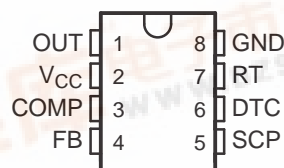


## PULSE-WIDTH-MODULATION CONTROL CIRCUITS

### FEATURES

- Qualified for Automotive Applications
- 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
- $\pm 3\%$  Tolerance on Reference Voltage
- Available in Q-Temperature Automotive
  - High-Reliability Automotive Applications
  - Configuration Control / Print Support
  - Qualification to Automotive Standards

D PACKAGE  
(TOP VIEW)



### DESCRIPTION

The TL5001A incorporates on a single monolithic chip all the functions required for a pulse-width-modulation (PWM) control circuit. Designed primarily for power-supply control, the TL5001A 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  $\pm 3\%$ .

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<sub>CC</sub> conditions, the UVLO circuit turns the output off until V<sub>CC</sub> recovers to its normal operating range.

The TL5001A is characterized for operation from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

#### AVAILABLE OPTIONS<sup>(1)</sup>

| T <sub>A</sub>                                 | PACKAGED DEVICES <sup>(2)</sup>     |
|--|-------------------------------------|
|  | SMALL OUTLINE<br>(D) <sup>(3)</sup> |
| $-40^{\circ}\text{C}$ to $125^{\circ}\text{C}$ | TL5001AQDRQ1                        |

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).
- (2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).
- (3) The D package is available taped and reeled. Add the suffix R to the device type (e.g., TL5001ADR).

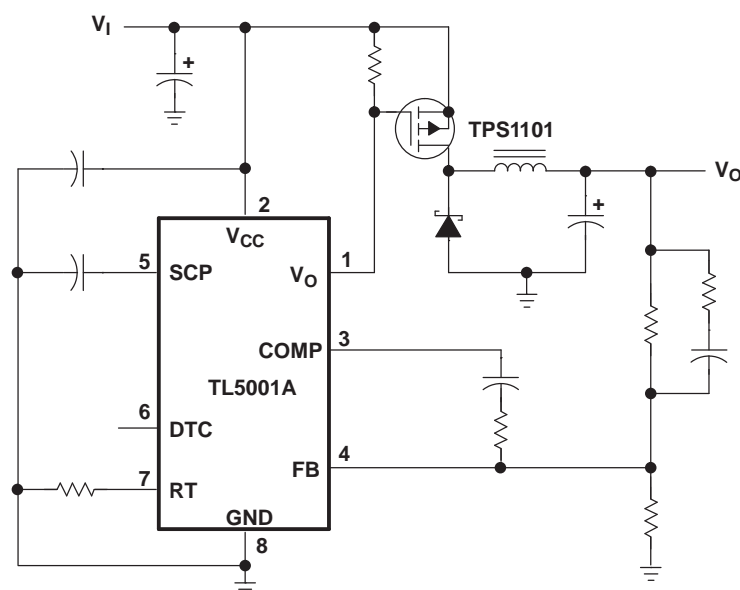
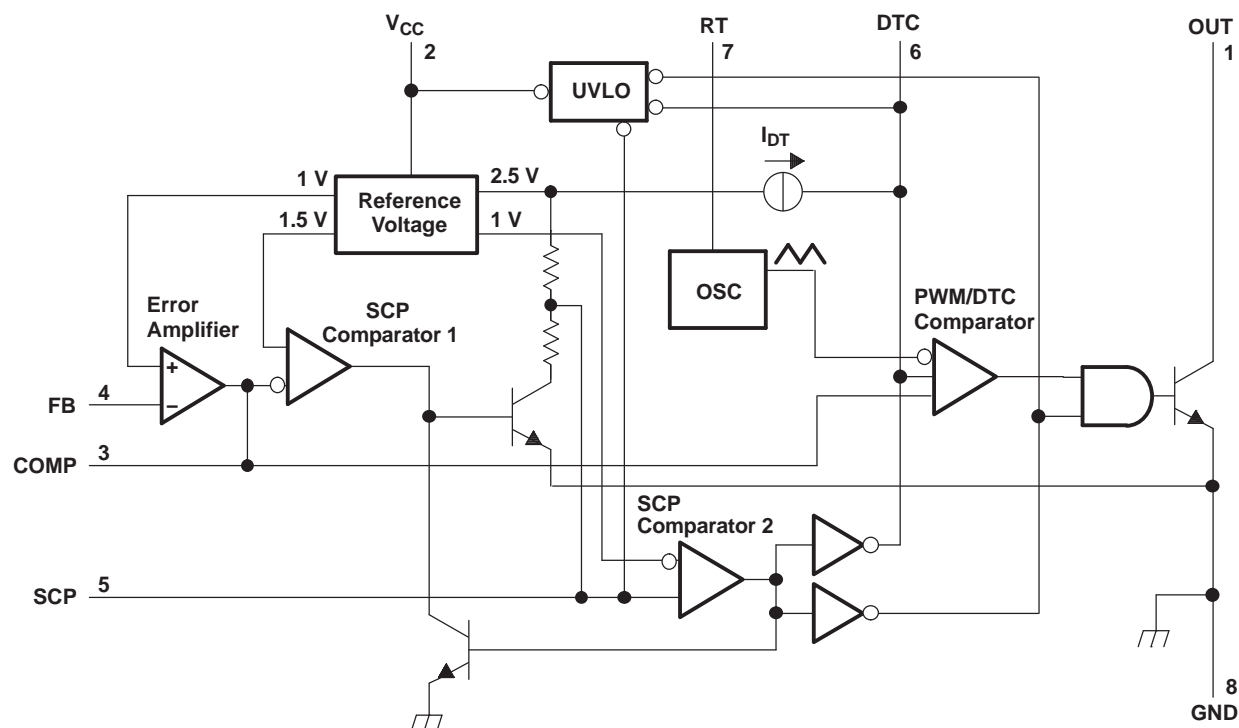


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**SCHEMATIC FOR TYPICAL APPLICATION****FUNCTIONAL BLOCK DIAGRAM**

## DETAILED DESCRIPTION

### VOLTAGE REFERENCE

A 2.5-V regulator operating from  $V_{CC}$  is used to power the internal circuitry of the 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:

$$V_O = (1 + R_1/R_2) (1 \text{ V})$$

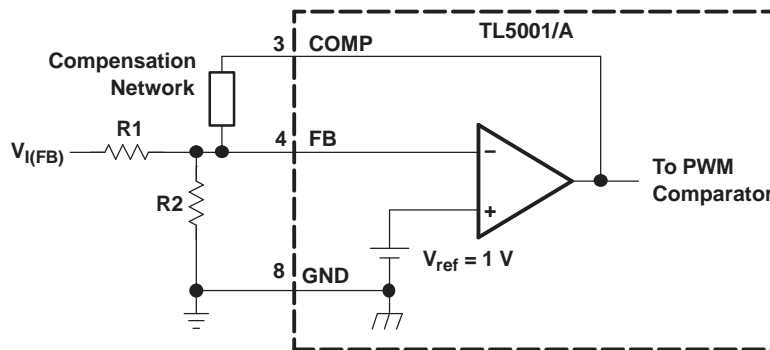


Figure 1. Error-Amplifier Gain Setting

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  $\mu$ A, the total dc-load resistance should be 100 k $\Omega$  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 k $\Omega$  to 250 k $\Omega$ . 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  $\Omega$ ), 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):

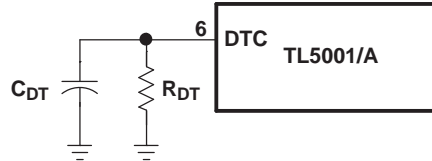
$$R_{DT} = \frac{(R_t + 1250) [D(V_{osc max} - V_{osc min}) + V_{osc min}]}{V_{RT}} ; V_{RT} = 1 \text{ V} \quad (1)$$

Where

$R_{DT}$  and  $R_t$  are in  $\Omega$ , D is 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:

$$V_{DT} \approx I_{DT} R_{DT} \left( 1 - e^{-\frac{t}{R_{DT} C_{DT}}} \right) \quad (2)$$



**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  $t_o/3$  to  $t_o/5$ . The TL5001A remains off until  $V_{DT} \approx 0.7$  V, the minimum ramp value.  $C_{DT}$  is discharged every time UVLO or SCP becomes active.

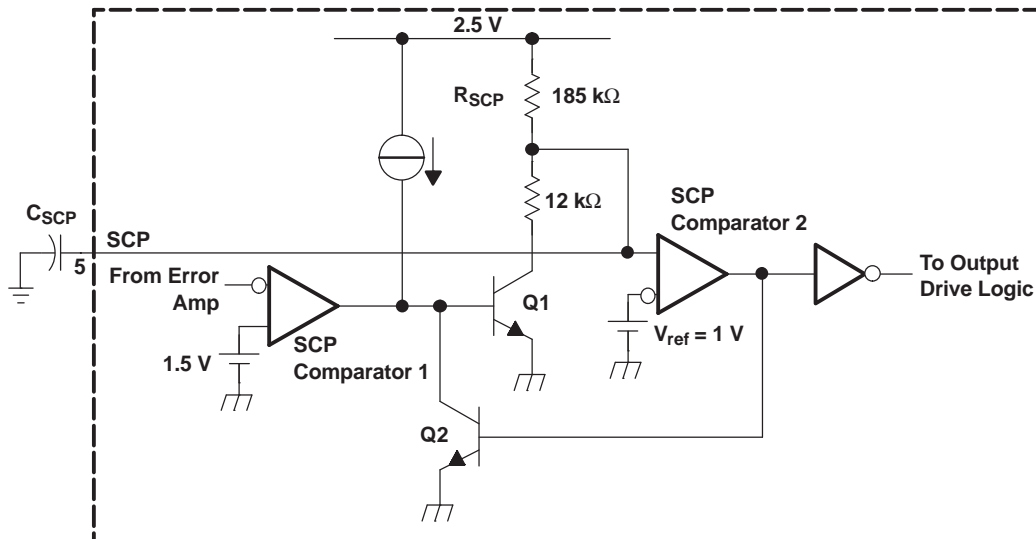
### UNDERVOLTAGE-LOCKOUT (UVLO) PROTECTION

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 TL5001A 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 TL5001A output transistor.



**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-k $\Omega$  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 [Equation 3](#):

$$V_{SCP} = (2.5 - 0.185) (1 - e^{-t/\tau}) + 0.185 \quad (3)$$

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 [Equation 4](#):

$$C_{SCP} = 12.46 \times t_{SCP} \quad (4)$$

Where

t is in seconds, C is in  $\mu$ F

$t_{SCP}$  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 TL5001A 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) <sup>(1)</sup>

|                      |  |                               |
|----------------------|--|-------------------------------|
| V <sub>CC</sub>      | Supply voltage <sup>(2)</sup>                                | 41 V                          |
| V <sub>I(FB)</sub>   | Amplifier input voltage                                      | 20 V                          |
| V <sub>O</sub>       | Output voltage, OUT  | 51 V                          |
| I <sub>O</sub>       | Output current, OUT  | 21 mA                         |
| I <sub>O(peak)</sub> | Output peak current, OUT                                     | 100 mA                        |
|                      | Continuous total power dissipation                           | See <i>Dissipation Rating</i> |
| T <sub>A</sub>       | Operating ambient temperature range, TL5001AQDRQ1            | –40°C to 125°C                |
| T <sub>stg</sub>     | Storage temperature range                                    | –65°C to 150°C                |
|                      | Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds | 260°C                         |

- (1) 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.
- (2) All voltage values are with respect to network ground terminal.

## DISSIPATION RATINGS

| PACKAGE | T <sub>A</sub> ≤ 25°C<br>POWER RATING | DERATING FACTOR<br>ABOVE T <sub>A</sub> = 25°C | T <sub>A</sub> = 70°C<br>POWER RATING | T <sub>A</sub> = 85°C<br>POWER RATING | T <sub>A</sub> = 125°C<br>POWER RATING |
|---------|---------------------------------------|--|---------------------------------------|---------------------------------------|--|
| D       | 725 mW                                | 5.8 mW/°C                                      | 464 mW                                | 377 mW                                | 145 mW                                 |

## RECOMMENDED OPERATING CONDITIONS

|                    |                               | MIN | MAX | UNIT |
|--------------------|-------------------------------|-----|-----|------|
| V <sub>CC</sub>    | Supply voltage                | 3.6 | 40  | V    |
| V <sub>I(FB)</sub> | Amplifier input voltage       | 0   | 1.5 | V    |
| V <sub>O</sub>     | Output voltage, OUT           |     | 50  | V    |
| I <sub>O</sub>     | Output current, OUT           |     | 20  | mA   |
|                    | COMP source current           |     | 45  | μA   |
|                    | COMP dc load resistance       | 100 |     | kΩ   |
| R <sub>t</sub>     | Oscillator timing resistor    | 15  | 250 | kΩ   |
| f <sub>OSC</sub>   | Oscillator frequency          | 20  | 500 | kHz  |
| T <sub>A</sub>     | Operating ambient temperature | –40 | 125 | °C   |

## ELECTRICAL CHARACTERISTICS

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

| PARAMETER                              | TEST CONDITIONS              |                           | TL5001AQ                             |                    |                                      | UNIT |
|--|------------------------------|---------------------------|--------------------------------------|--------------------|--------------------------------------|------|
|  |                              |                           | MIN                                  | TYP <sup>(1)</sup> | MAX                                  |      |
| REFERENCE                              |                              |                           |                                      |                    |                                      |      |
| Output voltage                         | T <sub>A</sub> = 25°C        | COMP connected to FB      | 0.97                                 | 1                  | 1.03                                 | V    |
|  | T <sub>A</sub> = MIN to MAX  |                           | 0.94                                 | 0.98               | 1.06                                 |      |
| Input regulation                       | T <sub>A</sub> = MIN to MAX, | VCC = 3.6 V to 40 V       |                                      | 2                  | 12.5                                 | mV   |
| Output voltage change with temperature | T <sub>A</sub> = MIN to MAX  |                           | –6% <sup>(2)</sup>                   | 2%                 | 6% <sup>(2)</sup>                    |      |
| UNDERVOLTAGE LOCKOUT                   |                              |                           |                                      |                    |                                      |      |
| Upper threshold voltage                | T <sub>A</sub> = MIN, 25°C   |                           | 3                                    |                    |                                      | V    |
|  | T <sub>A</sub> = MAX         |                           | 2.55                                 |                    |                                      |      |
| Lower threshold voltage                | T <sub>A</sub> = MIN, 25°C   |                           | 2.8                                  |                    |                                      | V    |
|  | T <sub>A</sub> = MAX         |                           | 2.0                                  |                    |                                      |      |
| Hysteresis                             | T <sub>A</sub> = MIN to MAX  |                           | 80                                   | 200                |                                      | mV   |
| Reset threshold voltage                | T <sub>A</sub> = MIN, 25°C   |                           | 2.1                                  | 2.55               |                                      | V    |
|  | T <sub>A</sub> = MAX         |                           | 0.35                                 | 0.63               |                                      |      |
| SHORT-CIRCUIT PROTECTION               |                              |                           |                                      |                    |                                      |      |
| SCP threshold voltage                  | T <sub>A</sub> = MIN, 25°C   |                           | 0.97                                 | 1                  | 1.03                                 | V    |
|  | T <sub>A</sub> = MAX         |                           | 0.94                                 | 0.98               | 1.06                                 |      |
| SCP voltage, latched                   | T <sub>A</sub> = MIN to MAX  | No pullup                 | 140                                  | 185                | 230                                  | mV   |
| SCP voltage, UVLO standby              | T <sub>A</sub> = MIN to MAX  | No pullup                 |                                      | 60                 | 120                                  | mV   |
| Equivalent timing resistance           | T <sub>A</sub> = MIN to MAX  |                           |                                      | 185                |                                      | kΩ   |
| SCP comparator 1 threshold voltage     | T <sub>A</sub> = MIN to MAX  |                           |                                      | 1.5                |                                      | V    |
| OSCILLATOR                             |                              |                           |                                      |                    |                                      |      |
| Frequency                              | T <sub>A</sub> = MIN to MAX  | R <sub>t</sub> = 100 kΩ   |                                      | 100                |                                      | kHz  |
| Standard deviation of frequency        | T <sub>A</sub> = MIN to MAX  |                           |                                      | 2                  |                                      | kHz  |
| Frequency change with voltage          | T <sub>A</sub> = MIN to MAX  | VCC = 3.6 V to 40 V       |                                      | 1                  |                                      | kHz  |
| Frequency change with temperature      | T <sub>A</sub> = MIN to MAX  | Q suffix                  | –9 <sup>(2)</sup>                    | 5                  | 9 <sup>(2)</sup>                     | kHz  |
|  |                              | M suffix                  | –9 <sup>(2)</sup>                    | 5                  | 9 <sup>(2)</sup>                     |      |
| Voltage at RT                          | T <sub>A</sub> = MIN to MAX  |                           |                                      | 1                  |                                      | V    |
| DEAD-TIME CONTROL                      |                              |                           |                                      |                    |                                      |      |
| Output (source) current                | T <sub>A</sub> = MIN to MAX  | V <sub>(DT)</sub> = 1.5 V | 0.9 × I <sub>RT</sub> <sup>(3)</sup> |                    | 1.1 × I <sub>RT</sub> <sup>(3)</sup> | μA   |
| Input threshold voltage                | T <sub>A</sub> = 25°C        | Duty cycle 0%             | 0.5                                  | 0.7                |                                      | V    |
|  |                              | Duty cycle 100%           |                                      | 1.3                | 1.5                                  |      |
|  | T <sub>A</sub> = MIN to MAX  | Duty cycle 0%             | 0.4                                  | 0.7                |                                      |      |
|  |                              | Duty cycle 100%           |                                      | 1.3                | 1.7                                  |      |

(1) All typical values are at  $T_A = 25^\circ\text{C}$ .

(2) Not production tested.

(3) Output source current at RT

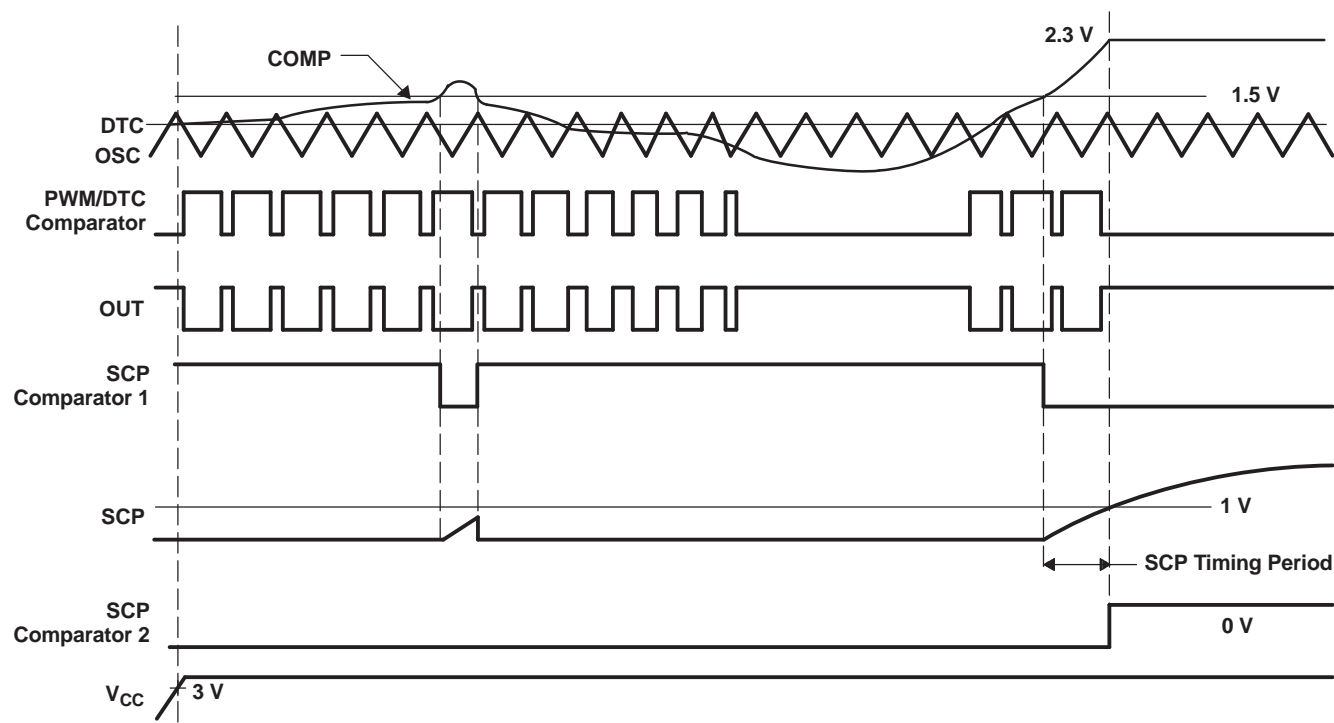
**ELECTRICAL CHARACTERISTICS**over recommended operating free-air temperature range,  $V_{CC} = 6\text{ V}$ ,  $f_{osc} = 100\text{ kHz}$  (unless otherwise noted)

| PARAMETER                       |           | TEST CONDITIONS             |  | TL5001AQ |                    |     | UNIT |
|---------------------------------|-----------|-----------------------------|--|----------|--------------------|-----|------|
|                                 |           |                             |  | MIN      | TYP <sup>(1)</sup> | MAX |      |
| ERROR AMPLIFIER                 |           |                             |  |          |                    |     |      |
| Input bias current              |           | T <sub>A</sub> = MIN to MAX |  | –160     | –500               | nA  |      |
| Output voltage swing            | Positive  | T <sub>A</sub> = MIN to MAX |  | 1.5      | 2.3                | V   |      |
|                                 | Negative  |                             |  | 0.3      | 0.4                | V   |      |
| Open-loop voltage amplification |           | T <sub>A</sub> = MIN to MAX |  | 80       |                    | dB  |      |
| Unity gain bandwidth            |           | T <sub>A</sub> = MIN to MAX |  | 1.5      |                    | MHz |      |
| Output (sink) current           |           | T <sub>A</sub> = MIN to MAX | V <sub>I(FB)</sub> = 1.2 V, COMP = 1 V     | 100      | 600                | μA  |      |
| Output (source) current         |           | T <sub>A</sub> = MIN, 25°C  | V <sub>I(FB)</sub> = 0 V, COMP = 1 V       | –45      | –70                | μA  |      |
|                                 |           | T <sub>A</sub> = MAX        |  | –30      | –45                |     |      |
| OUTPUT                          |           |                             |  |          |                    |     |      |
| Output saturation voltage       |           | T <sub>A</sub> = MIN to MAX | I <sub>O</sub> = 10 mA                     | 1.5      | 2                  | V   |      |
| Off-state current               |           | T <sub>A</sub> = MIN to MAX | V <sub>O</sub> = 50 V, V <sub>CC</sub> = 0 |          | 10                 | μA  |      |
|                                 |           |                             | V <sub>O</sub> = 50 V                      |          | 10                 |     |      |
| Short-circuit output current    |           | T <sub>A</sub> = MIN to MAX | V <sub>O</sub> = 6 V                       | 40       |                    | mA  |      |
| TOTAL DEVICE                    |           |                             |  |          |                    |     |      |
| Standby supply current          | Off state | T <sub>A</sub> = MIN to MAX |  | 1        | 1.5                | mA  |      |
| Average supply current          |           | T <sub>A</sub> = MIN to MAX | R <sub>L</sub> = 100 kΩ                    | 1.4      | 2.1                | mA  |      |

(1) All typical values are at  $T_A = 25^\circ\text{C}$ .



## PARAMETER MEASUREMENT INFORMATION



- 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

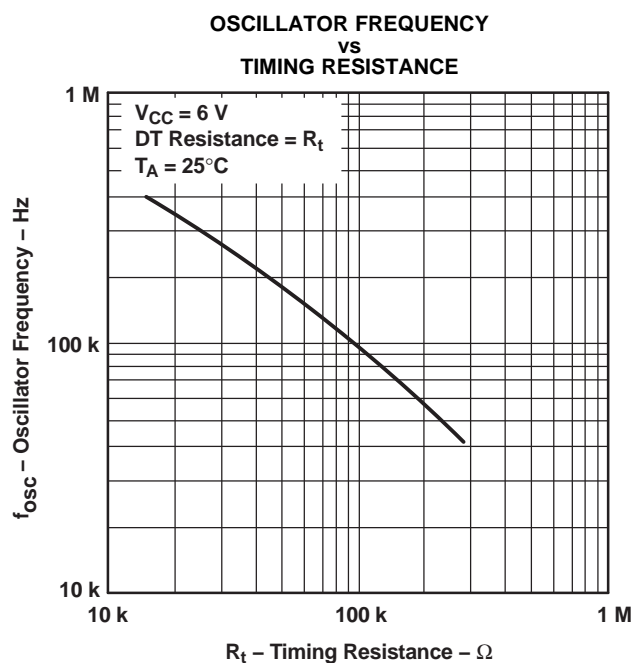


Figure 5.

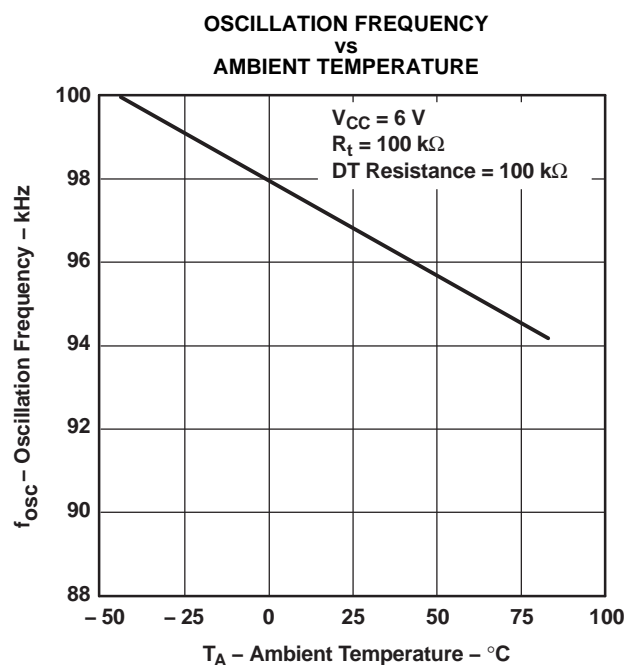


Figure 6.

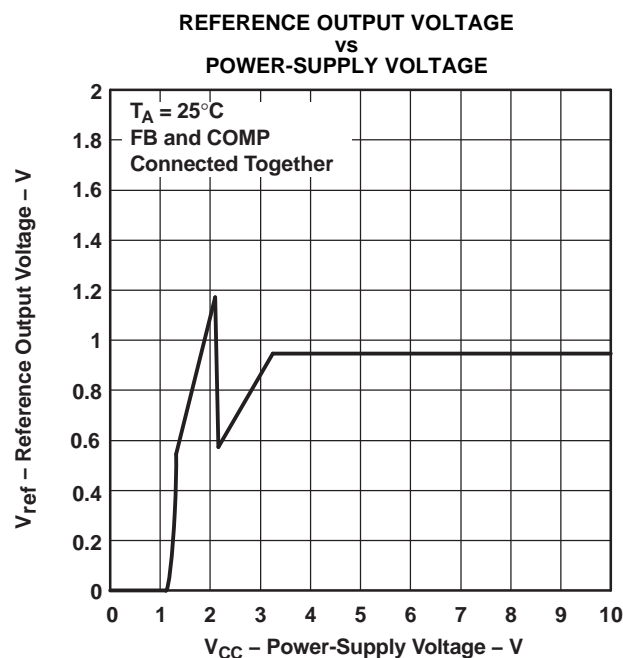


Figure 7.

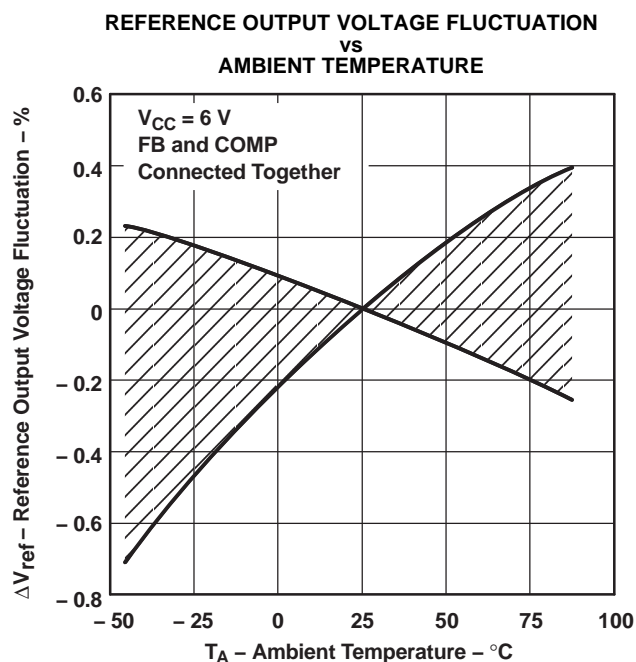


Figure 8.

## TYPICAL CHARACTERISTICS (continued)

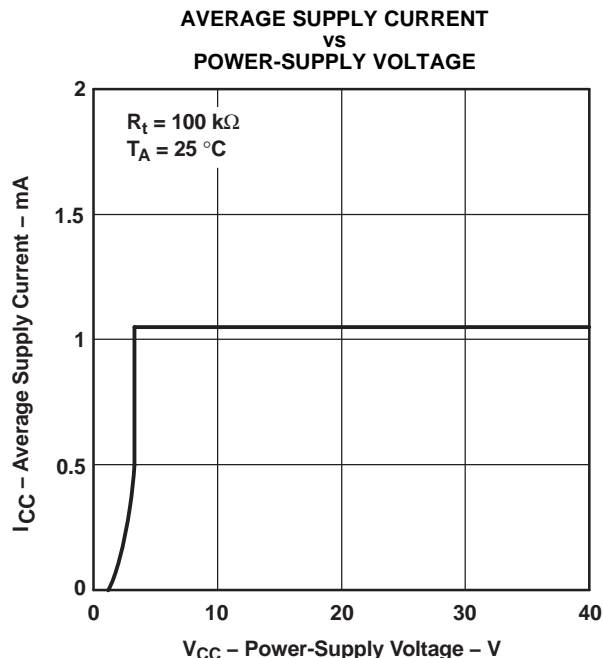


Figure 9.

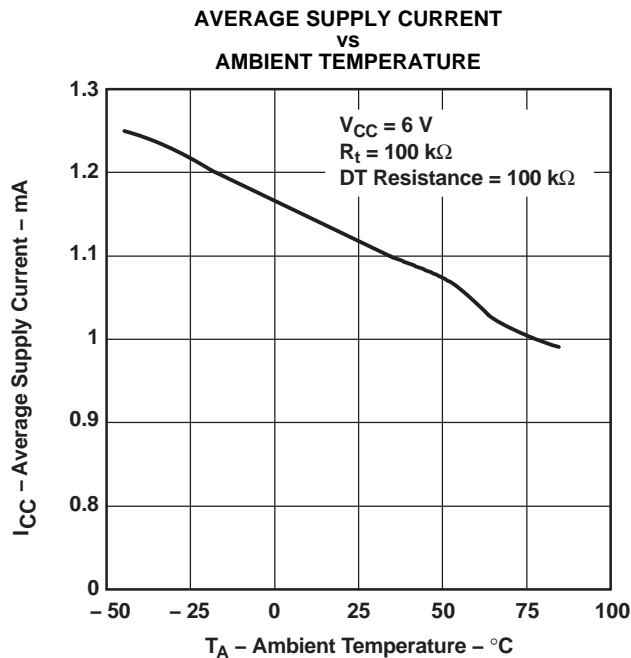


Figure 10.

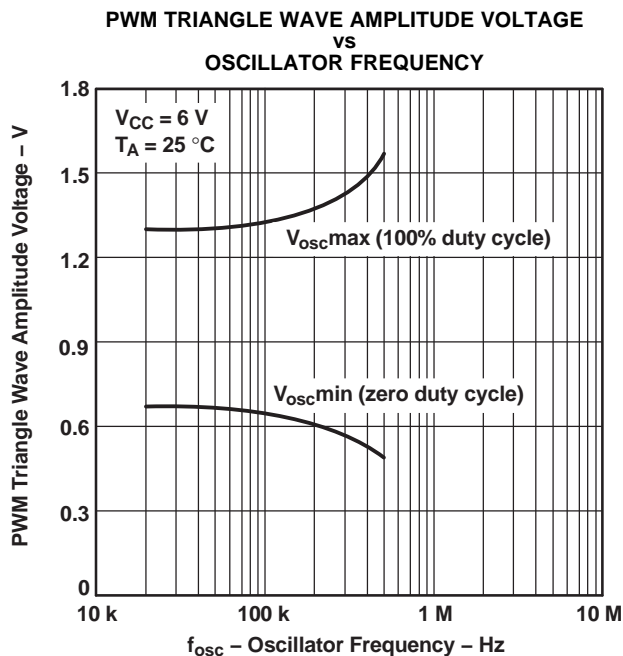


Figure 11.

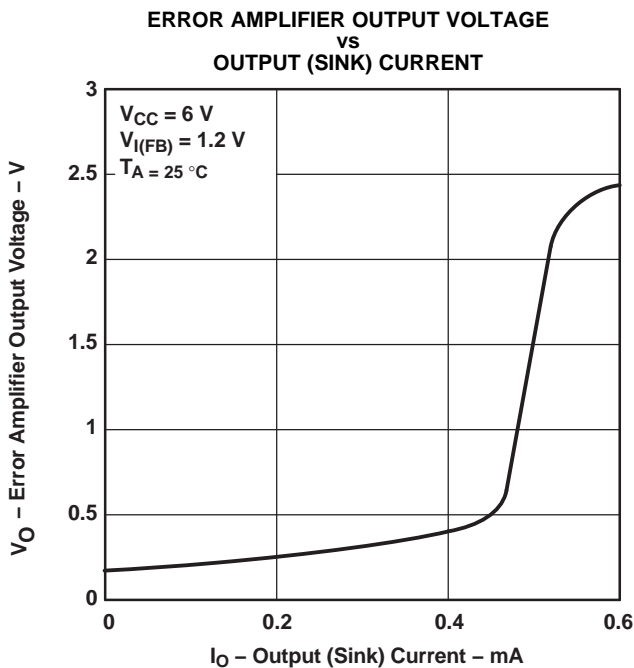


Figure 12.

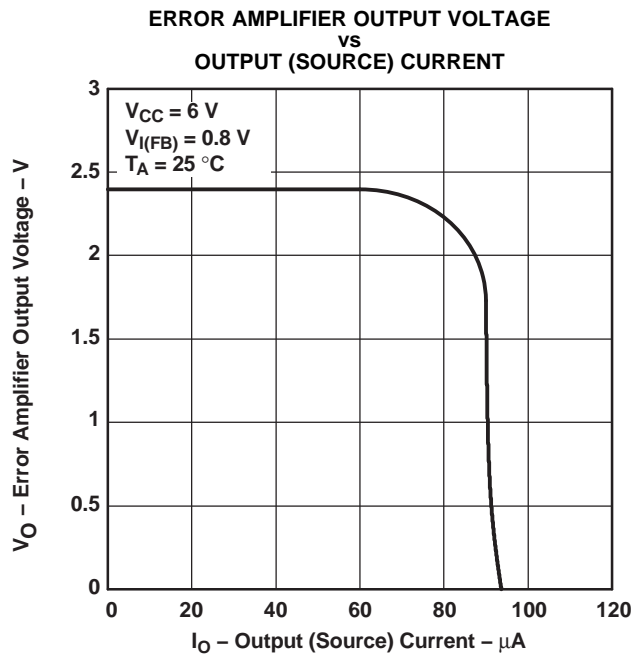
**TYPICAL CHARACTERISTICS (continued)**

Figure 13.

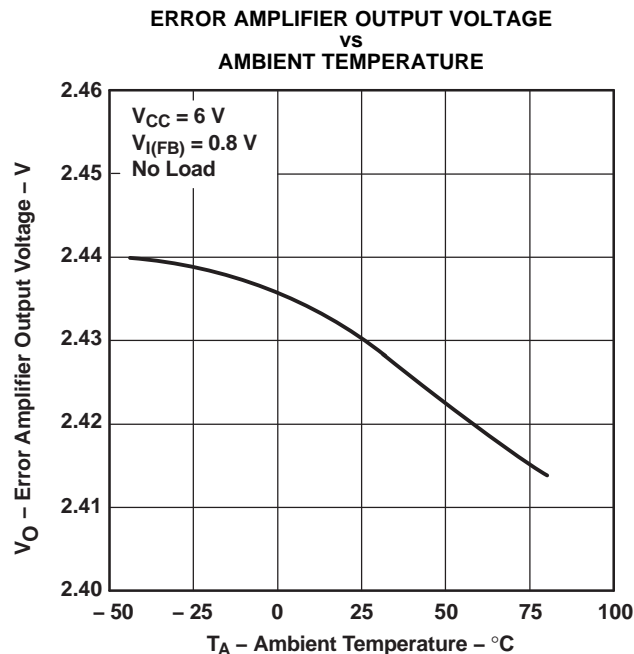


Figure 14.

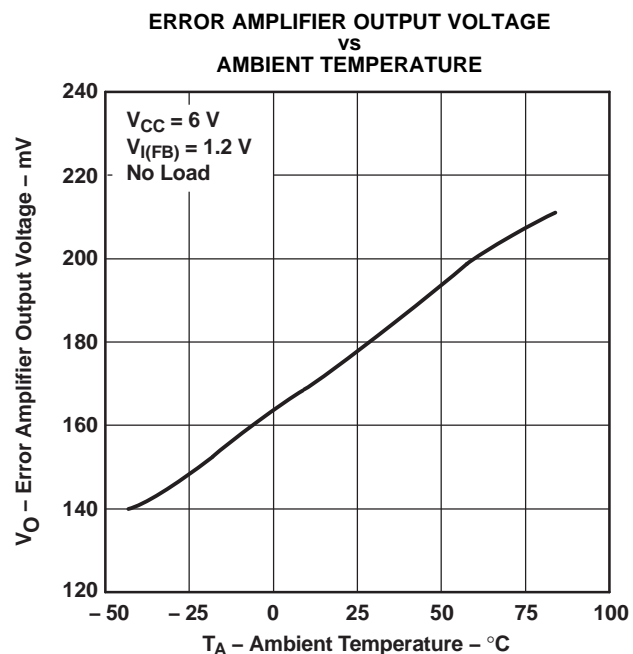


Figure 15.

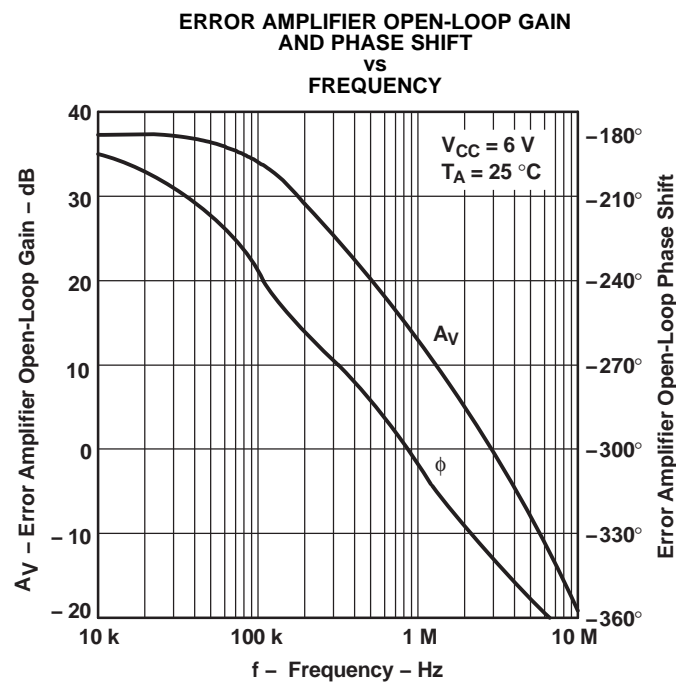


Figure 16.

## TYPICAL CHARACTERISTICS (continued)

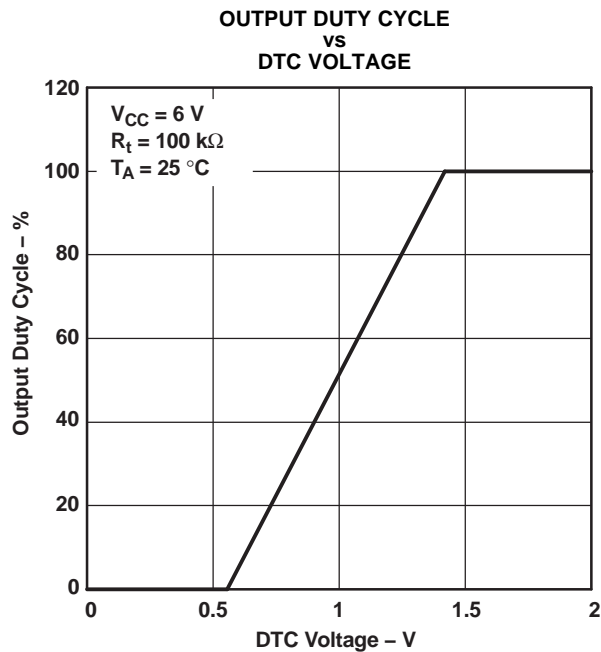


Figure 17.

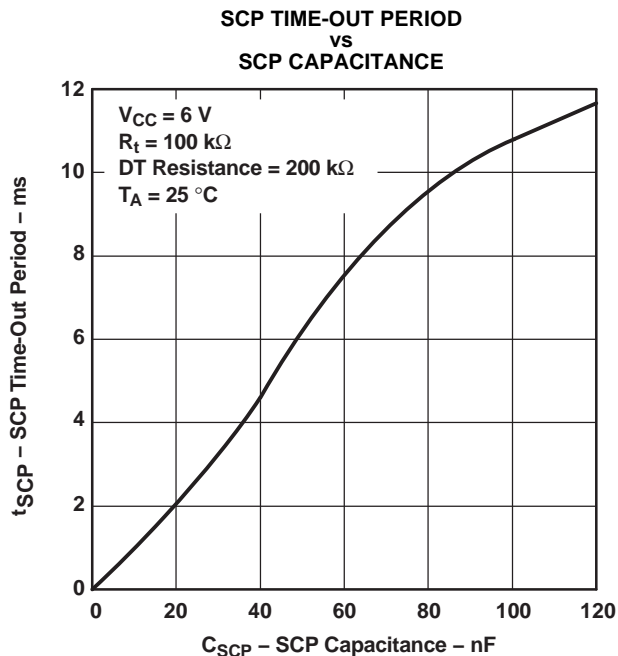


Figure 18.

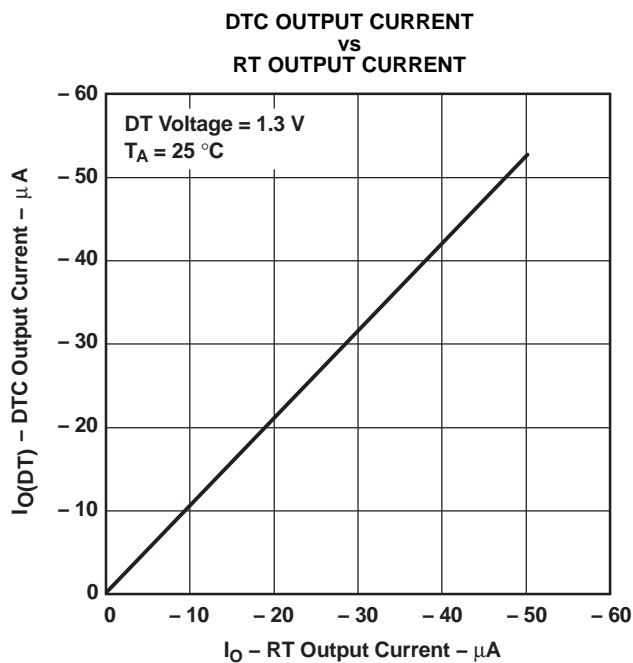


Figure 19.

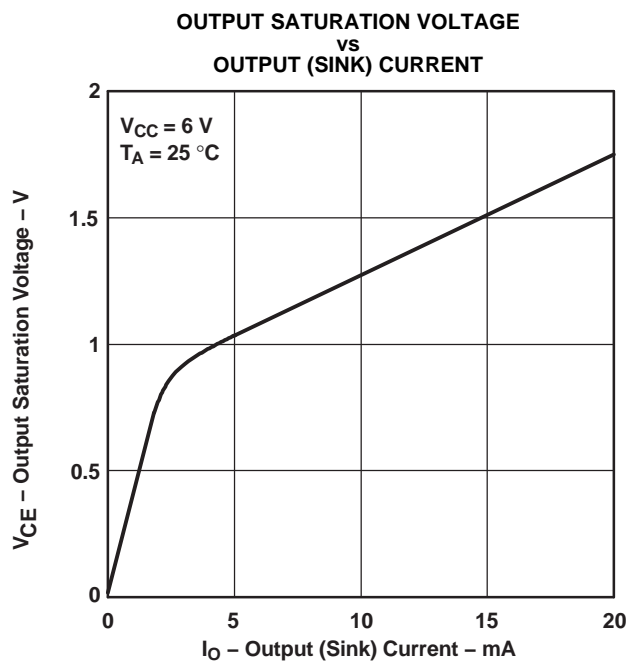
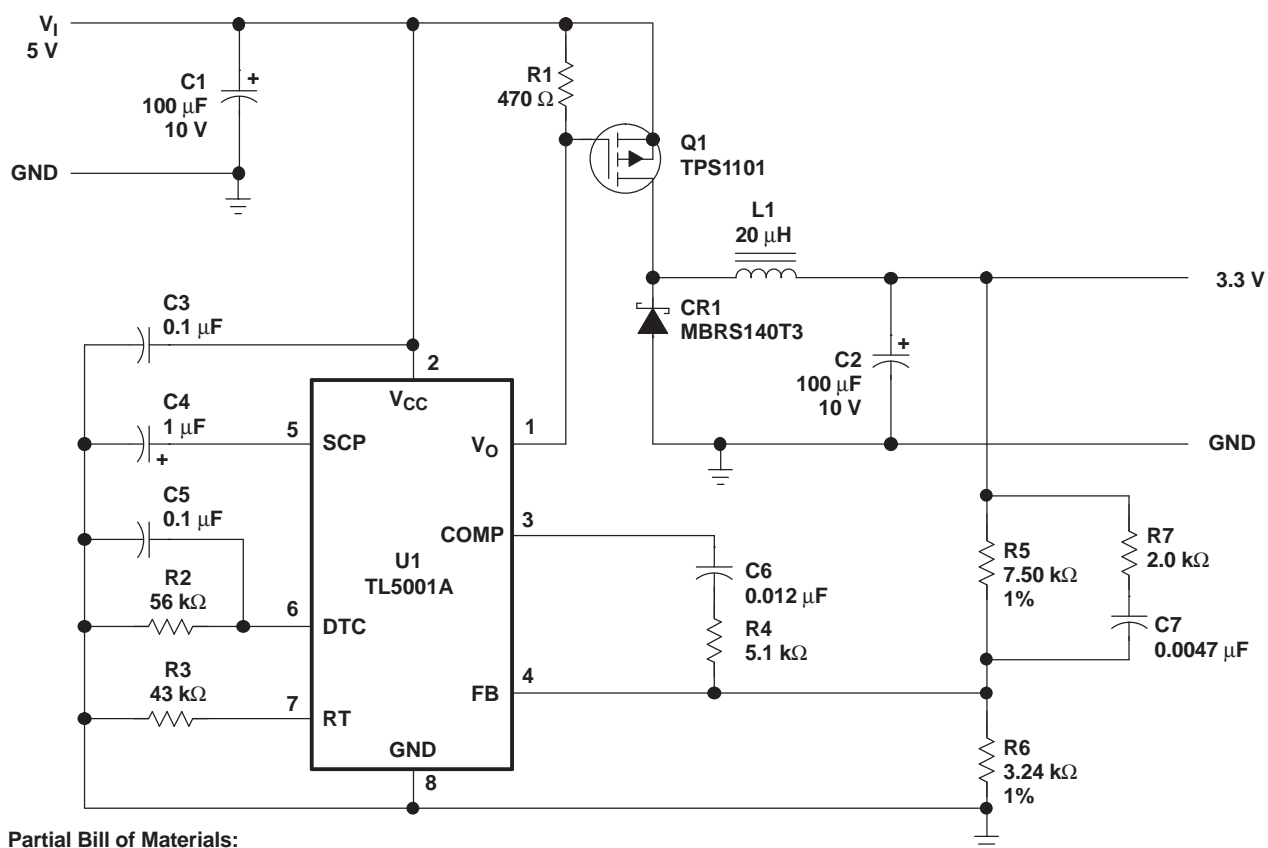


Figure 20.

**APPLICATION INFORMATION****Partial Bill of Materials:**

|     |   |                   |
|-----|---|-------------------|
| U1  | TL5001A   | 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          |

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

**Figure 21. Step Down Converter**

## 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> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TL5001AQDRG4Q1   | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TL5001AQDRQ1     | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |

<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.

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### OTHER QUALIFIED VERSIONS OF TL5001A-Q1 :

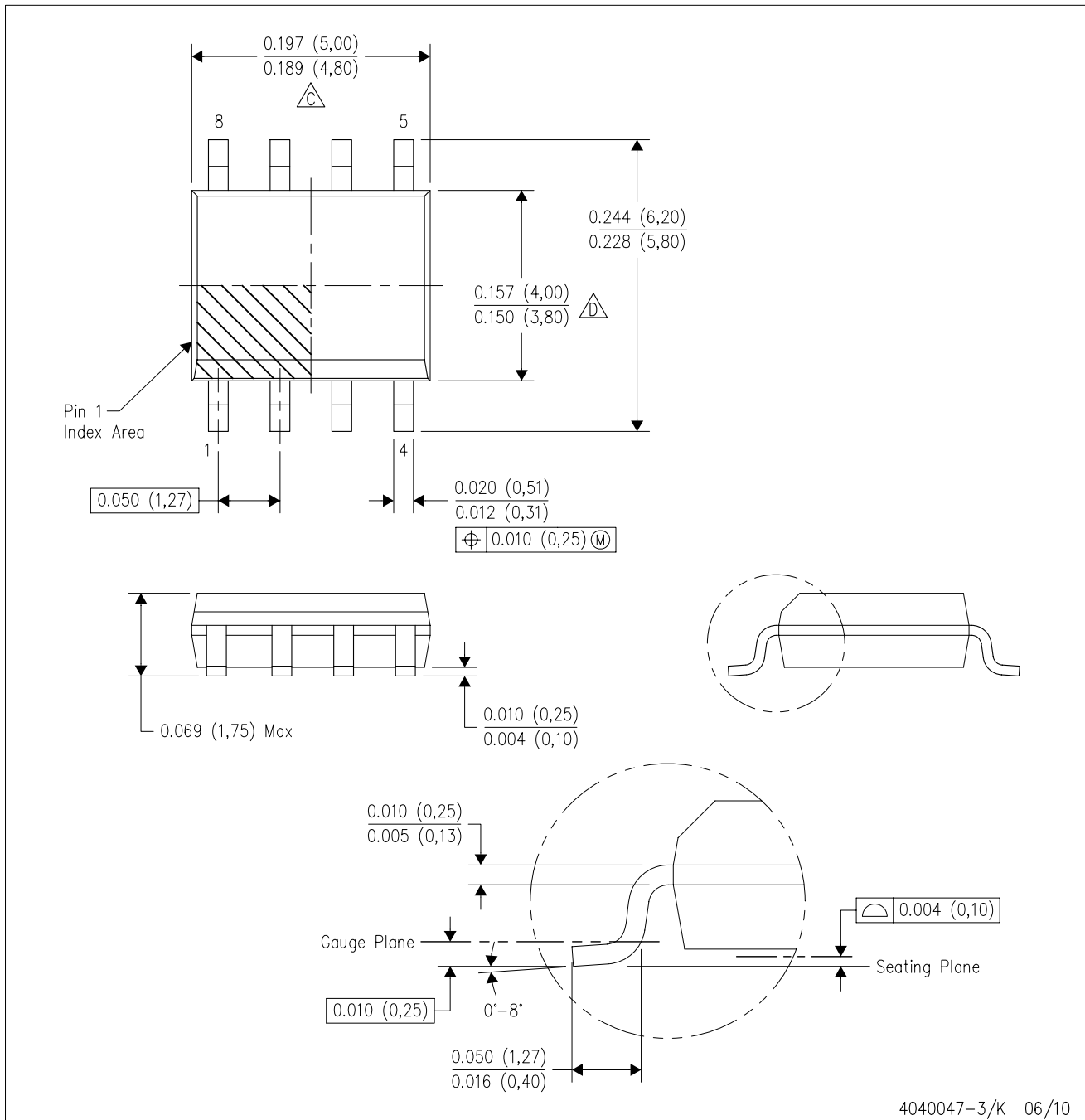
- Catalog: [TL5001A](#)
- Military: [TL5001AM](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

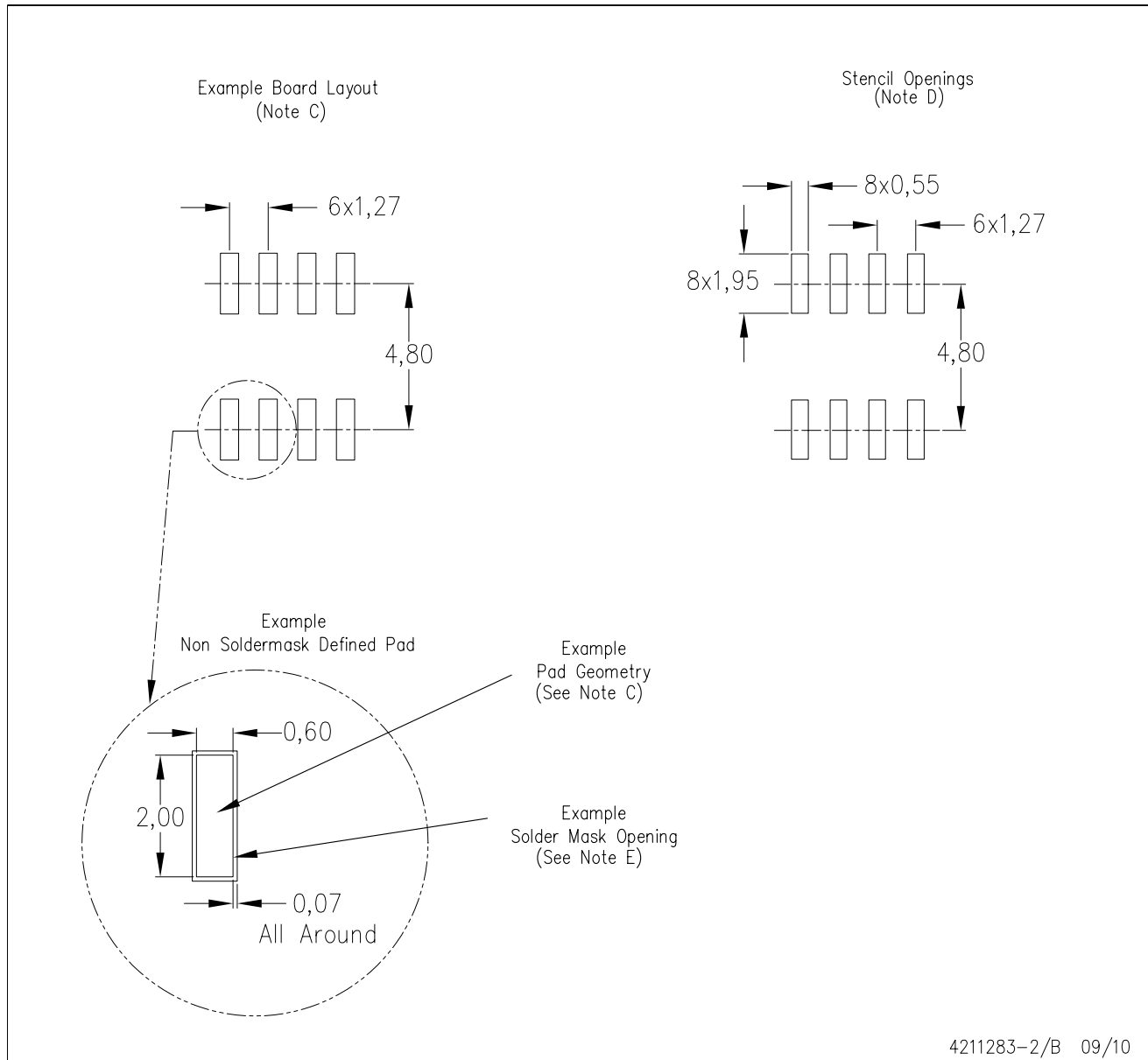


- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - (C) Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
  - (D) Body width does not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



D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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