5001AI . . . . . –40°C to 85°C
TL5001Q, TL5001AQ . . . . . –40°C to 125°C
TL5001M, TL5001AM . . . . . –55°C to 125°C
Storage temperature range, $T_{stg}$ . . . . . –65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 260°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.

NOTE 1: All voltage values are with respect to network ground terminal.

**DISSIPATION RATING TABLE**

| PACKAGE | $T_A \leq 25°C$ POWER RATING | DERATING FACTOR ABOVE $T_A$ = 25°C | $T_A$ = 70°C POWER RATING | $T_A$ = 85°C POWER RATING | $T_A$ = 125°C POWER RATING |
|---|---|---|---|---|---|
| D | 725 mW | 5.8 mW/°C | 464 mW | 377 mW | 145 mW |
| FK | 1375 mW | 11.0 mW/°C | 880 mW | 715 mW | 275 mW |
| JG | 1050 mW | 8.4 mW/°C | 672 mW | 546 mW | 210 mW |
| P | 1000 mW | 8.0 mW/°C | 640 mW | 520 mW | 200 mW |

### recommended operating conditions

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Supply voltage, $V_{CC}$ | | 3.6 | 40 | V |
| Amplifier input voltage, $V_{I(FB)}$ | | 0 | 1.5 | V |
| Output voltage, $V_O$, OUT | | | 50 | V |
| Output current, $I_O$, OUT | | | 20 | mA |
| COMP source current | | | 45 | µA |
| COMP dc load resistance | | 100 | | kΩ |
| Oscillator timing resistor, $R_t$ | | 15 | 250 | kΩ |
| Oscillator frequency, $f_{osc}$ | | 20 | 500 | kHz |
| Operating ambient temperature, $T_A$ | TL5001C, TL5001AC | –20 | 85 | °C |
| | TL5001I, TL5001AI | –40 | 85 | °C |
| | TL5001Q, TL5001AQ | –40 | 125 | °C |
| | TL5001M, TL5001AM | –55 | 125 | °C |

## electrical characteristics over recommended operating free-air temperature range, $V_{CC}$ = 6 V, $f_{osc}$ = 100 kHz (unless otherwise noted)

### reference

| PARAMETER | TEST CONDITIONS | TL5001C, TL5001I | | | TL5001AC, TL5001AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Output voltage | COMP connected to FB | 0.95 | 1 | 1.05 | 0.97 | 1 | 1.03 | V |
| Input regulation | $V_{CC}$ = 3.6 V to 40 V | | 2 | 12.5 | | 2 | 12.5 | mV |
| Output voltage change with temperature | $T_A$ = –20°C to 25°C (C suffix) | –10 | –1 | 10 | –10 | –1 | 10 | mV/V |
| | $T_A$ = –40°C to 25°C (I suffix) | –10 | –1 | 10 | –10 | –1 | 10 | |
| | $T_A$ = 25°C to 85°C | –10 | –2 | 10 | –10 | –2 | 10 | |

† All typical values are at $T_A$ = 25°C.

### undervoltage lockout

| PARAMETER | TEST CONDITIONS | TL5001C, TL5001I | | | TL5001AC, TL5001AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Upper threshold voltage | $T_A$ = 25°C | | 3 | | | 3 | | V |
| Lower threshold voltage | $T_A$ = 25°C | | 2.8 | | | 2.8 | | V |
| Hysteresis | $T_A$ = 25°C | 100 | 200 | | 100 | 200 | | mV |
| Reset threshold voltage | $T_A$ = 25°C | 2.1 | 2.55 | | 2.1 | 2.55 | | V |

† All typical values are at $T_A$ = 25°C.

### short-circuit protection

| PARAMETER | TEST CONDITIONS | TL5001C, TL5001I | | | TL5001AC, TL5001AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| SCP threshold voltage | $T_A$ = 25°C | 0.95 | 1.00 | 1.05 | 0.97 | 1.00 | 1.03 | V |
| SCP voltage, latched | No pullup | 140 | 185 | 230 | 140 | 185 | 230 | mV |
| SCP voltage, UVLO standby | No pullup | | 60 | 120 | | 60 | 120 | mV |
| Input source current | $T_A$ = 25°C | –10 | –15 | –20 | –10 | –15 | –20 | µA |
| SCP comparator 1 threshold voltage | | | 1.5 | | | 1.5 | | V |

† All typical values are at $T_A$ = 25°C.

### oscillator

| PARAMETER | TEST CONDITIONS | TL5001C, TL5001I | | | TL5001AC, TL5001AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Frequency | $R_t$ = 100 kΩ | | 100 | | | 100 | | kHz |
| Standard deviation of frequency | | | 15 | | | 15 | | kHz |
| Frequency change with voltage | $V_{CC}$ = 3.6 V to 40 V | | 1 | | | 1 | | kHz |
| Frequency change with temperature | $T_A$ = –40°C to 25°C | –4 | –0.4 | 4 | –4 | –0.4 | 4 | kHz |
| | $T_A$ = –20°C to 25°C | –4 | –0.4 | 4 | –4 | –0.4 | 4 | kHz |
| | $T_A$ = 25°C to 85°C | –4 | –0.2 | 4 | –4 | –0.2 | 4 | kHz |
| Voltage at RT | | | 1 | | | 1 | | V |

† All typical values are at $T_A$ = 25°C.

## electrical characteristics over recommended operating free-air temperature range, $V_{CC}$ = 6 V, $f_{osc}$ = 100 kHz (unless otherwise noted) (continued)

### dead-time control

| PARAMETER | | TEST CONDITIONS | TL5001C, TL5001I | | | TL5001AC, TL5001AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Output (source) current | TL5001C | $V_{(DT)}$ = 1.5 V | 0.9 × $I_{RT}$‡ | | 1.1 × $I_{RT}$ | 0.9 × $I_{RT}$‡ | | 1.1 × $I_{RT}$ | μA |
| | TL5001I | $V_{(DT)}$ = 1.5 V | 0.9 × $I_{RT}$‡ | | 1.2 × $I_{RT}$ | 0.9 × $I_{RT}$‡ | | 1.2 × $I_{RT}$ | |
| Input threshold voltage | | Duty cycle = 0% | 0.5 | 0.7 | | 0.5 | 0.7 | | V |
| | | Duty cycle = 100% | | 1.3 | 1.5 | | 1.3 | 1.5 | |

† All typical values are at $T_A$ = 25°C.
‡ Output source current at RT

### error amplifier

| PARAMETER | | TEST CONDITIONS | TL5001C, TL5001I | | | TL5001AC, TL5001AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Input voltage | | $V_{CC}$ = 3.6 V to 40 V | 0 | | 1.5 | 0 | | 1.5 | V |
| Input bias current | | | | –160 | –500 | | –160 | –500 | nA |
| Output voltage swing | Positive | | 1.5 | 2.3 | | 1.5 | 2.3 | | V |
| | Negative | | | 0.3 | 0.4 | | 0.3 | 0.4 | V |
| Open-loop voltage amplification | | | | 80 | | | 80 | | dB |
| Unity-gain bandwidth | | | | 1.5 | | | 1.5 | | MHz |
| Output (sink) current | | $V_{I(FB)}$ = 1.2 V, COMP = 1 V | 100 | 600 | | 100 | 600 | | μA |
| Output (source) current | | $V_{I(FB)}$ = 0.8 V, COMP = 1 V | –45 | –70 | | –45 | –70 | | μA |

† All typical values are at $T_A$ = 25°C.

### output

| PARAMETER | TEST CONDITIONS | TL5001C, TL5001I | | | TL5001AC, TL5001AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Output saturation voltage | $I_O$ = 10 mA | | 1.5 | 2 | | 1.5 | 2 | V |
| Off-state current | $V_O$ = 50 V, $V_{CC}$ = 0 | | | 10 | | | 10 | μA |
| | $V_O$ = 50 V | | | 10 | | | 10 | |
| Short-circuit output current | $V_O$ = 6 V | | 40 | | | 40 | | mA |

† All typical values are at $T_A$ = 25°C.

### total device

| PARAMETER | | TEST CONDITIONS | TL5001C, TL5001I | | | TL5001AC, TL5001AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Standby supply current | Off state | | | 1 | 1.5 | | 1 | 1.5 | mA |
| Average supply current | | $R_t$ = 100 kΩ | | 1.4 | 2.1 | | 1.4 | 2.1 | mA |

† All typical values are at $T_A$ = 25°C.

## electrical characteristics over recommended operating free-air temperature range, $V_{CC}$ = 6 V, $f_{osc}$ = 100 kHz (unless otherwise noted)

### reference

| PARAMETER | TEST CONDITIONS | | TL5001Q, TL5001M | | | TL5001AQ, TL5001AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Output voltage | $T_A$ = 25°C | COMP connected to FB | 0.95 | 1.00 | 1.05 | 0.97 | 1.00 | 1.03 | V |
| | $T_A$ = MIN to MAX | | 0.93 | 0.98 | 1.07 | 0.94 | 0.98 | 1.06 | |
| Input regulation | $T_A$ = MIN to MAX | $V_{CC}$ = 3.6 V to 40 V | | 2 | 12.5 | | 2 | 12.5 | mV |
| Output voltage change with temperature | $T_A$ = MIN to MAX | | *–6 | 2 | *6 | *–6 | 2 | *6 | % |

† All typical values are at $T_A$ = 25°C.
*Not production tested.

### undervoltage lockout

| PARAMETER | TEST CONDITIONS | TL5001Q, TL5001M | | | TL5001AQ, TL5001AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Upper threshold voltage | $T_A$ = MIN, 25°C | | 3.00 | | | 3.00 | | V |
| | $T_A$ = MAX | | 2.55 | | | 2.55 | | |
| Lower threshold voltage | $T_A$ = MIN, 25°C | | 2.8 | | | 2.8 | | V |
| | $T_A$ = MAX | | 2.0 | | | 2.0 | | |
| Hysteresis | $T_A$ = MIN to MAX | 100 | 200 | | 100 | 200 | | mV |
| Reset threshold voltage | $T_A$ = MIN, 25°C | 2.10 | 2.55 | | 2.10 | 2.55 | | V |
| | $T_A$ = MAX | 0.35 | 0.63 | | 0.35 | 0.63 | | |

† All typical values are at $T_A$ = 25°C.

### short-circuit protection

| PARAMETER | TEST CONDITIONS | | TL5001Q, TL5001M | | | TL5001AQ, TL5001AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| SCP threshold voltage | $T_A$ = MIN, 25°C | | 0.95 | 1.00 | 1.05 | 0.97 | 1.00 | 1.03 | V |
| | $T_A$ = MAX | | 0.93 | 0.98 | 1.07 | 0.94 | 0.98 | 1.06 | |
| SCP voltage, latched | $T_A$ = MIN to MAX | No pullup | 140 | 185 | 230 | 140 | 185 | 230 | mV |
| SCP voltage, UVLO standby | $T_A$ = MIN to MAX | No pullup | | 60 | 120 | | 60 | 120 | mV |
| Equivalent timing resistance | $T_A$ = MIN to MAX | | | 185 | | | 185 | | kΩ |
| SCP comparator 1 threshold voltage | $T_A$ = MIN to MAX | | | 1.5 | | | 1.5 | | V |

† All typical values are at $T_A$ = 25°C.

## electrical characteristics over recommended operating free-air temperature range, $V_{CC}$ = 6 V, $f_{osc}$ = 100 kHz (unless otherwise noted) (continued)

### oscillator

| PARAMETER | TEST CONDITIONS | | TL5001Q, TL5001M | | | TL5001AQ, TL5001AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Frequency | $T_A$ = MIN to MAX | $R_t$ = 100 kΩ | | 100 | | | 100 | | kHz |
| Standard deviation of frequency | $T_A$ = MIN to MAX | | | 2 | | | 2 | | kHz |
| Frequency change with voltage | $T_A$ = MIN to MAX | $V_{CC}$ = 3.6 V to 40 V | | 1 | | | 1 | | kHz |
| Frequency change with temperature | $T_A$ = MIN to MAX | Q suffix | *–6 | 3 | *6 | *–6 | 3 | *6 | kHz |
| | | M suffix | *–9 | 5 | *9 | *–9 | 5 | *9 | |
| Voltage at RT | $T_A$ = MIN to MAX | | | 1 | | | 1 | | V |

† All typical values are at $T_A$ = 25°C.
*Not production tested.

### dead-time control

| PARAMETER | TEST CONDITIONS | | TL5001Q, TL5001M | | | TL5001AQ, TL5001AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Output (source) current | $T_A$ = MIN to MAX | $V_{(DT)}$ = 1.5 V | $0.9 \times I_{RT}$‡ | | $1.1 \times I_{RT}$ | $0.9 \times I_{RT}$‡ | | $1.1 \times I_{RT}$ | µA |
| Input threshold voltage | $T_A$ = 25°C | Duty cycle = 0% | 0.5 | 0.7 | | 0.5 | 0.7 | | V |
| | | Duty cycle = 100% | | 1.3 | 1.5 | | 1.3 | 1.5 | |
| | $T_A$ = MIN to MAX | Duty cycle = 0% | 0.4 | 0.7 | | 0.4 | 0.7 | | |
| | | Duty cycle = 100% | | 1.3 | 1.7 | | 1.3 | 1.7 | |

† All typical values are at $T_A$ = 25°C.
‡ Output source current at RT

### error amplifier

| PARAMETER | | TEST CONDITIONS | | TL5001Q, TL5001M | | | TL5001AQ, TL5001AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Input bias current | | $T_A$ = MIN to MAX | | | –160 | –500 | | –160 | –500 | nA |
| Output voltage swing | Positive | $T_A$ = MIN to MAX | | 1.5 | 2.3 | | 1.5 | 2.3 | | V |
| | Negative | | | | 0.3 | 0.4 | | 0.3 | 0.4 | V |
| Open-loop voltage amplification | | $T_A$ = MIN to MAX | | | 80 | | | 80 | | dB |
| Unity-gain bandwidth | | $T_A$ = MIN to MAX | | | 1.5 | | | 1.5 | | MHz |
| Output (sink) current | | $T_A$ = MIN to MAX | $V_{I(FB)}$ = 1.2 V, COMP = 1 V | 100 | 600 | | 100 | 600 | | µA |
| Output (source) current | | $T_A$ = MIN, 25°C | $V_{I(FB)}$ = 0.8 V, COMP = 1 V | –45 | –70 | | –45 | –70 | | µA |
| | | $T_A$ = MAX | | –30 | –45 | | –30 | –45 | | |

† All typical values are at $T_A$ = 25°C.

## electrical characteristics over recommended operating free-air temperature range, $V_{CC}$ = 6 V, $f_{osc}$ = 100 kHz (unless otherwise noted) (continued)

### output

| PARAMETER | TEST CONDITIONS | | TL5001Q, TL5001M | | | TL5001AQ, TL5001AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Output saturation voltage | $T_A$ = MIN to MAX | $I_O$ = 10 mA | | 1.5 | 2 | | 1.5 | 2 | V |
| Off-state current | $T_A$ = MIN to MAX | $V_O$ = 50 V, $V_{CC}$ = 0 | | | 10 | | | 10 | μA |
| | | $V_O$ = 50 V | | | 10 | | | 10 | |
| Short-circuit output current | $T_A$ = MIN to MAX | $V_O$ = 6 V | | 40 | | | 40 | | mA |

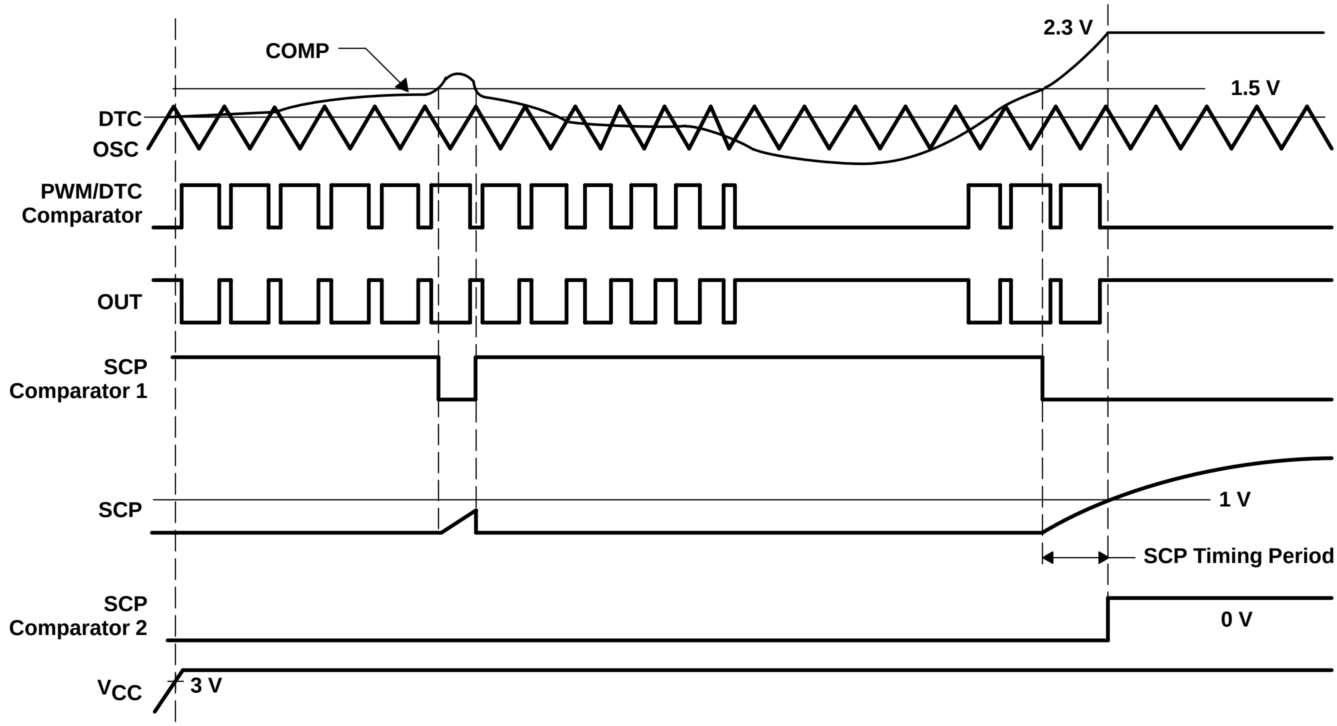
† All typical values are at $T_A$ = 25°C.

### total device

| PARAMETER | | TEST CONDITIONS | | TL5001Q, TL5001M | | | TL5001AQ, TL5001AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP† | MAX | MIN | TYP† | MAX | |
| Standby supply current | Off state | $T_A$ = MIN to MAX | | | 1 | 1.5 | | 1 | 1.5 | mA |
| Average supply current | | $T_A$ = MIN to MAX | $R_t$ = 100 kΩ | | 1.4 | 2.1 | | 1.4 | 2.1 | mA |

† All typical values are at $T_A$ = 25°C.

## PARAMETER MEASUREMENT INFORMATION




NOTE A: The waveforms show timing characteristics for an intermittent short circuit and a longer short circuit that is sufficient to activate SCP.

**Figure 4. PWM Timing Diagram**

## TYPICAL CHARACTERISTICS

**OSCILLATOR FREQUENCY vs TIMING RESISTANCE**

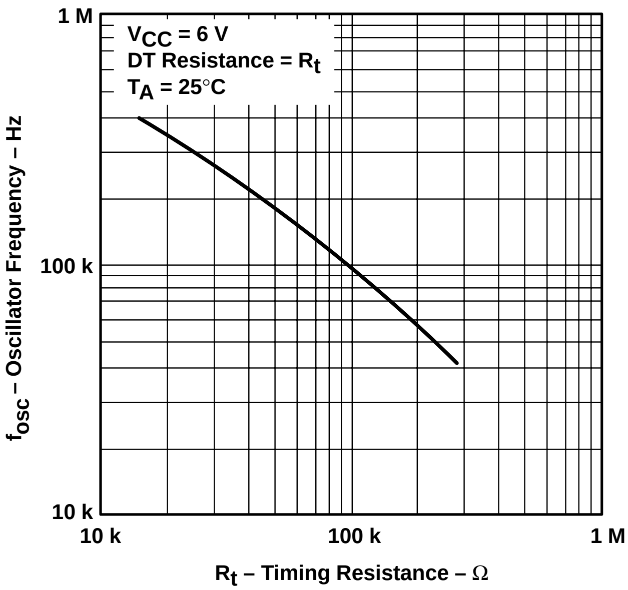



Figure 5

**OSCILLATION FREQUENCY vs AMBIENT TEMPERATURE**

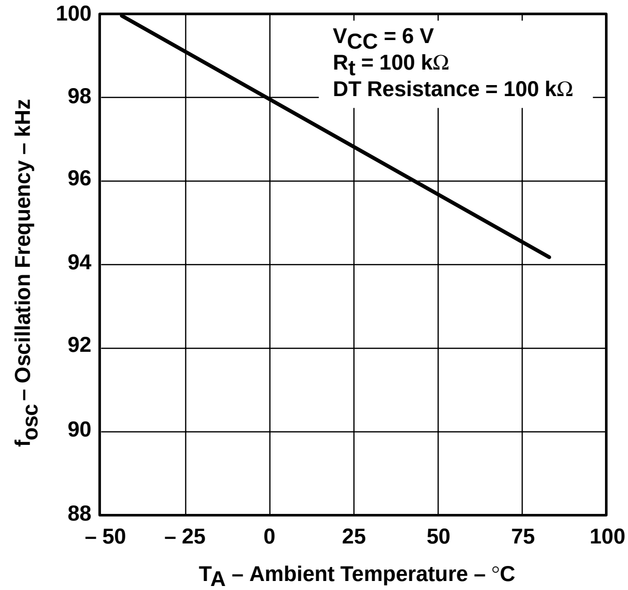



Figure 6

**REFERENCE OUTPUT VOLTAGE vs POWER-SUPPLY VOLTAGE**

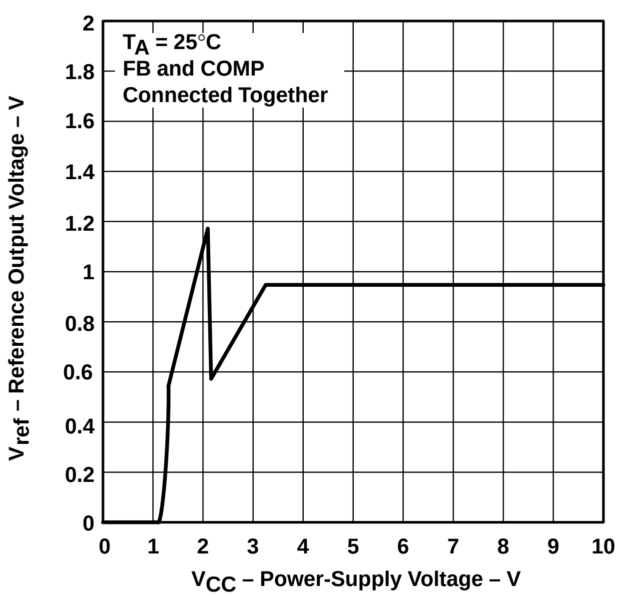



Figure 7

**REFERENCE OUTPUT VOLTAGE FLUCTUATION vs AMBIENT TEMPERATURE**

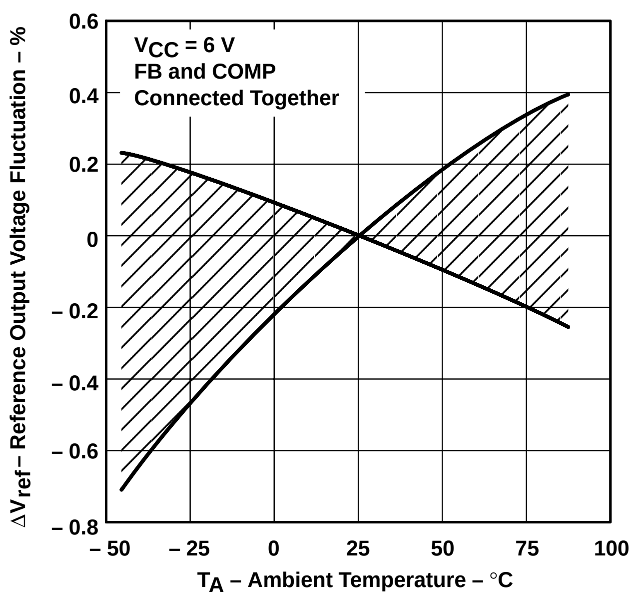



Figure 8

## TYPICAL CHARACTERISTICS

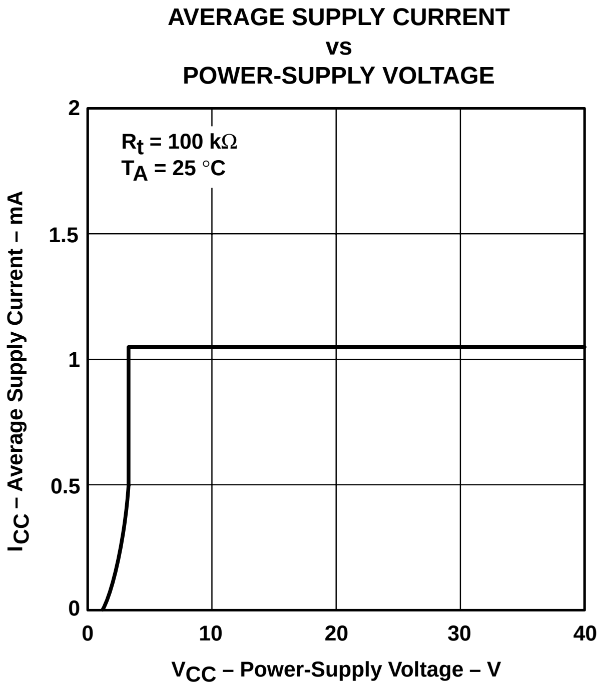



Figure 9

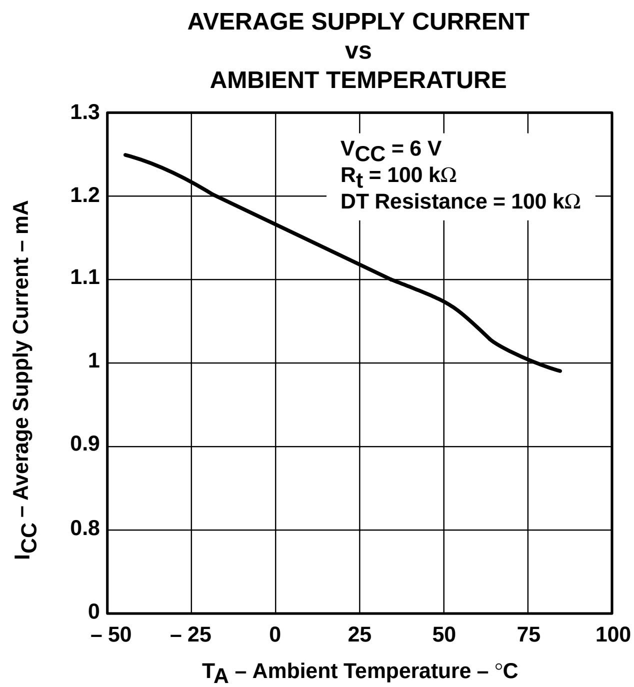



Figure 10

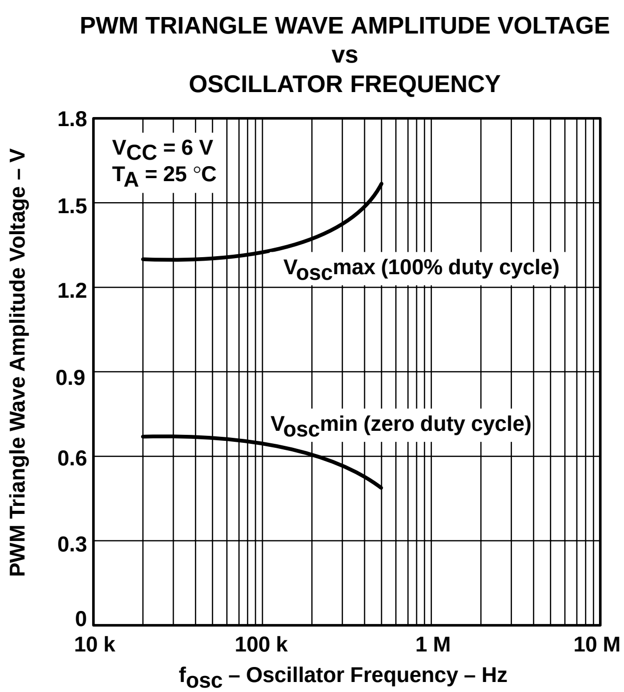



Figure 11

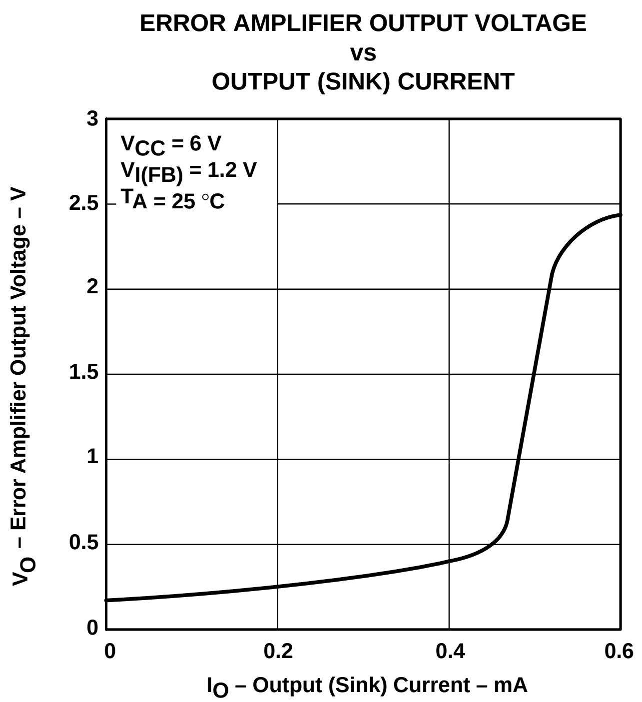



Figure 12

## TYPICAL CHARACTERISTICS

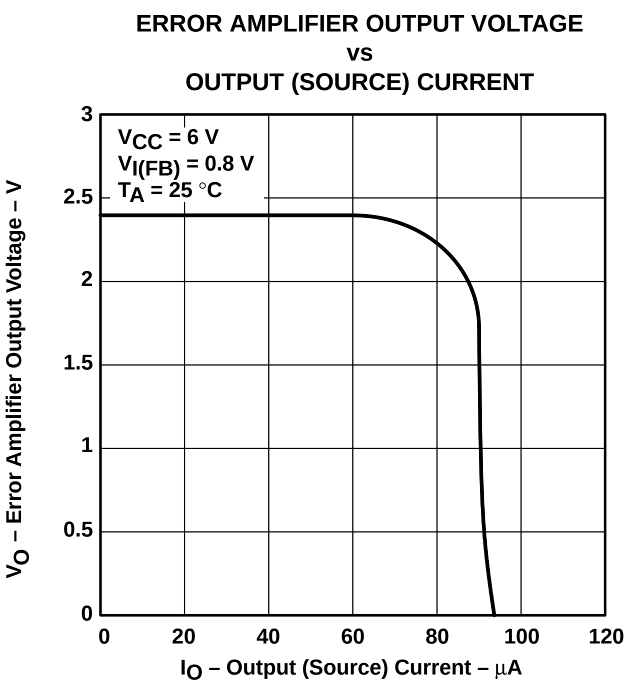



Figure 13

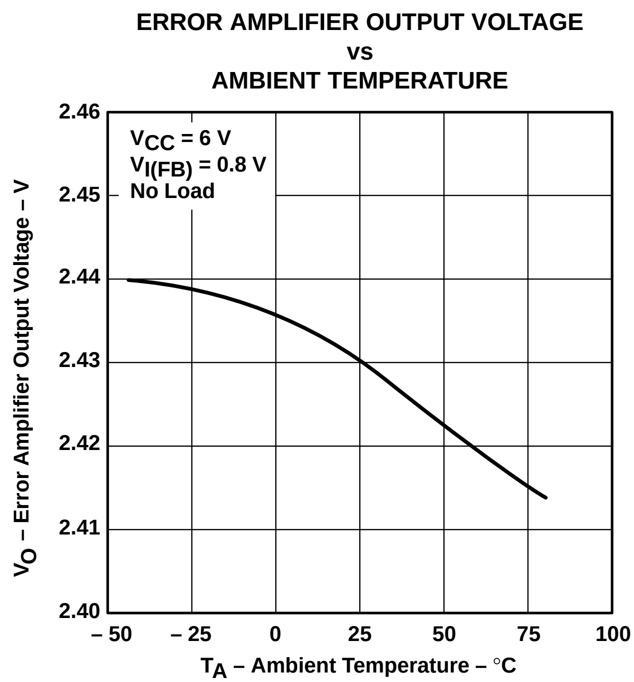



Figure 14

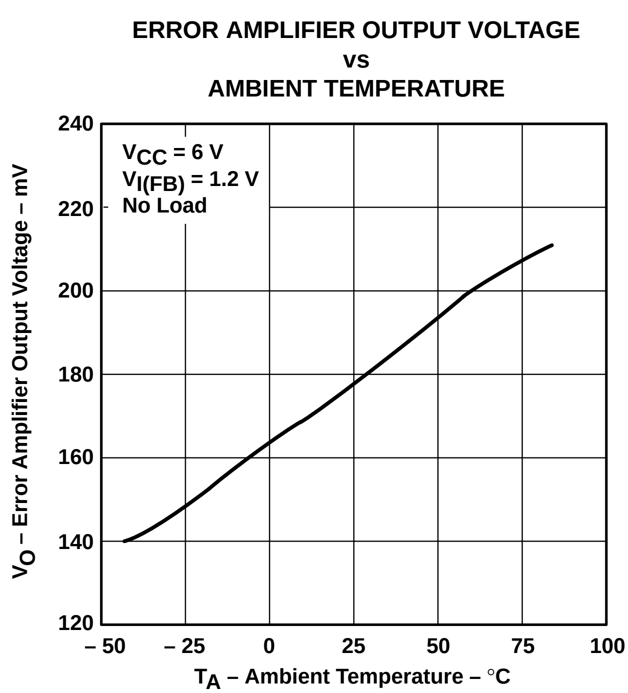



Figure 15

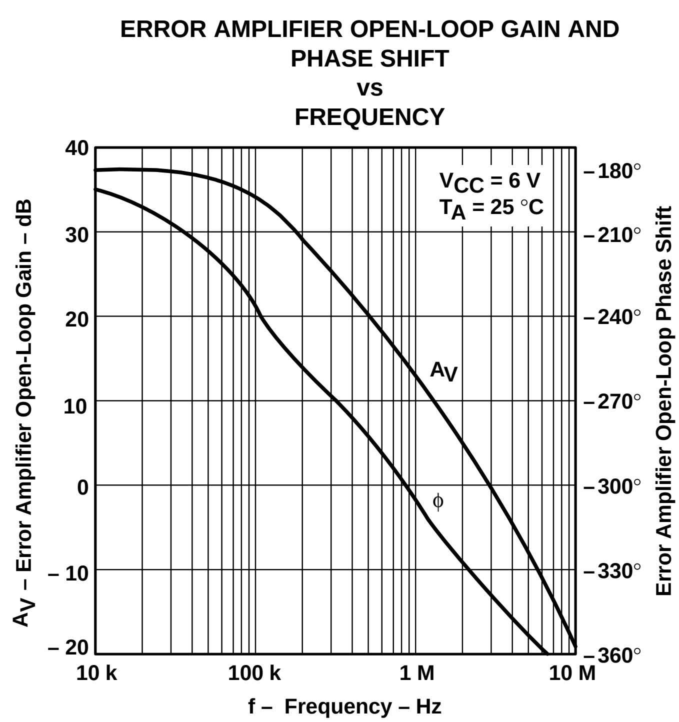



Figure 16

## TYPICAL CHARACTERISTICS

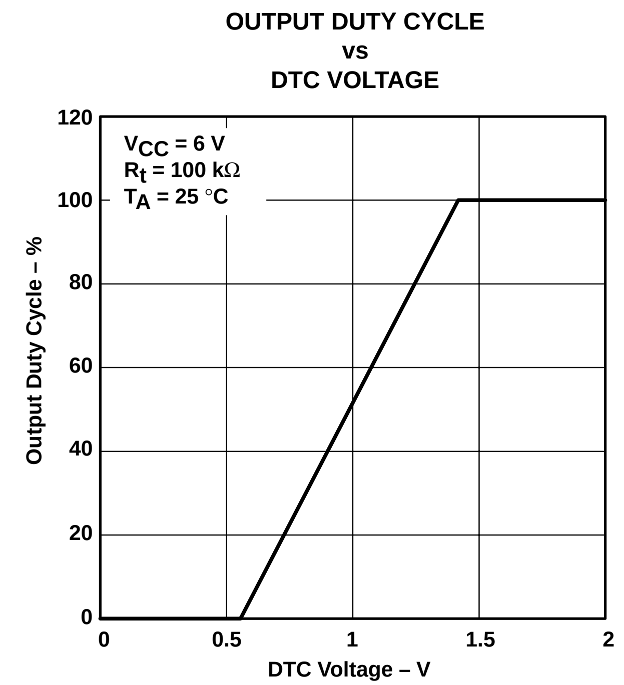



Figure 17

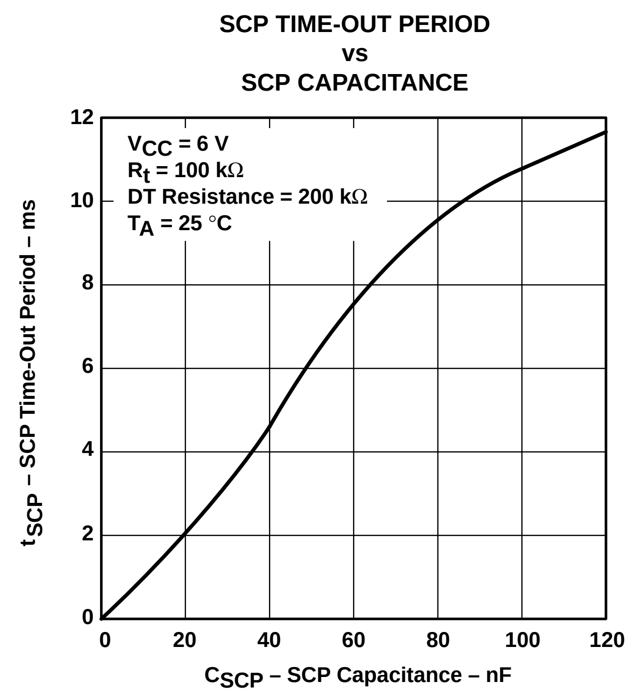



Figure 18

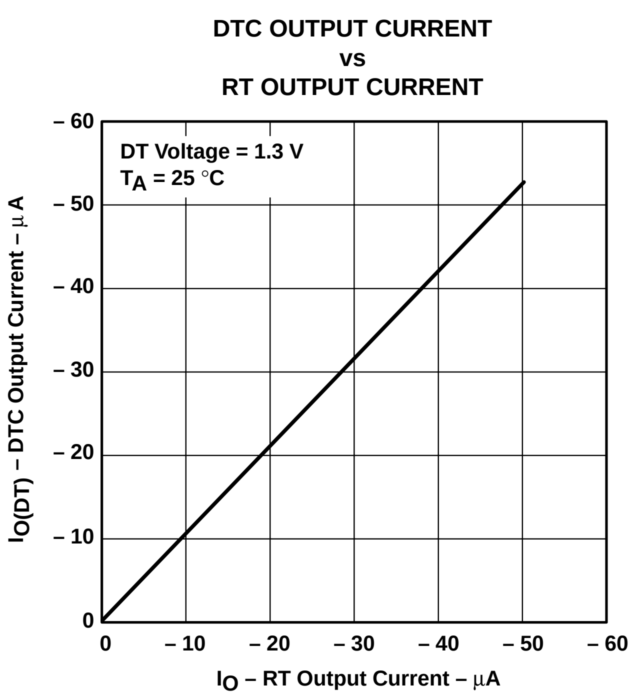



Figure 19

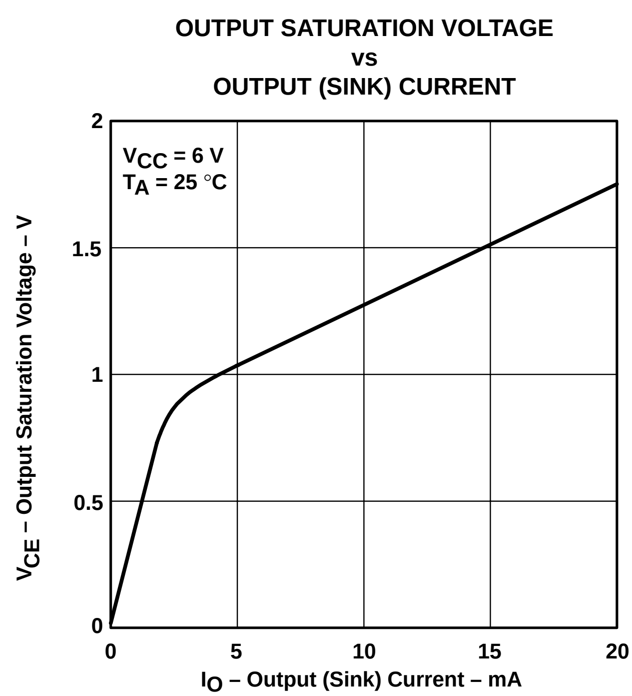
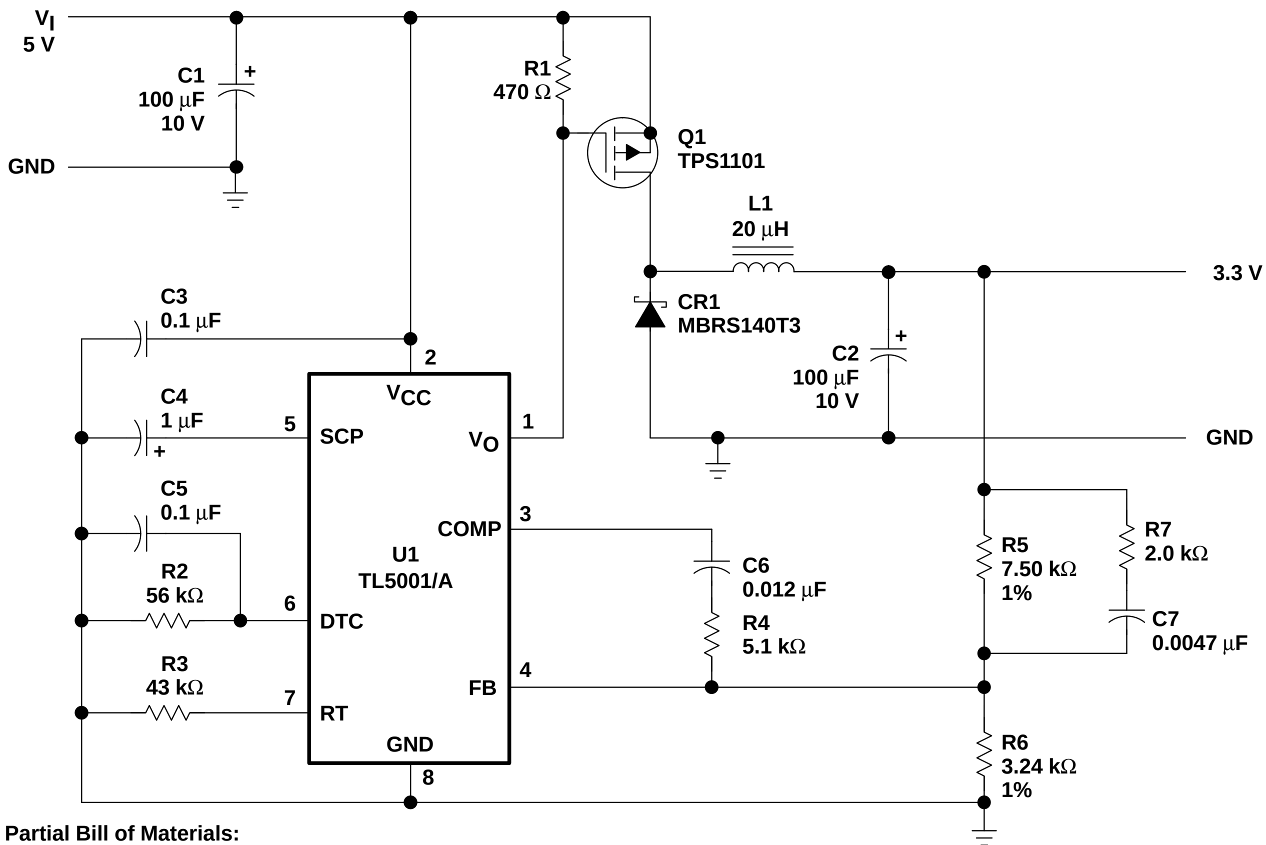



Figure 20

## APPLICATION INFORMATION




**Partial Bill of Materials:**

| | | |
|---|---|---|
| U1 | TL5001/A | Texas Instruments |
| Q1 | TPS1101 | Texas Instruments |
| LI | CTX20-1 or<br>23 turns of #28 wire on<br>Micrometals No. T50-26B core | Coiltronics |
| C1 | TPSD107M010R0100 | AVX |
| C2 | TPSD107M010R0100 | AVX |
| CR1 | MBRS140T3 | Motorola |

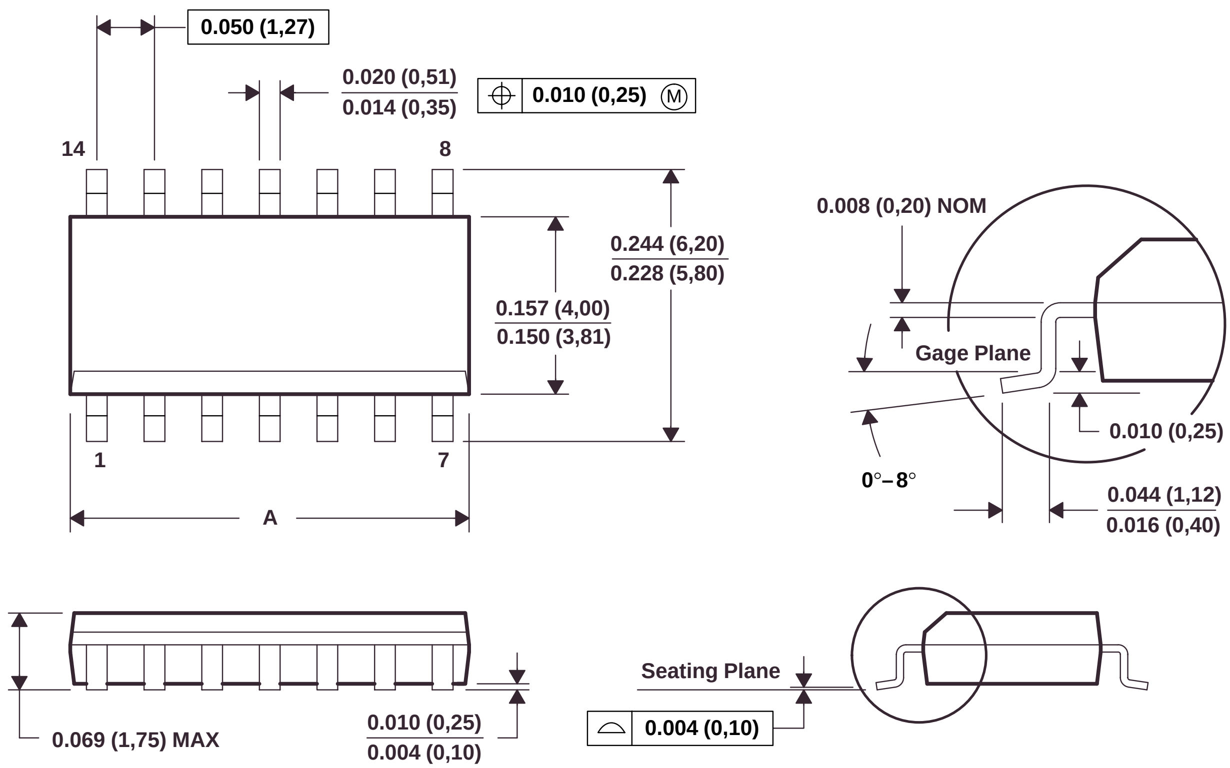
NOTES: A. Frequency = 200 kHz
B. Duty cycle = 90% max
C. Soft-start time constant (TC) = 5.6 ms
D. SCP TC = 70 msA

**Figure 21. Step-Down Converter**

## MECHANICAL DATA

**D (R-PDSO-G**)** **PLASTIC SMALL-OUTLINE PACKAGE**

**14 PIN SHOWN**




| PINS ** / DIM | 8 | 14 | 16 |
|---|---|---|---|
| A MAX | 0.197 (5,00) | 0.344 (8,75) | 0.394 (10,00) |
| A MIN | 0.189 (4,80) | 0.337 (8,55) | 0.386 (9,80) |

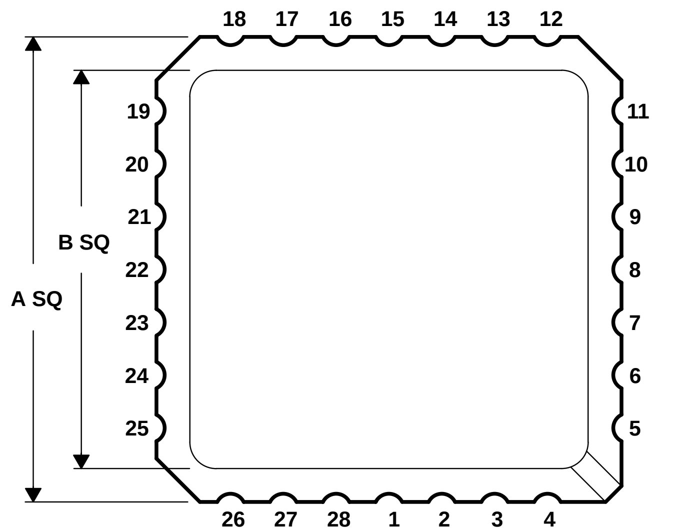
4040047 / D 10/96

NOTES: B. All linear dimensions are in inches (millimeters).
C. This drawing is subject to change without notice.
D. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
E. Falls within JEDEC MS-012

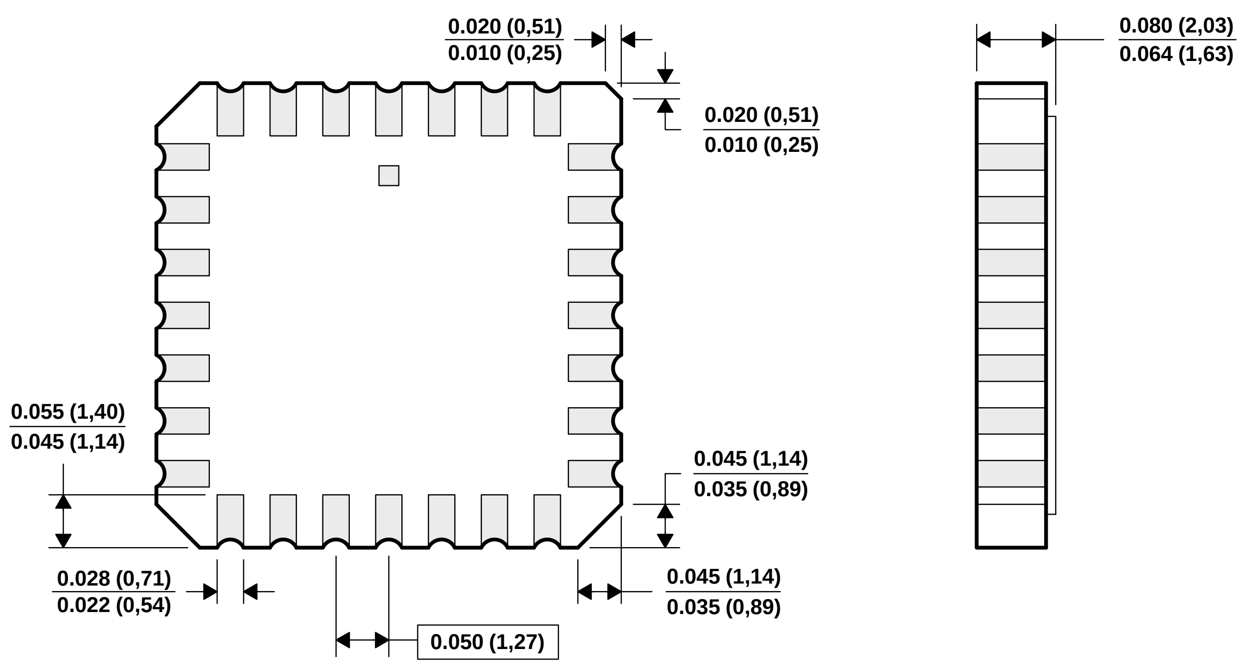
## MECHANICAL DATA

**FK (S-CQCC-N**)** — **LEADLESS CERAMIC CHIP CARRIER**

**28 TERMINALS SHOWN**




| NO. OF TERMINALS ** | A | | B | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| 20 | 0.342 (8,69) | 0.358 (9,09) | 0.307 (7,80) | 0.358 (9,09) |
| 28 | 0.442 (11,23) | 0.458 (11,63) | 0.406 (10,31) | 0.458 (11,63) |
| 44 | 0.640 (16,26) | 0.660 (16,76) | 0.495 (12,58) | 0.560 (14,22) |
| 52 | 0.740 (18,78) | 0.761 (19,32) | 0.495 (12,58) | 0.560 (14,22) |
| 68 | 0.938 (23,83) | 0.962 (24,43) | 0.850 (21,6) | 0.858 (21,8) |
| 84 | 1.141 (28,99) | 1.165 (29,59) | 1.047 (26,6) | 1.063 (27,0) |

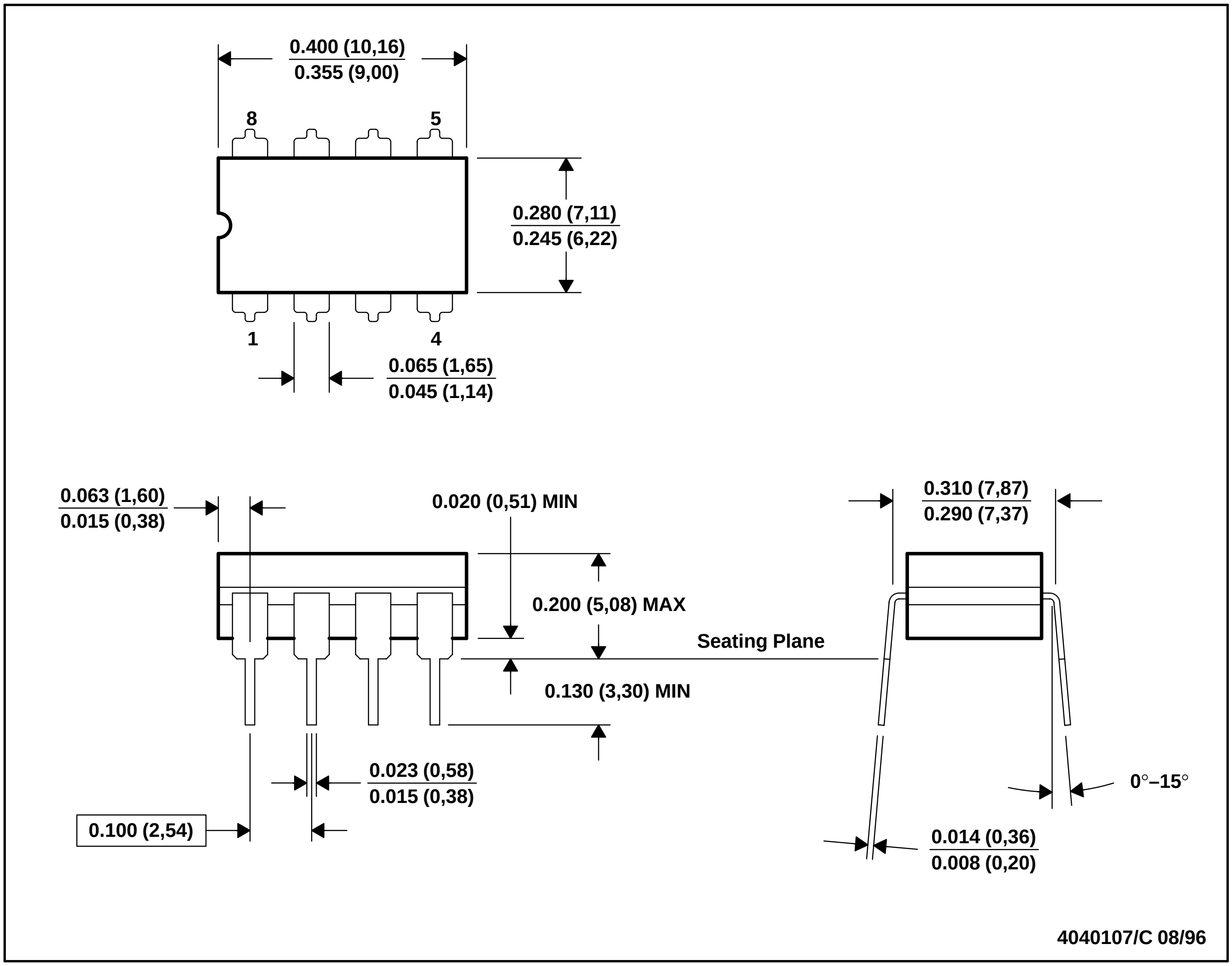



**4040140 / C 11/95**

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

## MECHANICAL DATA

**JG (R-GDIP-T8)** **CERAMIC DUAL-IN-LINE**




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.
- E. Falls within MIL STD 1835 GDIP1-T8

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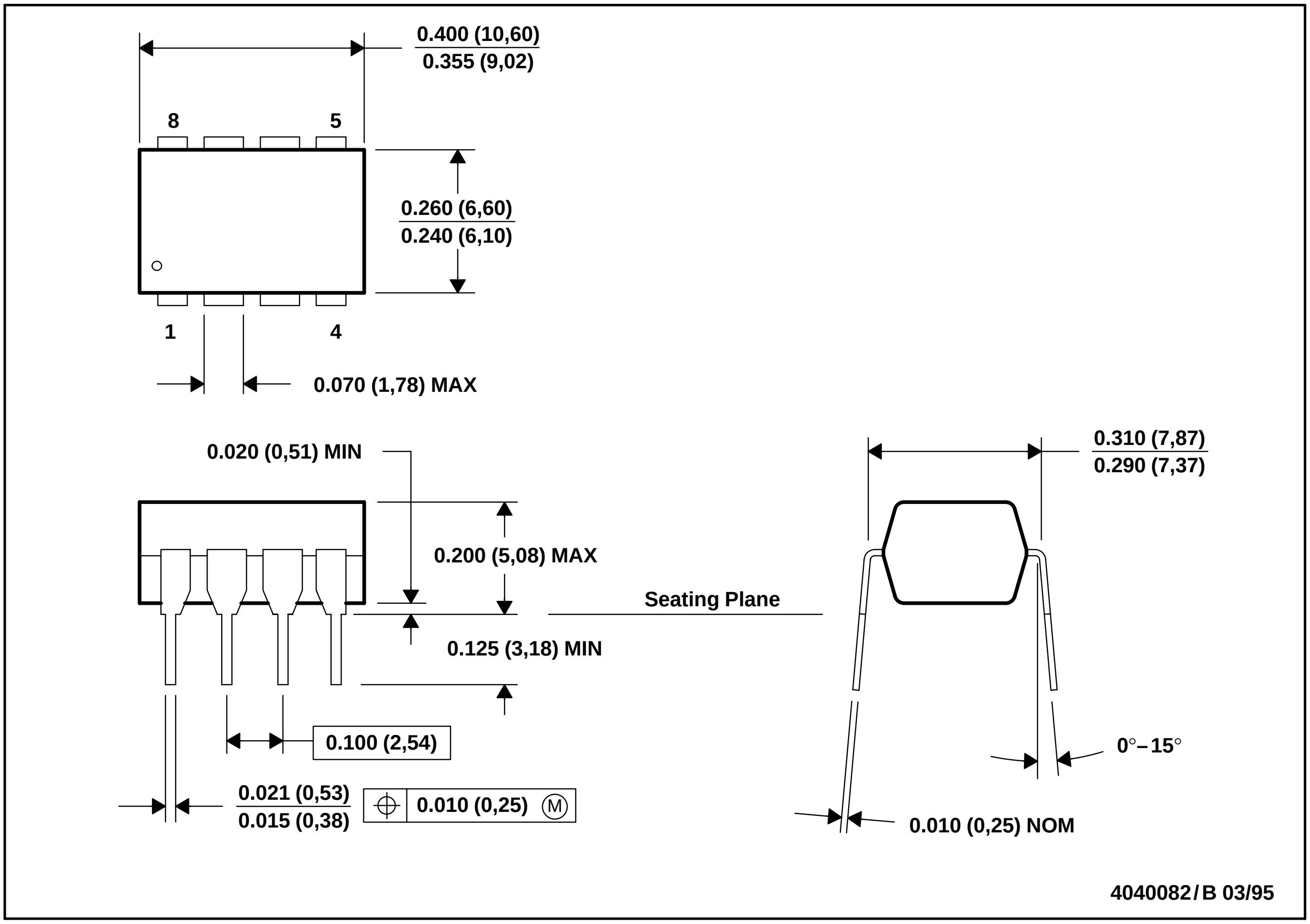
## MECHANICAL INFORMATION

**P (R-PDIP-T8)** **PLASTIC DUAL-IN-LINE PACKAGE**




NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001

## IMPORTANT NOTICE



Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265