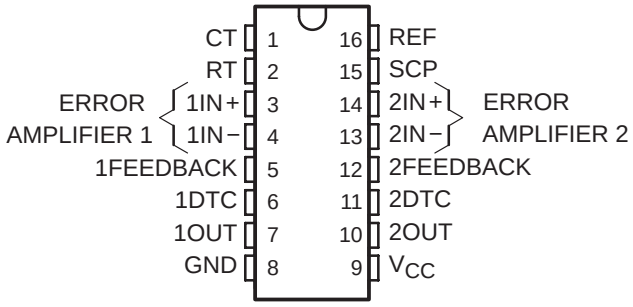
- **Qualification in Accordance With AEC-Q100(1)**
- **Qualified for Automotive Applications**
- **Customer-Specific Configuration Control Can Be Supported Along With Major-Change Approval**
- **Complete PWM Power Control Circuitry**
- **Completely Synchronized Operation**
- **Internal Undervoltage Lockout Protection**
- **Wide Supply Voltage Range**
- **Internal Short-Circuit Protection**
- **Oscillator Frequency . . . 500 kHz Max**
- **Variable Dead Time Provides Control Over Total Range**
- **Internal Regulator Provides a Stable 2.5-V Reference Supply**
- **Available in Q-Temp Automotive HighRel Automotive Applications Configuration Control / Print Support Qualification to Automotive Standards**

NOTE 1: Contact Texas Instruments for details. Q100 qualification data available on request.

**PW PACKAGE**
**(TOP VIEW)**




## description

The TL1451A incorporates on a single monolithic chip all the functions required in the construction of two pulse-width-modulation (PWM) control circuits. Designed primarily for power-supply control, the TL1451A contains an on-chip 2.5-V regulator, two error amplifiers, an adjustable oscillator, two dead-time comparators, undervoltage lockout circuitry, and dual common-emitter output transistor circuits.

The uncommitted output transistors provide common-emitter output capability for each controller. The internal amplifiers exhibit a common-mode voltage range from 1.04 V to 1.45 V. The dead-time control (DTC) comparator has no offset unless externally altered and can provide 0% to 100% dead time. The on-chip oscillator can be operated by terminating RT and CT. During low $V_{CC}$ conditions, the undervoltage lockout control circuit feature locks the outputs off until the internal circuitry is operational.

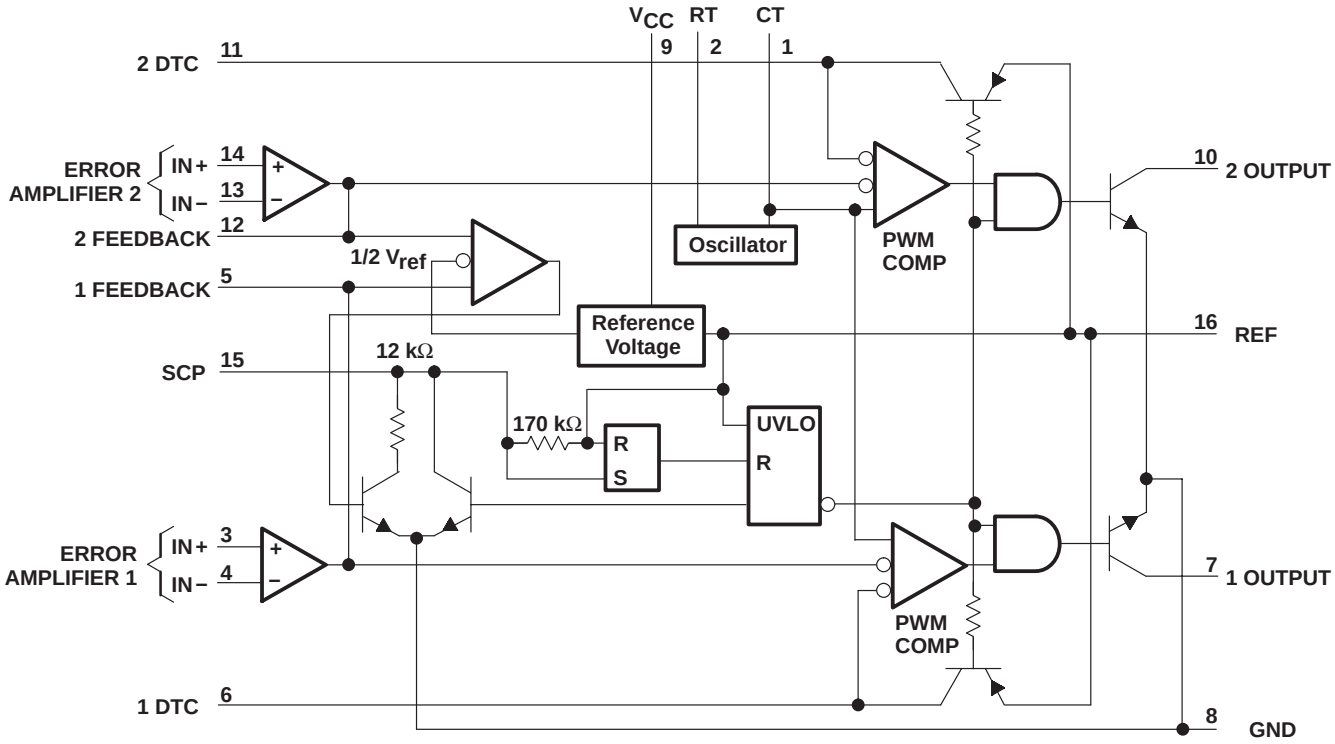
The TL1451AQ–Q1 is characterized for operation from −40°C to 125°C.

**AVAILABLE OPTIONS**

| $T_A$ | PACKAGED DEVICES |
|---|---|
| | TSSOP (PW)† |
| −40°C to 125°C | TL1451AQPWRQ1 |

† The PW package is only available left-end taped and reeled.

## functional block diagram




**COMPONENT COUNT**

| | |
|---|---|
| Resistors | 65 |
| Capacitors | 8 |
| Transistors | 105 |
| JFETs | 18 |

## absolute maximum ratings over operating free-air temperature range†

Supply voltage, $V_{CC}$ . . . . . 51 V
Amplifier input voltage, $V_I$ . . . . . 20 V
Collector output voltage, $V_O$ . . . . . 51 V
Collector output current, $I_O$ . . . . . 21 mA
Continuous power total dissipation . . . . . See Dissipation Rating Table
Operating free-air temperature range, $T_A$ . . . . . −40°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.

**DISSIPATION RATING TABLE**

| PACKAGE | $T_A \le 25°C$ 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 |
|---|---|---|---|---|---|
| PW | 838 mW | 6.7 mW/°C | 536 mW | 436 mW | 168 mW |

## recommended operating conditions

| | MIN | MAX | UNIT |
|---|---|---|---|
| Supply voltage, $V_{CC}$ | 3.6 | 50 | V |
| Amplifier input voltage, $V_I$ | 1.05 | 1.45 | V |
| Collector output voltage, $V_O$ | | 50 | V |
| Collector output current, $I_O$ | | 20 | mA |
| Current into feedback terminal | | 45 | μA |
| Feedback resistor, $R_F$ | 100 | | kΩ |
| Timing capacitor, $C_T$ | 150 | 15000 | pF |
| Timing resistor, $R_T$ | 5.1 | 100 | kΩ |
| Oscillator frequency | 1 | 500 | kHz |
| Operating free-air temperature, $T_A$ | −40 | 125 | °C |

## electrical characteristics over recommended operating free-air temperature range, $V_{CC}$ = 6 V, f = 200 kHz (unless otherwise noted)

### reference section

| PARAMETER | TEST CONDITIONS | | TL1451AQ | | | UNIT |
|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | |
| Output voltage (pin 16) | $I_O$ = 1 mA | $T_A$ = 25°C | 2.4 | 2.5 | 2.6 | V |
| | | $T_A$ = MIN and 125°C | 2.35 | 2.46 | 2.65 | |
| Output voltage change with temperature | | | | −0.63% | ±4%‡ | |
| Input voltage regulation | $V_{CC}$ = 3.6 V to 40 V | $T_A$ = 25°C | | 2.0 | 12.5 | mV |
| | | $T_A$ = 125°C | | 0.7 | 15 | |
| | | $T_A$ = MIN | | 0.3 | 30 | |
| Output voltage regulation | $I_O$ = 0.1 mA to 1 mA | $T_A$ = 25°C | | 1 | 7.5 | mV |
| | | $T_A$ = 125°C | | 0.3 | 14 | |
| | | $T_A$ = MIN | | 0.3 | 20 | |
| Short-circuit output current | $V_O$ = 0 | | 3 | 10 | 30 | mA |

† All typical values are at $T_A$ = 25°C unless otherwise indicated.
‡ These parameters are not production tested.

### undervoltage lockout section

| PARAMETER | TEST CONDITIONS | | TL1451AQ | | | UNIT |
|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | |
| Upper threshold voltage ($V_{CC}$) | | $T_A$ = 25°C | | 2.72 | | V |
| | | $T_A$ = 125°C | | 1.7 | | |
| | | $T_A$ = MIN | | 3.15 | | |
| Lower threshold voltage ($V_{CC}$) | | $T_A$ = 25°C | | 2.6 | | V |
| | | $T_A$ = 125°C | | 1.65 | | |
| | | $T_A$ = MIN | | 3.09 | | |
| Hysteresis ($V_{CC}$) | | $T_A$ = 25°C | 80 | 120 | | mV |
| | | $T_A$ = 125°C | 10 | 50 | | |
| | | $T_A$ = MIN | 10 | 60 | | |
| Reset threshold voltage ($V_{CC}$) | | $T_A$ = 25°C | 1.5 | | | V |
| | | $T_A$ = 125°C | 0.95 | | | |
| | | $T_A$ = MIN | 1.5 | | | |

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

### short-circuit protection control section

| PARAMETER | TEST CONDITIONS | TL1451AQ | | | UNIT |
|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | |
| Input threshold voltage (SCP) | $T_A$ = 25°C | 650 | 700 | 750 | mV |
| | $T_A$ = 125°C | 400 | 478 | 650 | |
| | $T_A$ = MIN | 800 | 880 | 950 | |
| Standby voltage (SCP) | | 140 | 185 | 230 | mV |
| Latched input voltage (SCP) | $T_A$ = 25°C | | 60 | 120 | mV |
| | $T_A$ = 125°C | | 70 | 120 | |
| | $T_A$ = MIN | | 60 | 120 | |
| Equivalent timing resistance | | | 170 | | kΩ |
| Comparator threshold voltage (FEEDBACK) | | | 1.18 | | V |

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

### oscillator section

| PARAMETER | TEST CONDITIONS | | TL1451AQ | | | UNIT |
|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | |
| Frequency | $C_T$ = 330 pF, $R_T$ = 10 kΩ | $T_A$ = 25°C | | 200 | | kHz |
| | | $T_A$ = 125°C | | 195 | | |
| | | $T_A$ = MIN | | 193 | | |
| Standard deviation of frequency | $C_T$ = 330 pF, | $R_T$ = 10 kΩ | | 2% | | |
| Frequency change with voltage | $V_{CC}$ = 3.6 V to 40 V | $T_A$ = 25°C | | 1% | | |
| | | $T_A$ = 125°C | | 1% | | |
| | | $T_A$ = MIN | | 3% | | |
| Frequency change with temperature | | | | 1.37% | ±10%‡ | |

† All typical values are at $T_A$ = 25°C unless otherwise indicated.
‡ These parameters are not production tested.

### dead-time control section

| PARAMETER | TEST CONDITIONS | TL1451AQ | | | UNIT |
|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | |
| Input bias current (DTC) | $T_A$ = 25°C | | | 1 | μA |
| | $T_A$ = MIN and 125°C | | | 3 | |
| Latch mode (source) current (DTC) | | −80 | −145 | | μA |
| Latched input voltage (DTC) | $T_A$ = 25°C | 2.3 | | | V |
| | $T_A$ = 125°C | 2.22 | 2.32 | | |
| | $T_A$ = MIN | 2.28 | 2.4 | | |
| Input threshold voltage at f = 10 kHz (DTC) | Zero duty cycle | | 2.05 | 2.25‡ | V |
| | Maximum duty cycle | 1.2‡ | 1.45 | | |

† All typical values are at $T_A$ = 25°C unless otherwise indicated.
‡ These parameters are not production tested.

### error-amplifier section

| PARAMETER | TEST CONDITIONS | | TL1451AQ | | | UNIT |
|---|---|---|---|---|---|---|
| | | | MIN | TYP† | MAX | |
| Input offset voltage | $V_O$ (FEEDBACK) = 1.25 V | $T_A$ = 25°C | | | ±7 | mV |
| | | $T_A$ = 125°C | | | ±10 | |
| | | $T_A$ = MIN | | | ±12 | |
| Input offset current | $V_O$ (FEEDBACK) = 1.25 V | $T_A$ = 25°C | | | ±100 | nA |
| | | $T_A$ = 125°C | | | ±100 | |
| | | $T_A$ = MIN | | | ±200 | |
| Input bias current | $V_O$ (FEEDBACK) = 1.25 V | $T_A$ = 25°C | | 160 | 500 | nA |
| | | $T_A$ = 125°C | | 100 | 500 | |
| | | $T_A$ = MIN | | 142 | 700 | |
| Common-mode input voltage range | $V_{CC}$ = 3.6 V to 40 V | | 1.05 to 1.45 | | | V |
| Open-loop voltage amplification | $R_F$ = 200 kΩ | $T_A$ = 25°C | 70 | 80 | | dB |
| | | $T_A$ = 125°C | 70 | 80 | | |
| | | $T_A$ = MIN | 64 | 80 | | |
| Unity-gain bandwidth | | | | 1.5 | | MHz |
| Common-mode rejection ratio | | | 60 | 80 | | dB |
| Positive output voltage swing | | | 2 | | | V |
| Negative output voltage swing | | | | | 1 | V |
| Output (sink) current (FEEDBACK) | $V_{ID}$ = −0.1 V, $V_O$ = 1.25 V | $T_A$ = 25°C | 0.5 | 1.6 | | mA |
| | | $T_A$ = 125°C | 0.4 | 1.8 | | |
| | | $T_A$ = MIN | 0.3 | 1.7 | | |
| Output (source) current (FEEDBACK) | $V_{ID}$ = 0.1 V, $V_O$ = 1.25 V | $T_A$ = 25°C | −45 | −70 | | µA |
| | | $T_A$ = 125°C | −25 | −50 | | |
| | | $T_A$ = MIN | −15 | −70 | | |

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

### output section

| PARAMETER | TEST CONDITIONS | TL1451AQ | | | UNIT |
|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | |
| Collector off-state current | $V_O$ = 50 V | | | 10 | µA |
| Output saturation voltage | $T_A$ = 25°C | | 1.2 | 2 | V |
| | $T_A$ = 125°C | | 1.6 | 2.4 | |
| | $T_A$ = MIN | | 1.36 | 2.2 | |
| Short-circuit output current | $V_O$ = 6 V | | 90 | | mA |

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

### pwm comparator section

| PARAMETER | TEST CONDITIONS | TL1451AQ | | | UNIT |
|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | |
| Input threshold voltage at f = 10 kHz (FEEDBACK) | Zero duty cycle | | 2.05 | 2.25‡ | V |
| | Maximum duty cycle | 1.2‡ | 1.45 | | |

† All typical values are at $T_A$ = 25°C unless otherwise indicated.
‡ These parameters are not production tested.

### total device

| PARAMETER | TEST CONDITIONS | TL1451AQ | | | UNIT |
|---|---|---|---|---|---|
| | | MIN | TYP† | MAX | |
| Standby supply current | Off-state | | 1.3 | 1.8 | mA |
| Average supply current | $R_T$ = 10 kΩ | | 1.7 | 2.4 | mA |

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

## PARAMETER MEASUREMENT INFORMATION

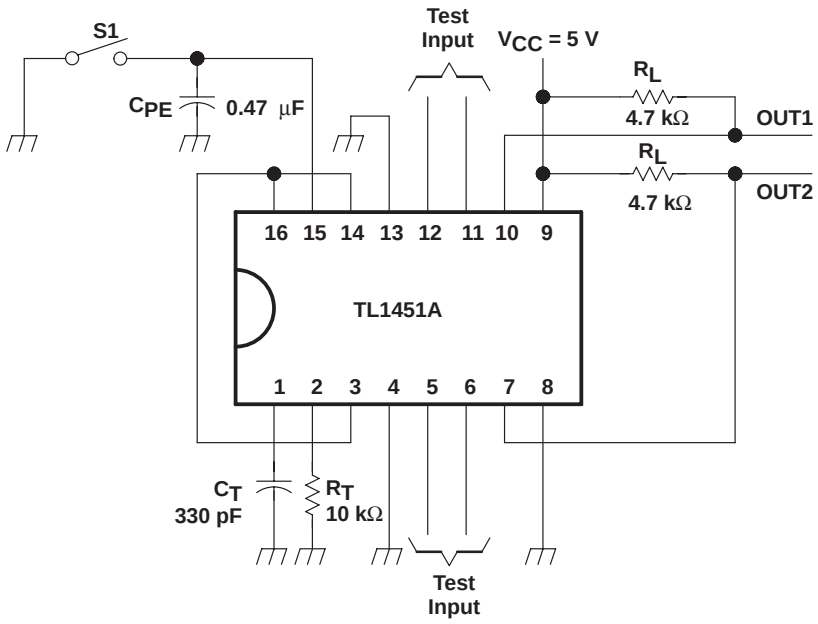
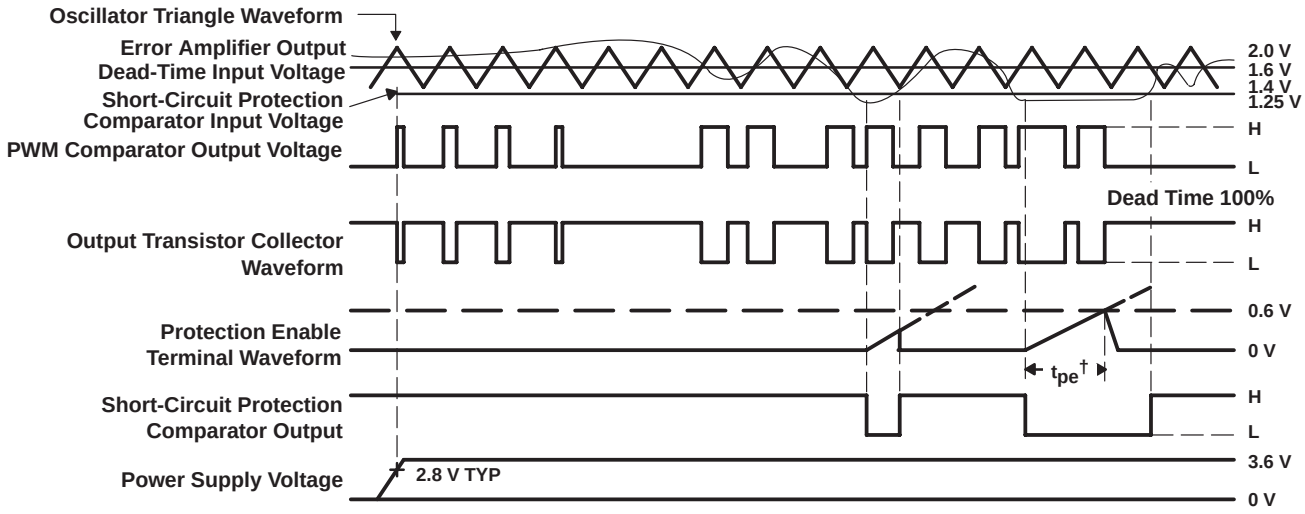



**Figure 1. Test Circuit**




† Protection Enable Time, $t_{pe} = (0.051 \times 10^6 \times C_{pe})$ in seconds

**Figure 2. TL1451A Timing Diagram**

## TYPICAL CHARACTERISTICS

**TRIANGLE OSCILLATOR FREQUENCY vs TIMING RESISTANCE**

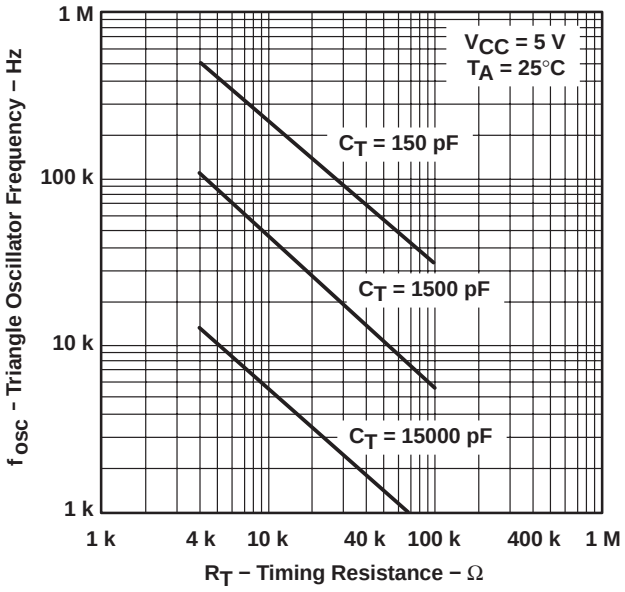



**Figure 3**

**OSCILLATOR FREQUENCY VARIATION vs FREE-AIR TEMPERATURE**

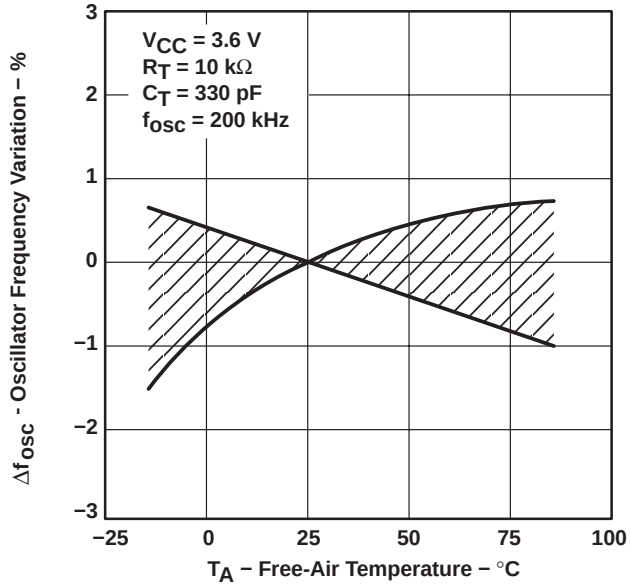



**Figure 4**

**TRIANGLE WAVEFORM SWING VOLTAGE vs TIMING CAPACITANCE**

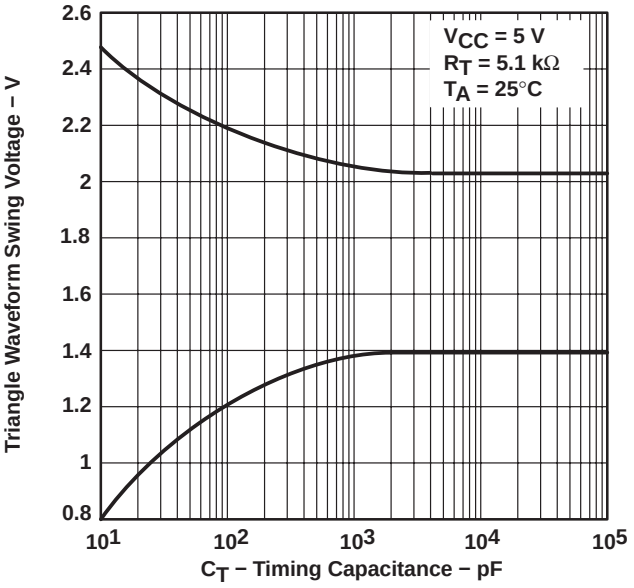



**Figure 5**

**TRIANGLE WAVEFORM PERIOD vs TIMING CAPACITANCE**

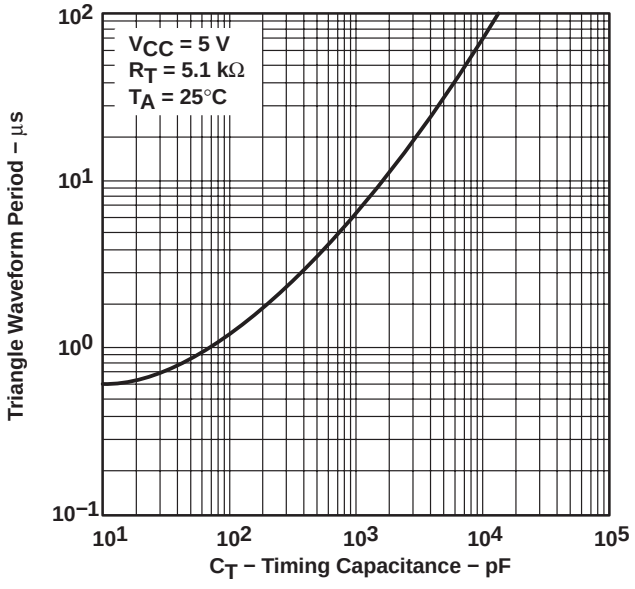



**Figure 6**

## TYPICAL CHARACTERISTICS

**REFERENCE OUTPUT VOLTAGE VARIATION vs FREE-AIR TEMPERATURE**

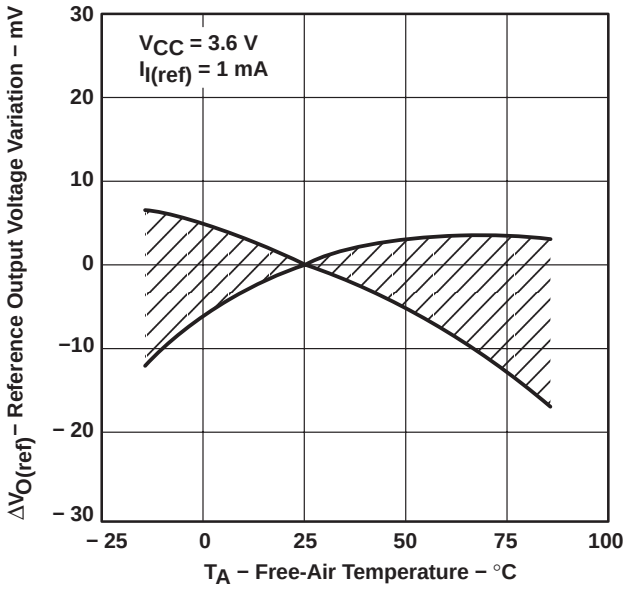



**Figure 7**

**REFERENCE OUTPUT VOLTAGE VARIATION vs FREE-AIR TEMPERATURE**

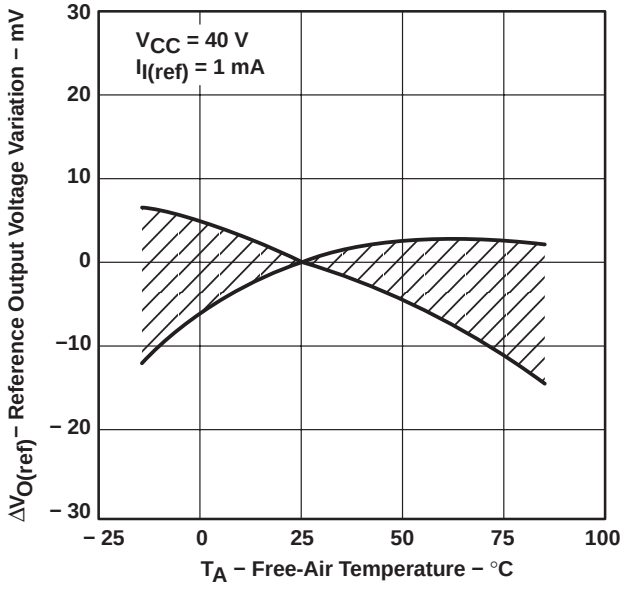



**Figure 8**

**REFERENCE OUTPUT VOLTAGE vs SUPPLY VOLTAGE**

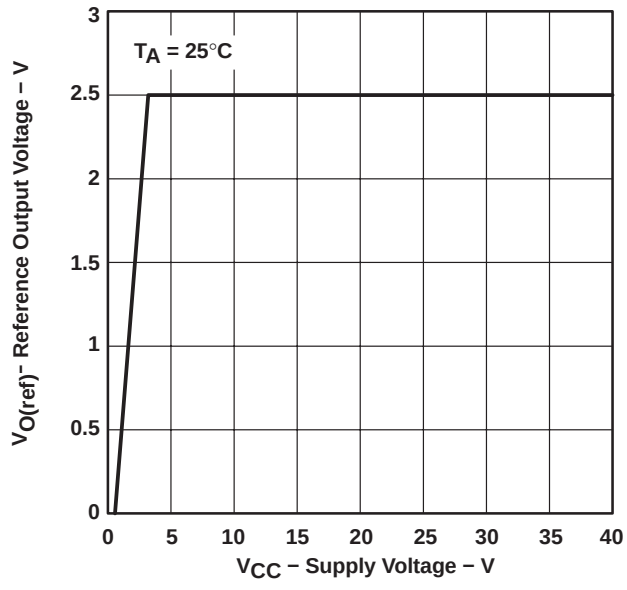



**Figure 9**

**DROPOUT VOLTAGE VARIATION vs FREE-TEMPERATURE**

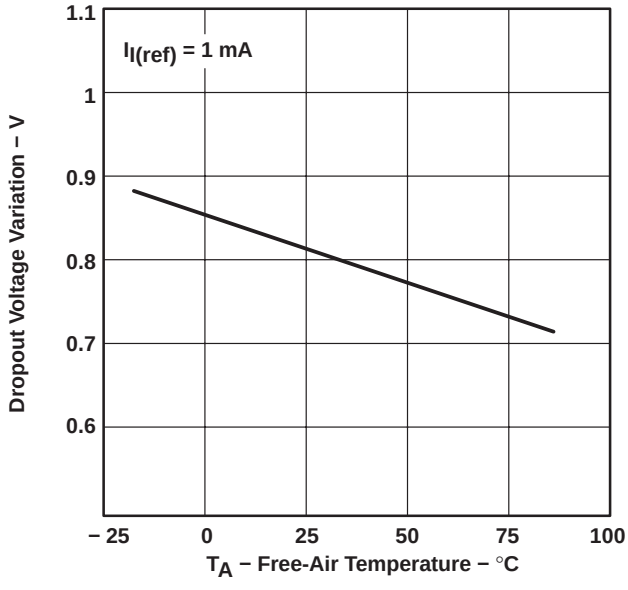



**Figure 10**

## TYPICAL CHARACTERISTICS

UNDERVOLTAGE LOCKOUT
HYSTERESIS CHARACTERISTICS

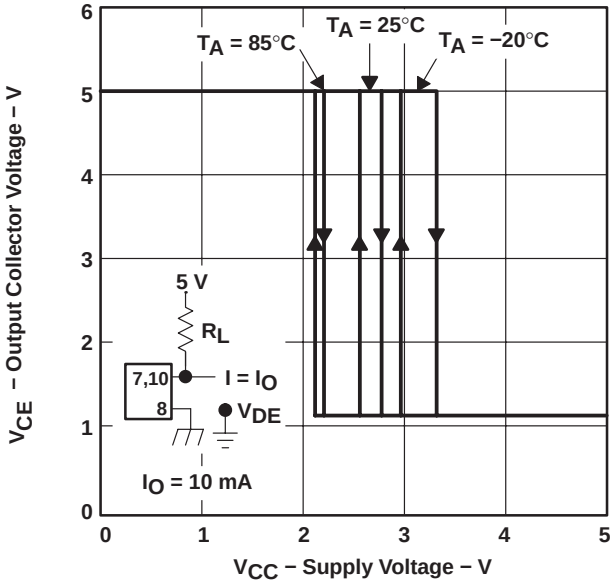



Figure 11

UNDERVOLTAGE LOCKOUT CHARACTERISTIC

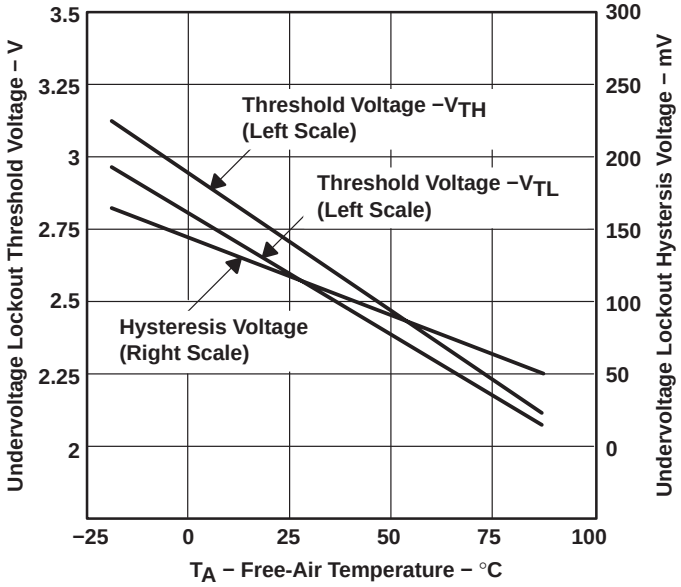



Figure 12

SHORT-CIRCUIT PROTECTION CHARACTERISTICS

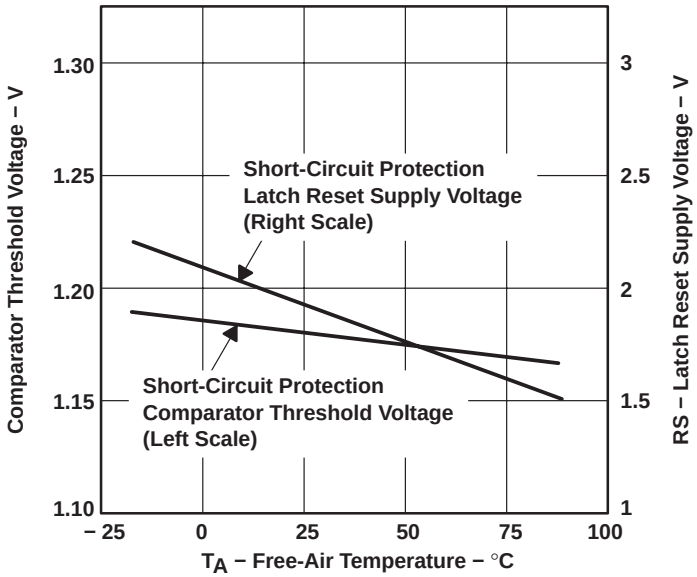



Figure 13

## TYPICAL CHARACTERISTICS

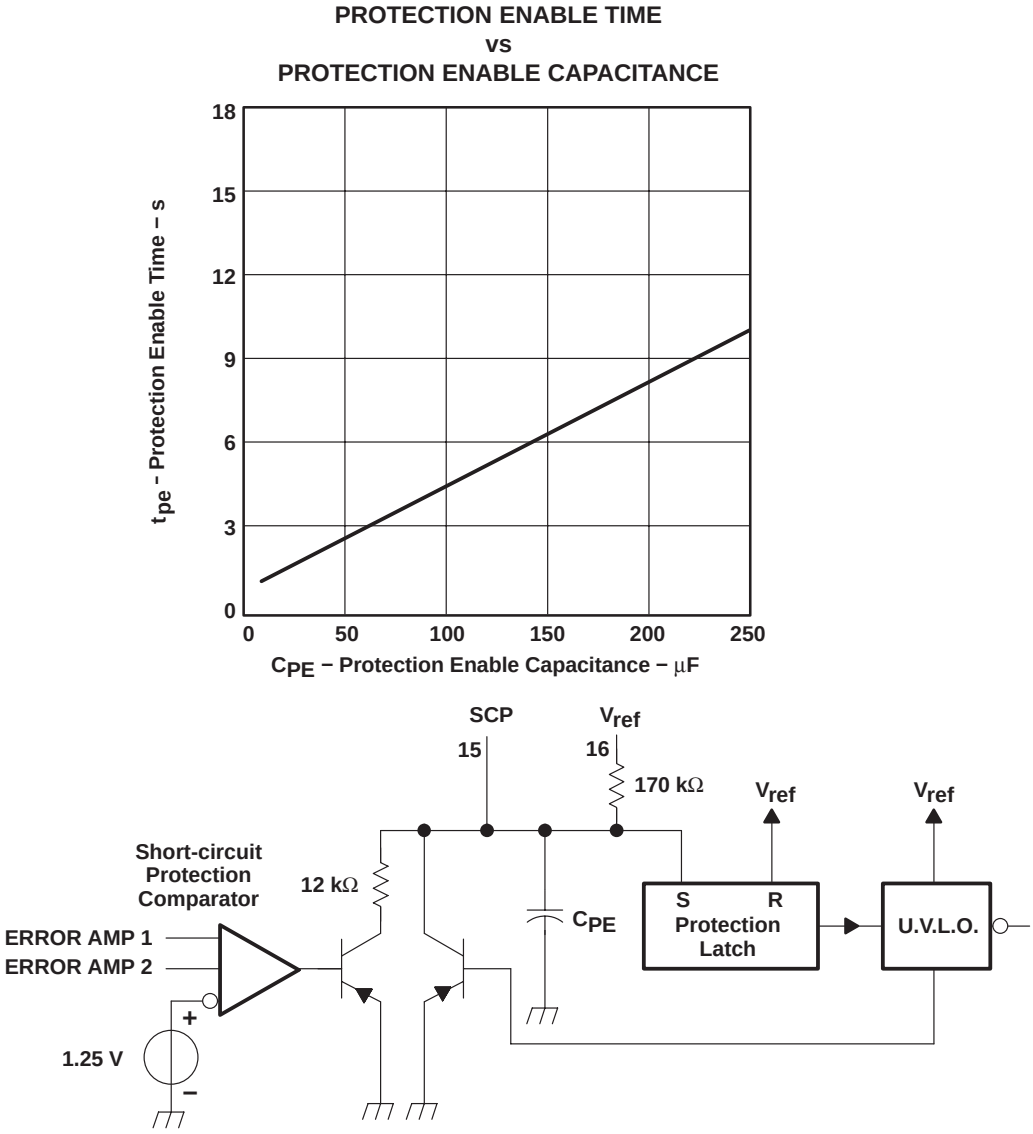



**Figure 14**

## TYPICAL CHARACTERISTICS

**ERROR AMP MAXIMUM OUTPUT VOLTAGE SWING vs FREQUENCY**

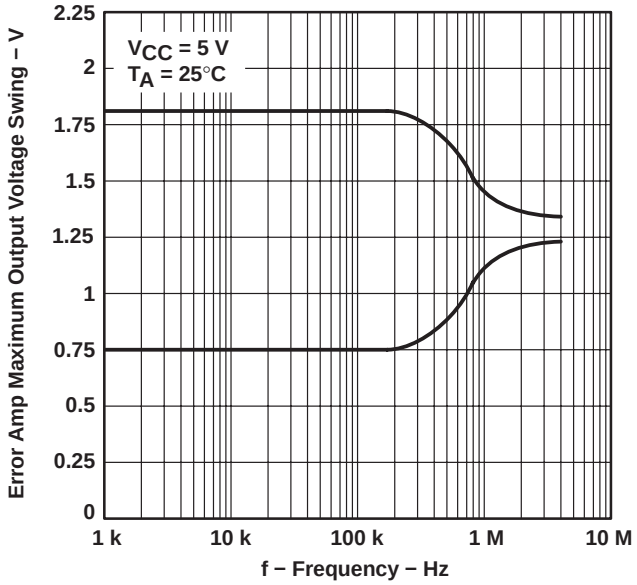



Figure 15

**OPEN-LOOP VOLTAGE AMPLIFICATION vs FREQUENCY**

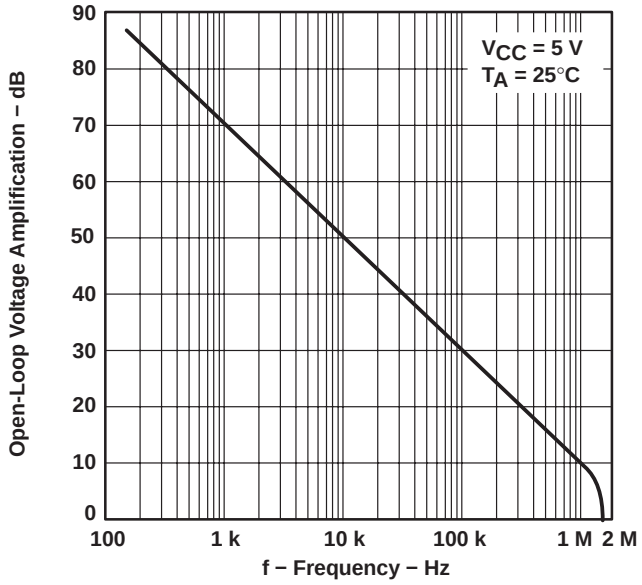



Figure 16

**GAIN (AMPLIFIER IN UNITY-GAIN CONFIGURATION) vs FREQUENCY**

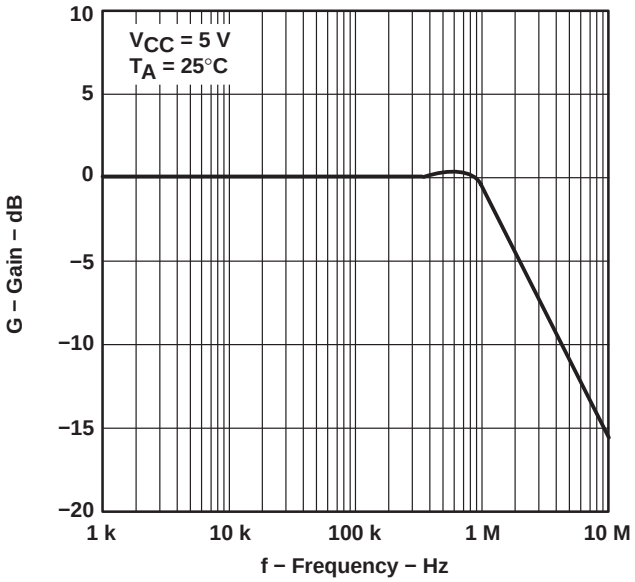
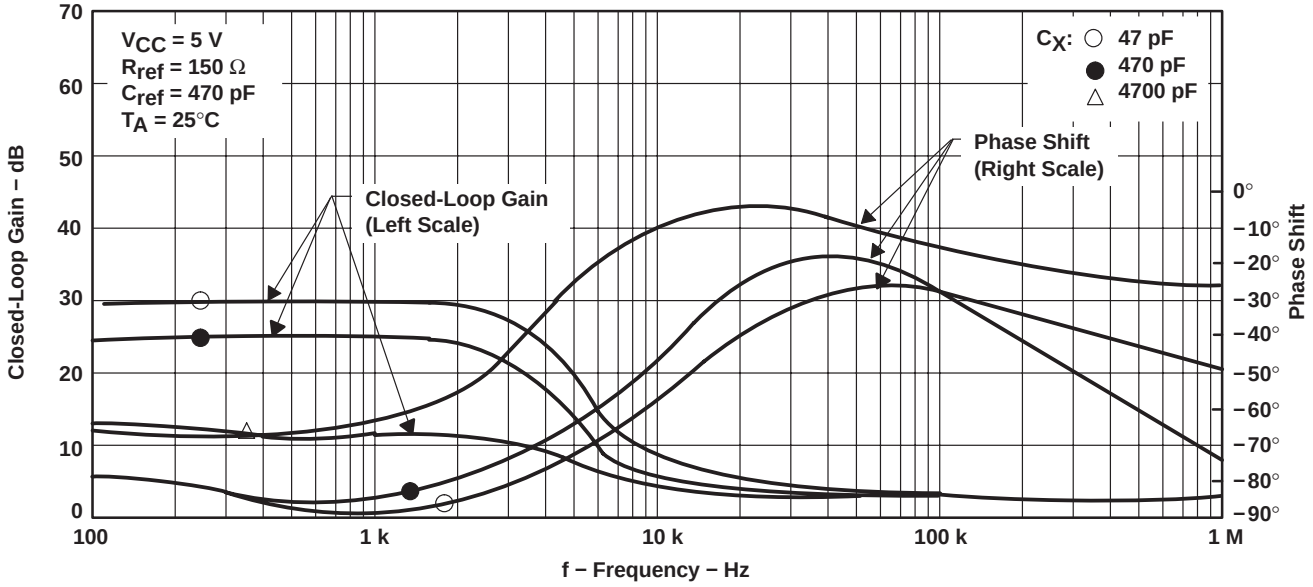
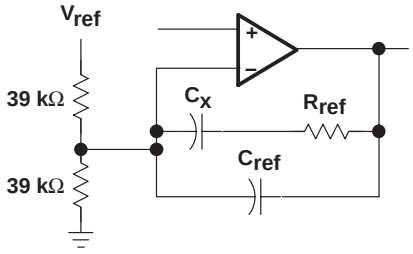



Figure 17

## TYPICAL CHARACTERISTICS

**CLOSED-LOOP GAIN AND PHASE SHIFT
vs
FREQUENCY**



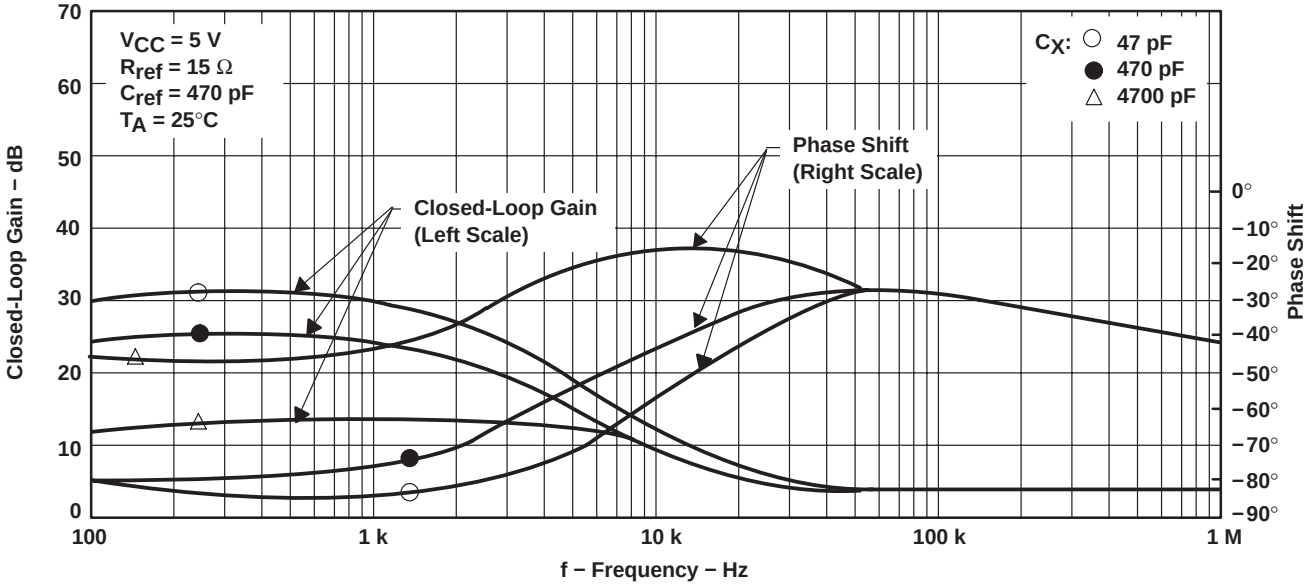



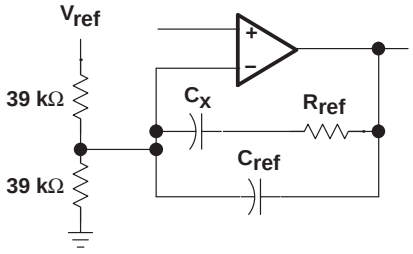

Test Circuit

**Figure 18**

## TYPICAL CHARACTERISTICS

**CLOSED-LOOP GAIN AND PHASE SHIFT
vs
FREQUENCY**



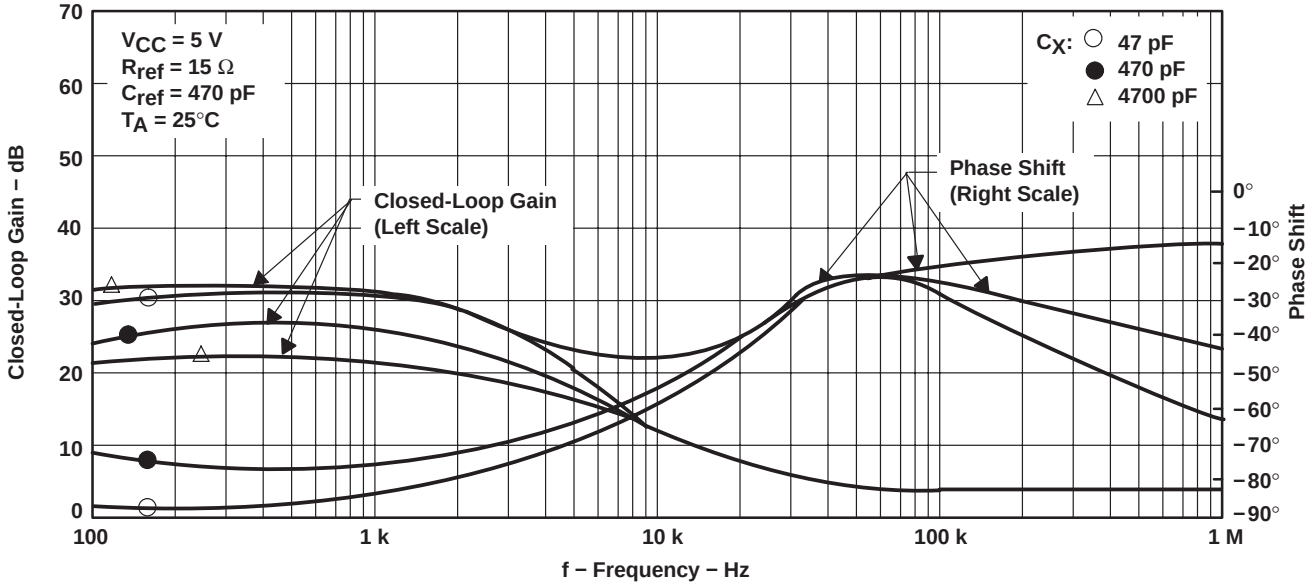



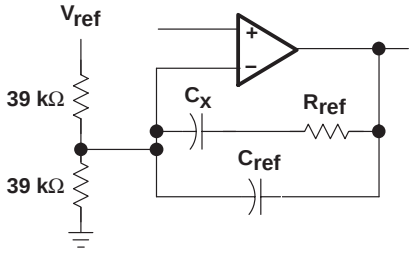

Test Circuit

**Figure 19**

## TYPICAL CHARACTERISTICS

**CLOSED-LOOP GAIN AND PHASE SHIFT
vs
FREQUENCY**



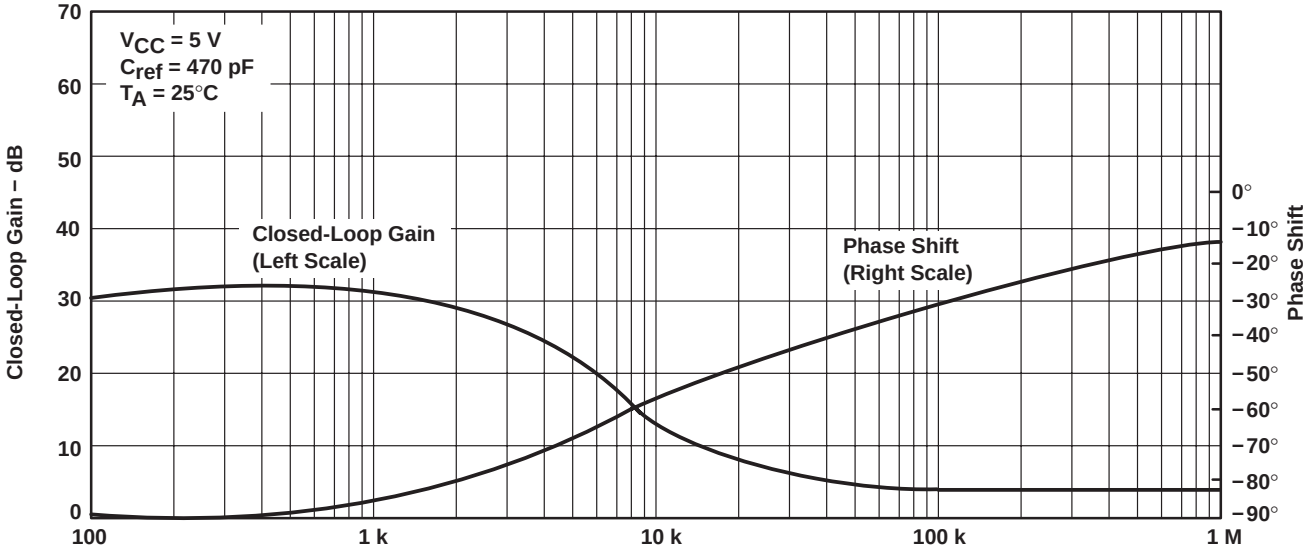



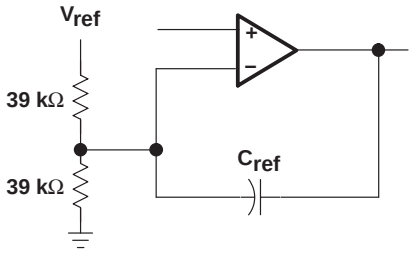

Test Circuit

**Figure 20**

## TYPICAL CHARACTERISTICS

**CLOSED-LOOP GAIN AND PHASE SHIFT
vs
FREQUENCY**




Test Circuit

**Figure 21**

## TYPICAL CHARACTERISTICS

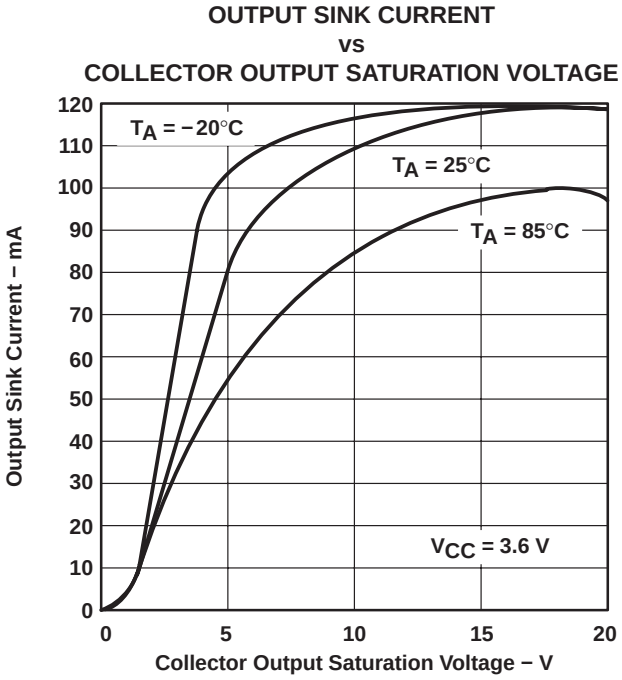
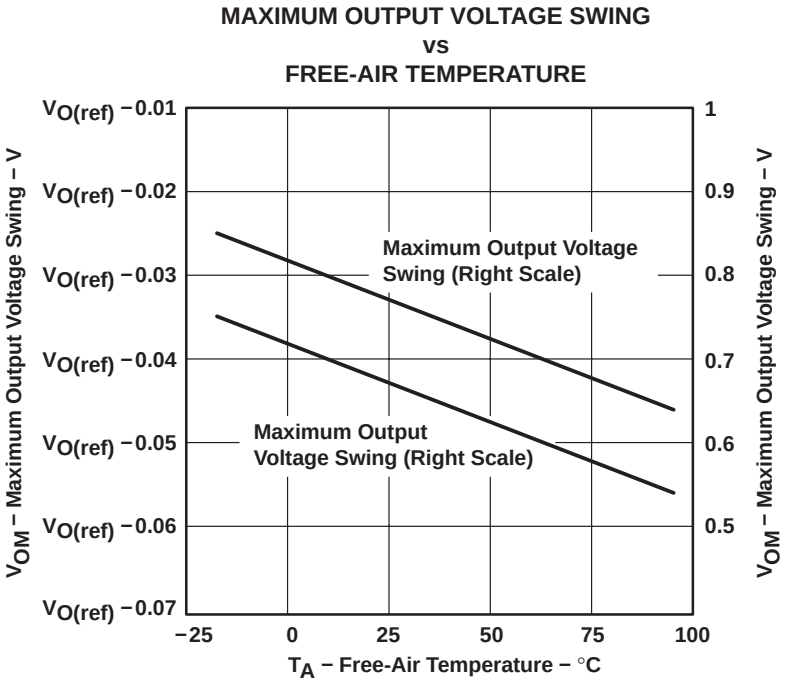
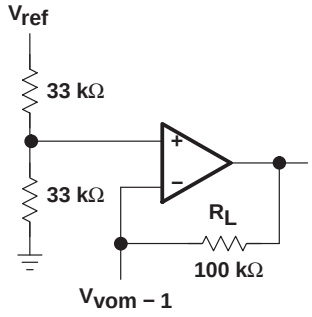



**Figure 22**




$V_{CC}$ = 3.6 V
$R_L$ = 100 kΩ
$V_{OM+1}$ = 1.25 V
$V_{OM\ -1}$ = 1.15 V (Right Scale)
$V_{OM\ -1}$ = 1.35 V (Left Scale)

**TEST CIRCUIT**

**Figure 23**

## TYPICAL CHARACTERISTICS

**OUTPUT TRANSISTOR ON DUTY CYCLE vs DEAD-TIME INPUT VOLTAGE**

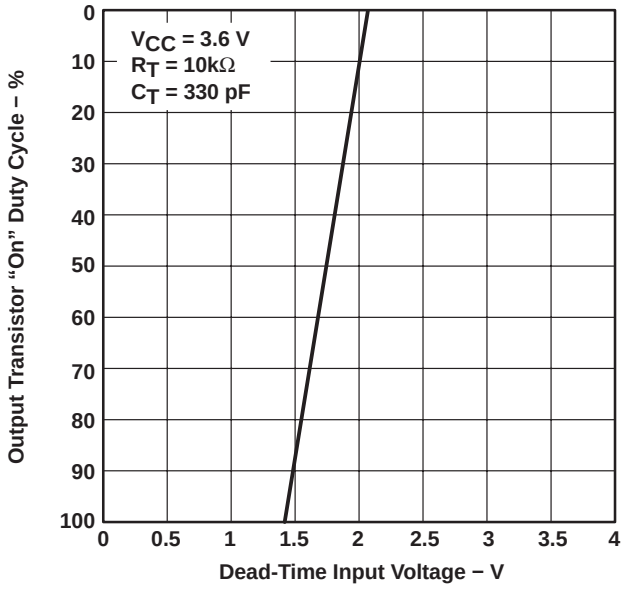



**Figure 24**

**STANDBY CURRENT vs SUPPLY VOLTAGE**

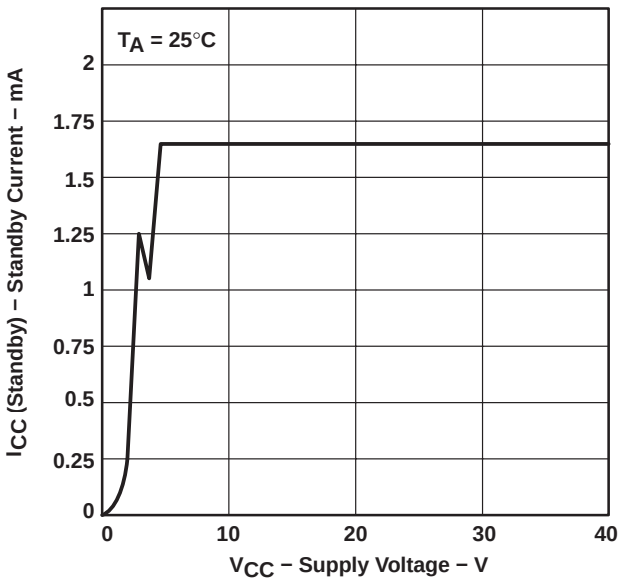



**Figure 25**

**STANDBY CURRENT vs FREE-AIR TEMPERATURE**

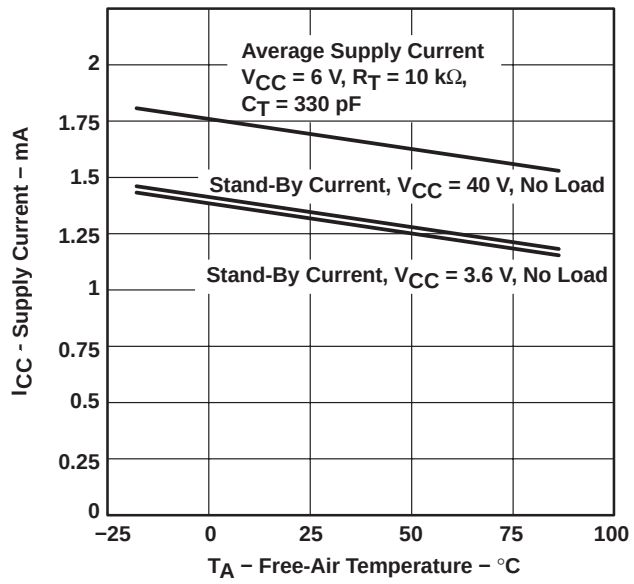



**Figure 26**

**MAXIMUM CONTINUOUS POWER DISSIPATION vs FREE-AIR TEMPERATURE**

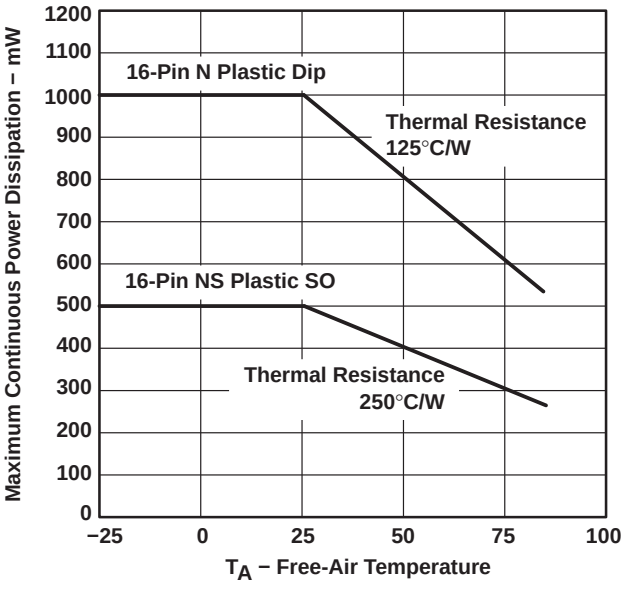
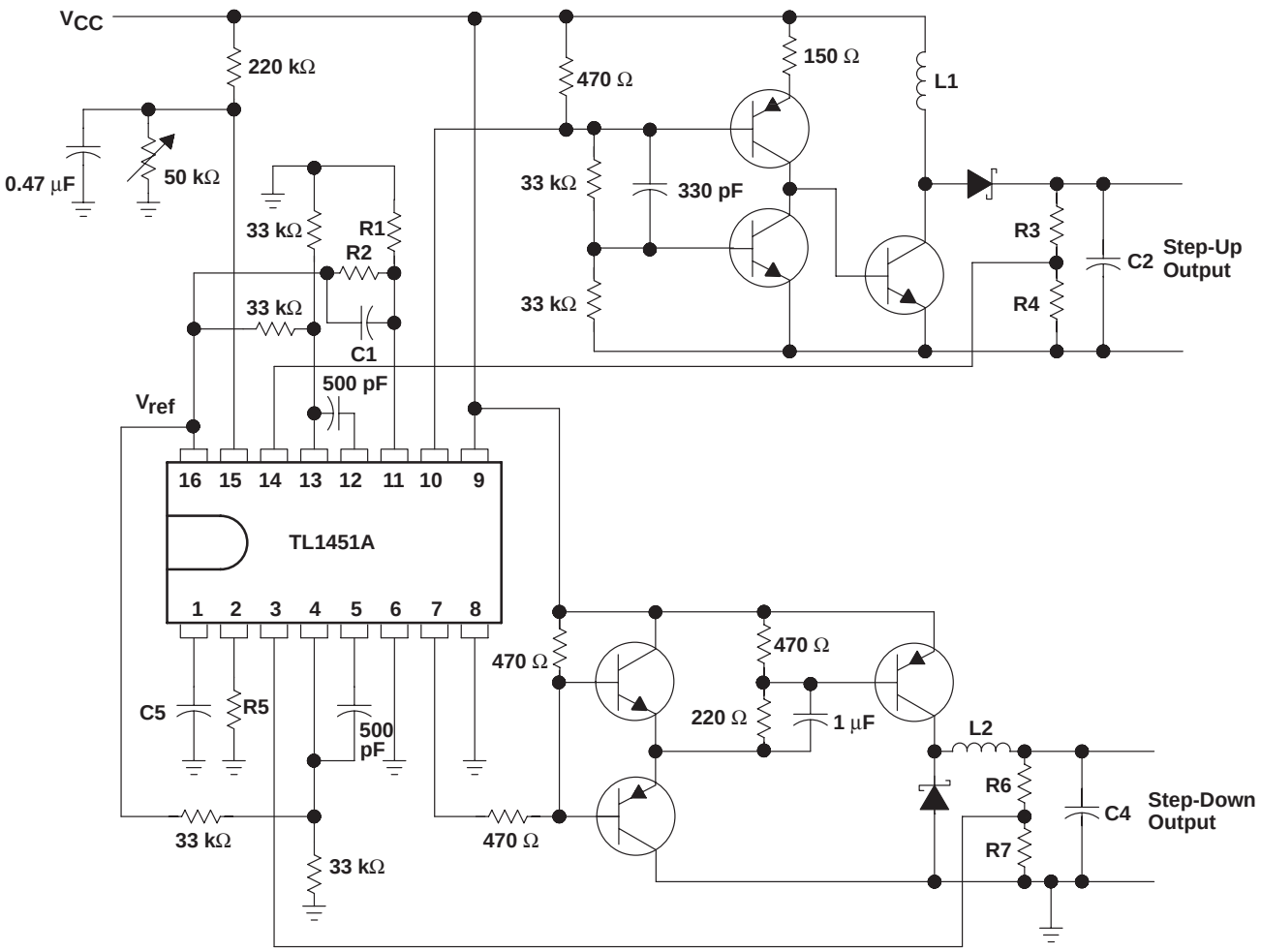



**Figure 27**

## APPLICATION INFORMATION




NOTE A: Values for R1 through R7, C1 through C4, and L1 and L2 depend upon individual application.

**Figure 28. High-Speed Dual Switching Regulator**

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) |
|---|---|---|---|---|---|---|---|---|
| TL1451AQPWRQ1 | ACTIVE | TSSOP | PW | 16 | 2000 | TBD | CU NIPDAU | Level-1-250C-UNLIM |

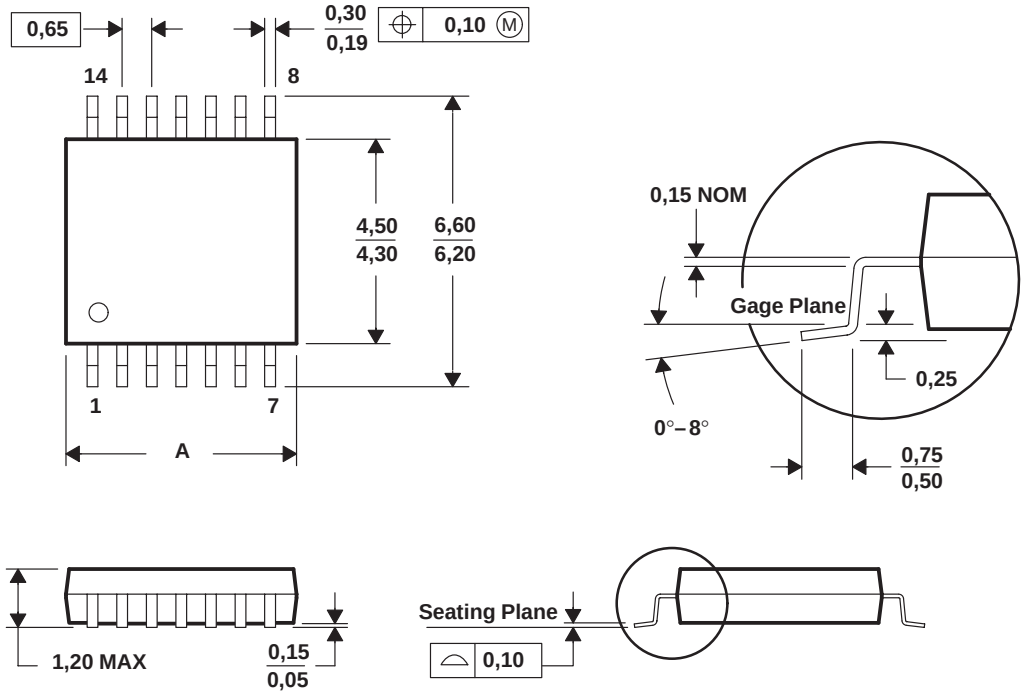
(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing 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.

(2) 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)

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

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

**14 PINS SHOWN**




| DIM \ PINS ** | 8 | 14 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|---|
| A MAX | 3,10 | 5,10 | 5,10 | 6,60 | 7,90 | 9,80 |
| A MIN | 2,90 | 4,90 | 4,90 | 6,40 | 7,70 | 9,60 |

**4040064/F 01/97**

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

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Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265