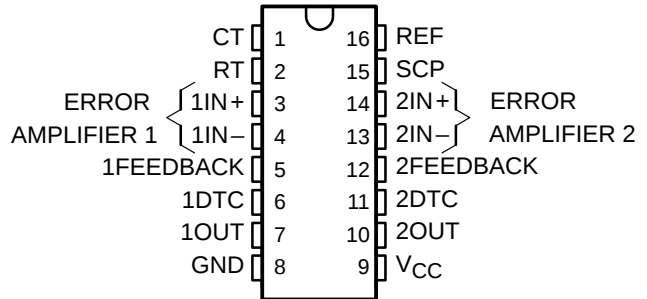


# TL1451AC, TL1451AY DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024C – FEBRUARY 1983 – REVISED OCTOBER 1995

- 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

DB, N, NS, OR PW PACKAGE  
(TOP VIEW)



## description

The TL1451AC 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 TL1451AC 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 TL1451AC is characterized for operation from  $-20^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

AVAILABLE OPTIONS

| $T_A$                                         | PACKAGED DEVICES                   |                    |                       |                            | CHIP FORM<br>(Y) |
|-----------------------------------------------|------------------------------------|--------------------|-----------------------|----------------------------|------------------|
|                                               | SMALL OUTLINE<br>(DB) <sup>†</sup> | PLASTIC DIP<br>(N) | SMALL OUTLINE<br>(NS) | TSSOP<br>(PW) <sup>†</sup> |                  |
| $-20^{\circ}\text{C}$ to $85^{\circ}\text{C}$ | TL1451ACDB                         | TL1451ACN          | TL1451ACNS            | TL1451ACPW                 | TL1451AY         |

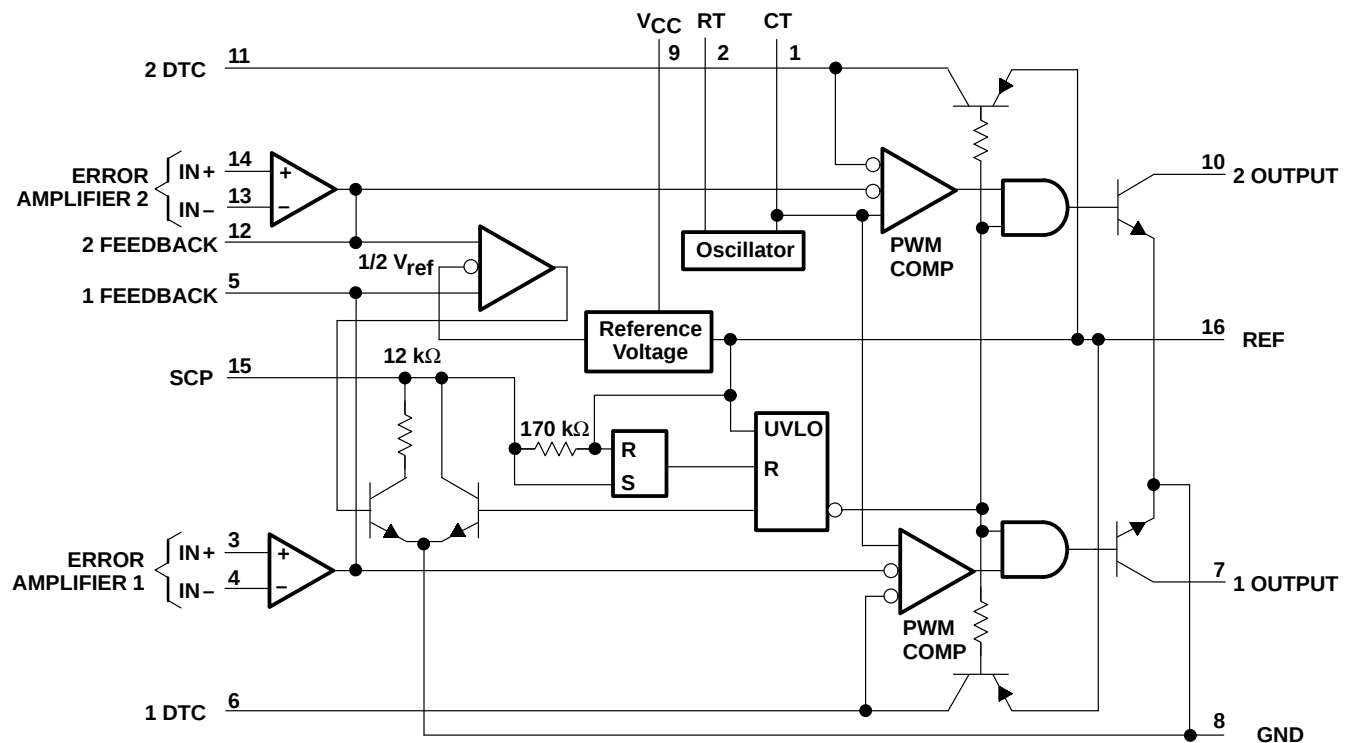
<sup>†</sup> The DB and PW packages are only available left-end taped and reeled (add LE suffix, i.e., TL1451ACPWLE).

# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### functional block diagram



#### COMPONENT COUNT

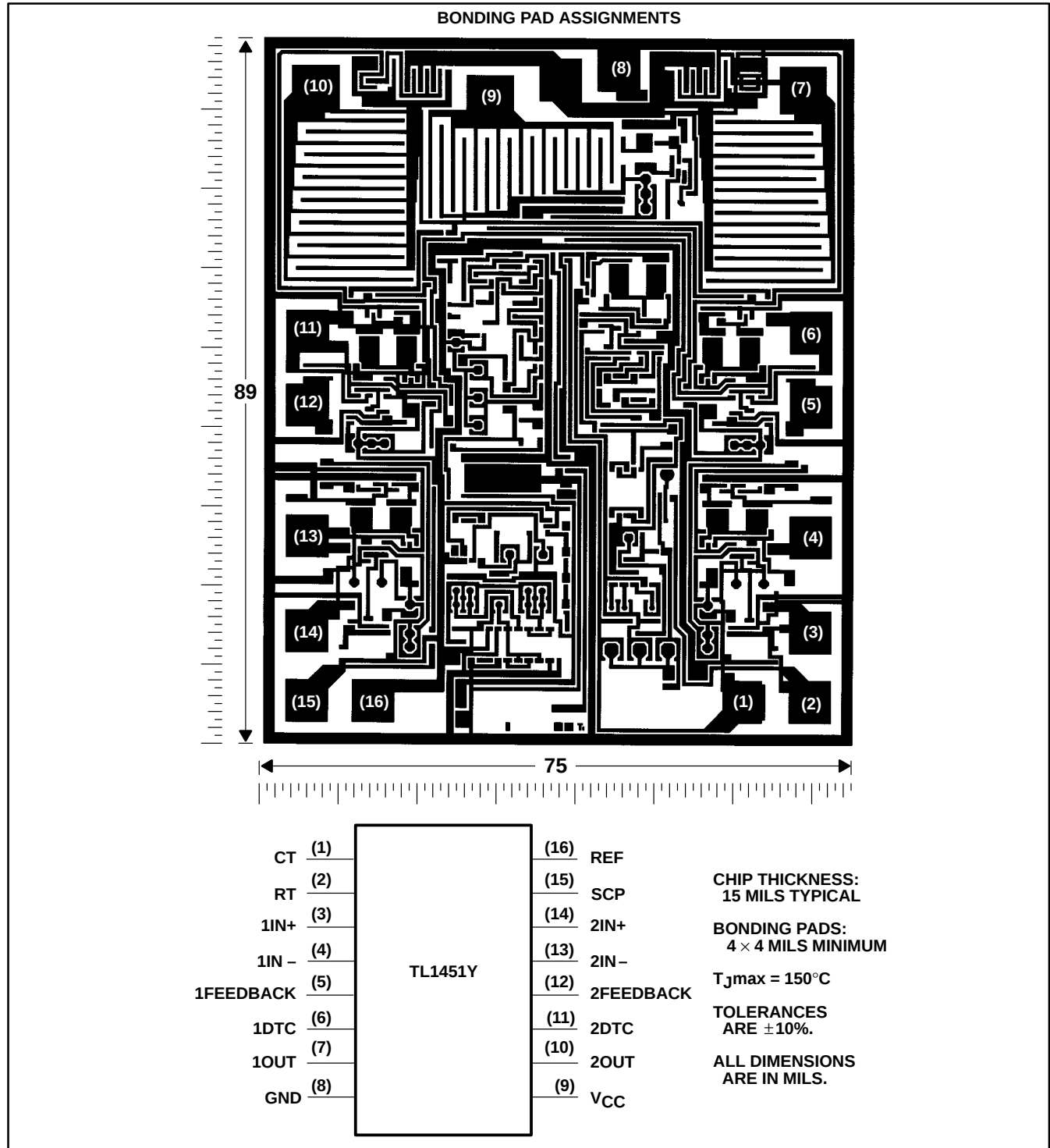
|             |     |
|-------------|-----|
| Resistors   | 65  |
| Capacitors  | 8   |
| Transistors | 105 |
| JFETs       | 18  |

# TL1451AC, TL1451AY DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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## TL1451AY chip information

This chip, when properly assembled, displays characteristics similar to the TL1451AC. Thermal compression or ultrasonic bonding may be used on the doped aluminum bonding pads. The chip may be mounted with conductive epoxy or a gold-silicon preform.



# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### 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, $T_A$                  | –20°C to 85°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 | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | DERATING FACTOR<br>ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$<br>POWER RATING | $T_A = 85^\circ\text{C}$<br>POWER RATING |
|---------|---------------------------------------------|---------------------------------------------------|------------------------------------------|------------------------------------------|
| DB      | 775 mW                                      | 6.2 mW/°C                                         | 496 mW                                   | 403 mW                                   |
| N       | 1000 mW                                     | 8.0 mW/°C                                         | 640 mW                                   | 520 mW                                   |
| NS      | 500 mW                                      | 4.0 mW/°C                                         | 320 mW                                   | 260 mW                                   |
| PW      | 700 mW                                      | 5.6 mW/°C                                         | 448 mW                                   | 364 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, $T_A$ | –20  | 85    | °C   |

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

### reference section

| PARAMETER                              | TEST CONDITIONS                                 | TL1451AC |       |      | TL1451Y |       |     | UNIT |
|----------------------------------------|-------------------------------------------------|----------|-------|------|---------|-------|-----|------|
|                                        |                                                 | MIN      | TYP†  | MAX  | MIN     | TYP†  | MAX |      |
| Output voltage (pin 16)                | $I_O = 1\text{ mA}$                             | 2.4      | 2.5   | 2.6  |         | 2.5   |     | V    |
| Output voltage change with temperature | $T_A = -20^\circ\text{C}$ to $25^\circ\text{C}$ |          | –0.1% | ±1%  |         | –0.1% |     |      |
|                                        | $T_A = 25^\circ\text{C}$ to $85^\circ\text{C}$  |          | –0.2% | ±1%  |         | –0.2% |     |      |
| Input voltage regulation               | $V_{CC} = 3.6\text{ V}$ to $40\text{ V}$        |          | 2     | 12.5 |         | 2     |     | mV   |
| Output voltage regulation              | $I_O = 0.1\text{ mA}$ to $1\text{ mA}$          |          | 1     | 7.5  |         | 1     |     | mV   |
| Short-circuit output current           | $V_O = 0$                                       | 3        | 10    | 30   |         | 10    |     | mA   |

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



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# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### undervoltage lockout section

| PARAMETER                            | TEST CONDITIONS                                          | TL1451AC, TL1451AY |                  |     | UNIT |
|--------------------------------------|----------------------------------------------------------|--------------------|------------------|-----|------|
|                                      |                                                          | MIN                | TYP <sup>†</sup> | MAX |      |
| Upper threshold voltage ( $V_{CC}$ ) | $I_{O(ref)} = 0.1 \text{ mA}$ , $T_A = 25^\circ\text{C}$ | 2.72               |                  |     | V    |
| Lower threshold voltage ( $V_{CC}$ ) |                                                          | 2.6                |                  |     | V    |
| Hysteresis ( $V_{CC}$ )              |                                                          | 80                 | 120              |     | mV   |
| Reset threshold voltage ( $V_{CC}$ ) |                                                          | 1.5                | 1.9              |     | V    |

<sup>†</sup> All typical values are at  $T_A = 25^\circ\text{C}$ .

### short-circuit protection control section

| PARAMETER                               | TEST CONDITIONS                                  | TL1451AC |                  |      | TL1451AY |                  |      | UNIT          |
|-----------------------------------------|--------------------------------------------------|----------|------------------|------|----------|------------------|------|---------------|
|                                         |                                                  | MIN      | TYP <sup>†</sup> | MAX  | MIN      | TYP <sup>†</sup> | MAX  |               |
| Input threshold voltage (SCP)           | $T_A = 25^\circ\text{C}$                         | 0.65     | 0.7              | 0.75 | 0.65     | 0.7              | 0.75 | V             |
| Standby voltage (SCP)                   | No pullup                                        | 140      | 185              | 230  | 185      |                  |      | mV            |
| Latched input voltage (SCP)             | No pullup                                        | 60       |                  |      | 60       |                  |      | mV            |
| Input (source) current                  | $V_I = 0.7 \text{ V}$ , $T_A = 25^\circ\text{C}$ | -10      | -15              | -20  | -10      | -15              | -20  | $\mu\text{A}$ |
| Comparator threshold voltage (FEEDBACK) |                                                  | 1.18     |                  |      | 1.18     |                  |      | V             |

<sup>†</sup> All typical values are at  $T_A = 25^\circ\text{C}$ .

### oscillator section

| PARAMETER                         | TEST CONDITIONS                                 | TL1451C   |      |     | TL1451AY |      |     | UNIT |
|-----------------------------------|-------------------------------------------------|-----------|------|-----|----------|------|-----|------|
|                                   |                                                 | MIN       | TYP† | MAX | MIN      | TYP† | MAX |      |
| Frequency                         | C <sub>T</sub> = 330 pF, R <sub>T</sub> = 10 kΩ | 200       |      |     | 200      |      |     | kHz  |
| Standard deviation of frequency   | C <sub>T</sub> = 330 pF, R <sub>T</sub> = 10 kΩ | 10%       |      |     | 10%      |      |     |      |
| Frequency change with voltage     | V <sub>CC</sub> = 3.6 V to 40 V                 | 1%        |      |     | 1%       |      |     |      |
| Frequency change with temperature | T <sub>A</sub> = −20°C to 25°C                  | −0.4% ±2% |      |     | −0.4%    |      |     |      |
|                                   | T <sub>A</sub> = 25°C to 85°C                   | −0.2% ±2% |      |     | −0.2%    |      |     |      |

<sup>†</sup> All typical values are at  $T_A = 25^\circ\text{C}$ .

### dead-time control section

| PARAMETER                                   | TEST CONDITIONS        | TL1451AC |      |     | TL1451AY |      |     | UNIT |
|---------------------------------------------|------------------------|----------|------|-----|----------|------|-----|------|
|                                             |                        | MIN      | TYP† | MAX | MIN      | TYP† | MAX |      |
| Input bias current (DTC)                    |                        | 1        |      |     |          |      |     | μA   |
| Latch mode (source) current (DTC)           | T <sub>A</sub> = 25°C  | −80      | −145 |     | −80      | −145 |     | μA   |
| Latched input voltage (DTC)                 | I <sub>O</sub> = 40 μA | 2.3      |      |     |          |      |     | V    |
| Input threshold voltage at f = 10 kHz (DTC) | Zero duty cycle        | 2.05     |      |     | 2.05     |      |     | V    |
|                                             | Maximum duty cycle     | 1.2      | 1.45 |     | 1.45     |      |     |      |

<sup>†</sup> All typical values are at  $T_A = 25^\circ\text{C}$ .

# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### error-amplifier section

| PARAMETER                          | TEST CONDITIONS                   | TL1451AC      |      |      | TL1451AY |      |     | UNIT    |
|------------------------------------|-----------------------------------|---------------|------|------|----------|------|-----|---------|
|                                    |                                   | MIN           | TYP† | MAX  | MIN      | TYP† | MAX |         |
| Input offset voltage               | $V_O$ (FEEDBACK) = 1.25 V         |               |      | ±6   |          |      |     | mV      |
| Input offset current               | $V_O$ (FEEDBACK) = 1.25 V         |               |      | ±100 |          |      |     | nA      |
| Input bias current                 | $V_O$ (FEEDBACK) = 1.25 V         |               | 160  | 500  |          | 160  |     | nA      |
| 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 k $\Omega$            | 70            | 80   |      |          | 80   |     | dB      |
| Unity-gain bandwidth               |                                   |               | 1.5  |      |          | 1.5  |     | MHz     |
| Common-mode rejection ratio        |                                   | 60            | 80   |      |          | 80   |     | dB      |
| Positive output voltage swing      |                                   | $V_{ref}-0.1$ |      |      |          |      |     | V       |
| Negative output voltage swing      |                                   | 1             |      |      |          |      |     | V       |
| Output (sink) current (FEEDBACK)   | $V_{ID} = -0.1$ V, $V_O = 1.25$ V | 0.5           | 1.6  |      |          | 1.6  |     | mA      |
| Output (source) current (FEEDBACK) | $V_{ID} = 0.1$ V, $V_O = 1.25$ V  | -45           | -70  |      |          | -70  |     | $\mu$ A |

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

### output section

| PARAMETER                    | TEST CONDITIONS | TL1451AC |      |     | TL1451AY |      |     | UNIT    |
|------------------------------|-----------------|----------|------|-----|----------|------|-----|---------|
|                              |                 | MIN      | TYP† | MAX | MIN      | TYP† | MAX |         |
| Collector off-state current  | $V_O = 50$ V    |          |      | 10  |          |      |     | $\mu$ A |
| Output saturation voltage    | $I_O = 10$ mA   |          | 1.2  | 2   |          | 1.2  |     | V       |
| Short-circuit output current | $V_O = 6$ V     |          | 90   |     |          | 90   |     | mA      |

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

### pwm comparator section

| PARAMETER                                          | TEST CONDITIONS    | TL1451AC |      |      | TL1451AY |      |     | UNIT |
|----------------------------------------------------|--------------------|----------|------|------|----------|------|-----|------|
|                                                    |                    | MIN      | TYP† | MAX  | MIN      | TYP† | MAX |      |
| Input threshold voltage at $f = 10$ kHz (FEEDBACK) | Zero duty cycle    |          | 2.05 | 2.25 |          | 2.05 |     | V    |
|                                                    | Maximum duty cycle | 1.2      | 1.45 |      |          | 1.45 |     |      |

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

### total device

| PARAMETER              | TEST CONDITIONS       | TL1451AC |      |     | TL1451AY |      |     | UNIT |
|------------------------|-----------------------|----------|------|-----|----------|------|-----|------|
|                        |                       | MIN      | TYP† | MAX | MIN      | TYP† | MAX |      |
| Standby supply current | Off-state             |          | 1.3  | 1.8 |          | 1.3  |     | mA   |
| Average supply current | $R_T = 10$ k $\Omega$ |          | 1.7  | 2.4 |          | 1.7  |     | mA   |

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



PARAMETER MEASUREMENT INFORMATION

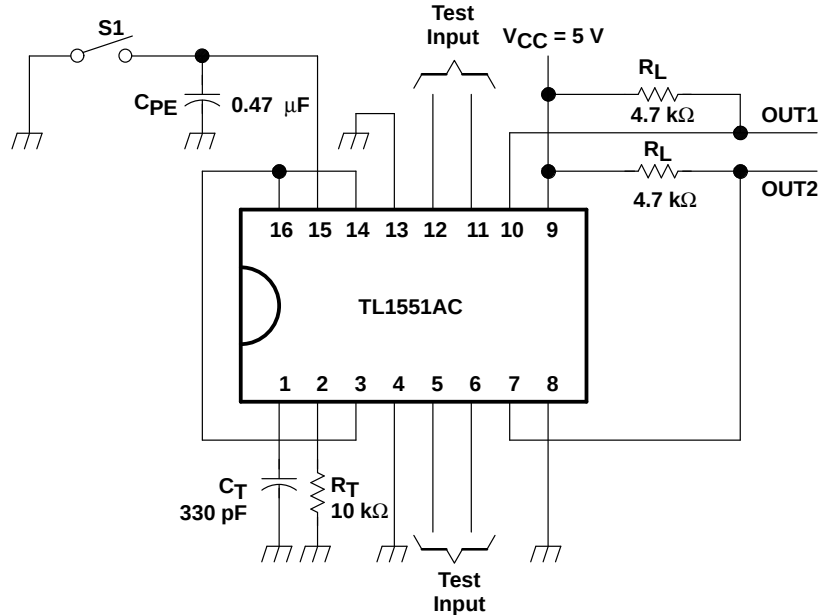
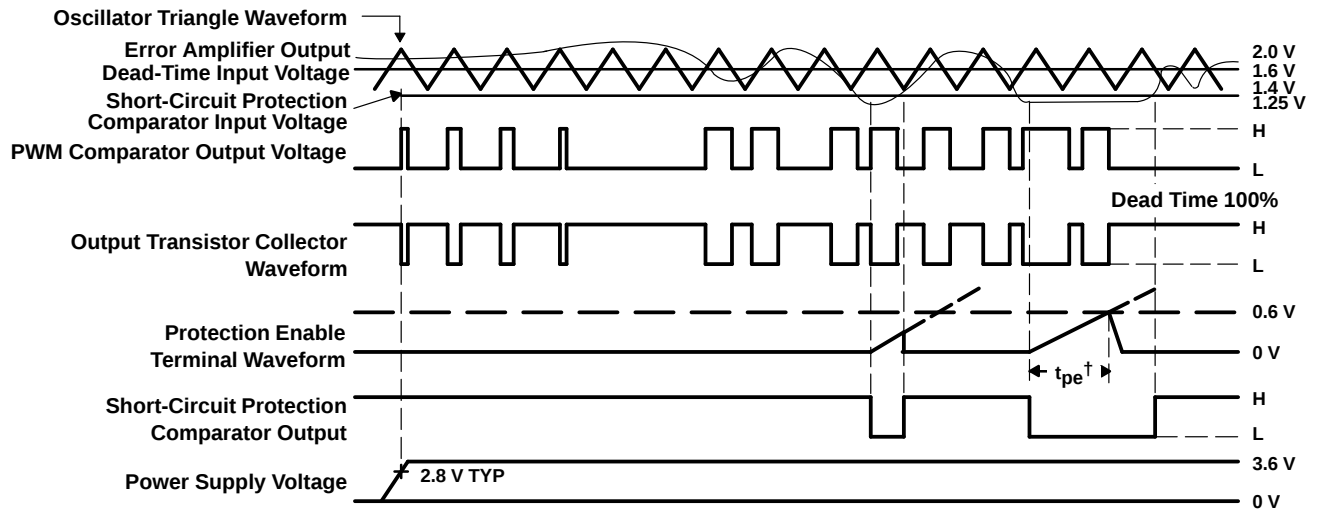


Figure 1. Test Circuit



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

Figure 2. TL1451AC Timing Diagram

# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### TYPICAL CHARACTERISTICS

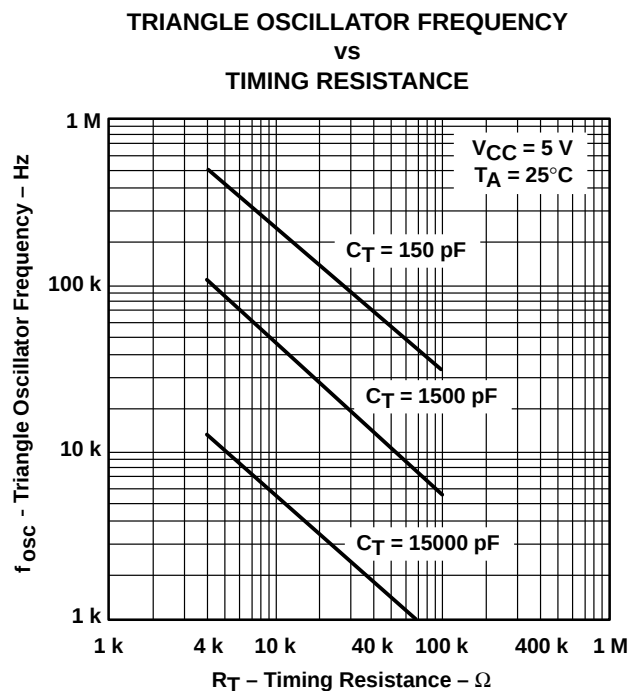


Figure 3

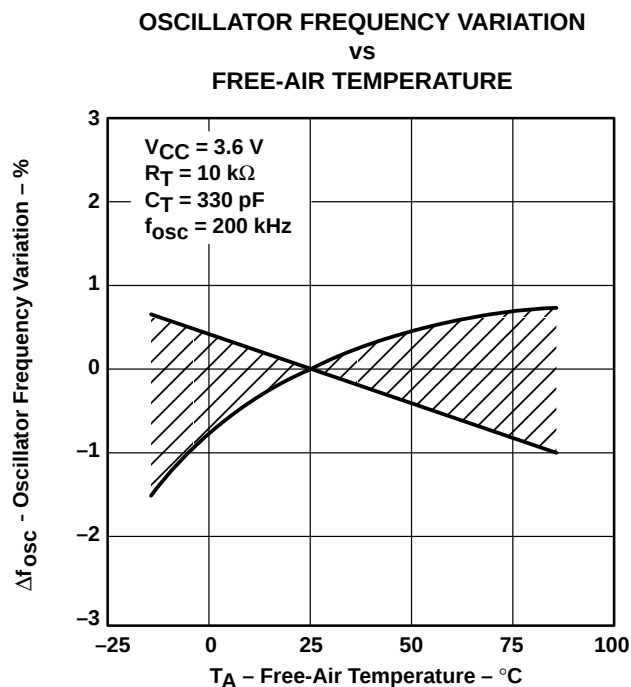


Figure 4

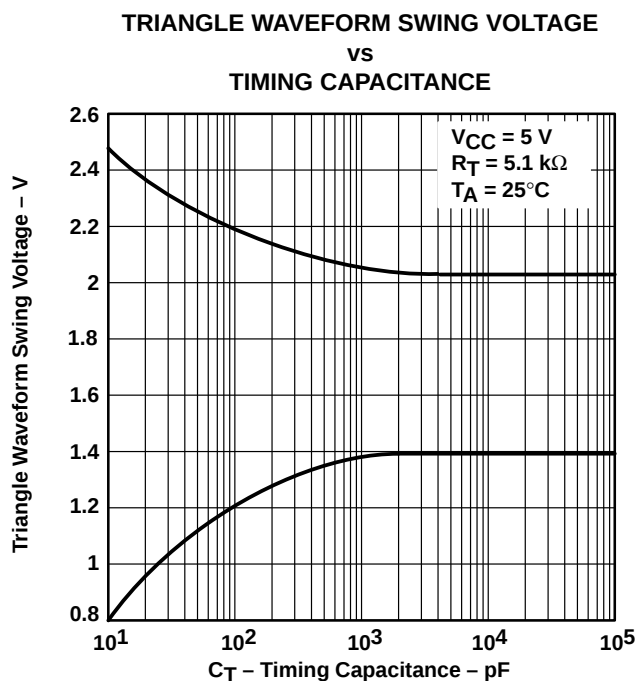


Figure 5

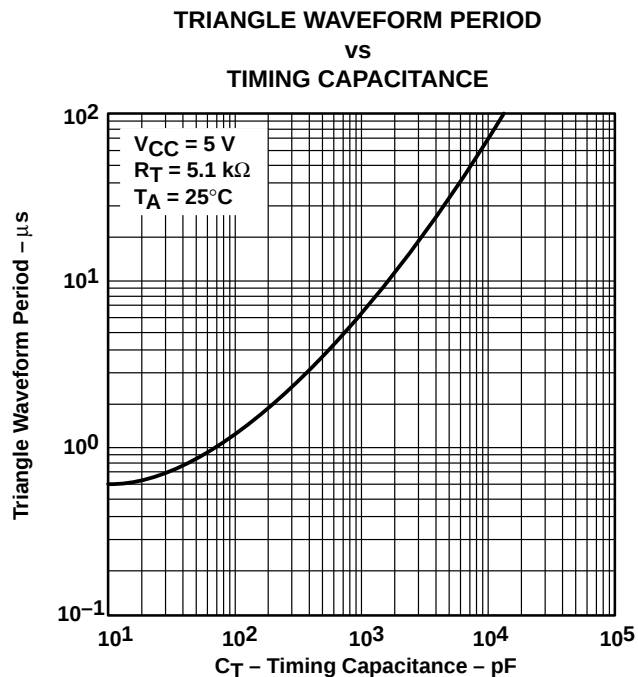


Figure 6

TYPICAL CHARACTERISTICS

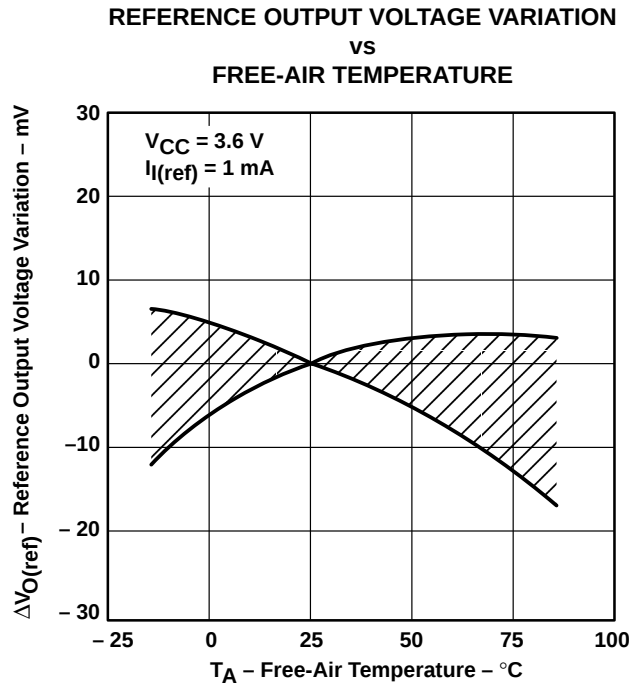


Figure 7

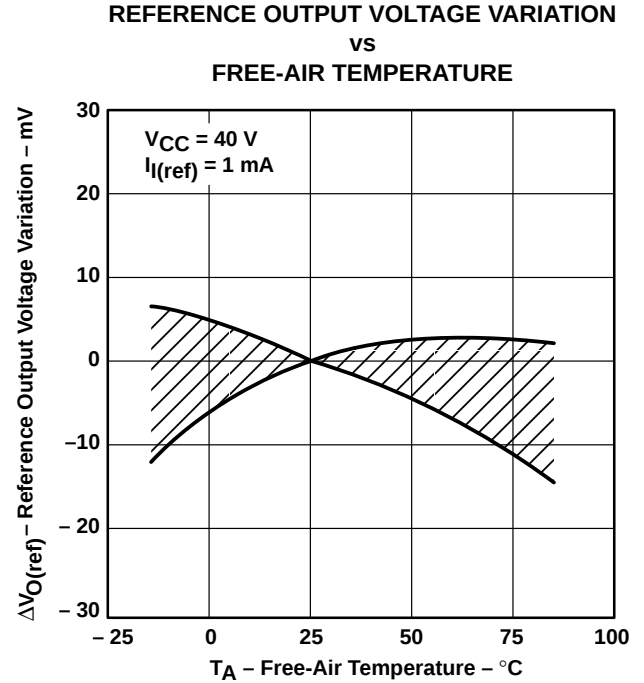


Figure 8

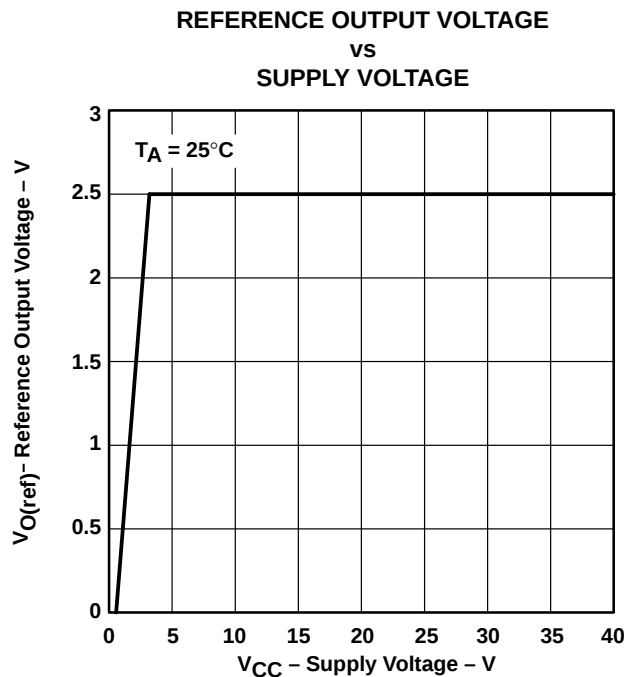


Figure 9

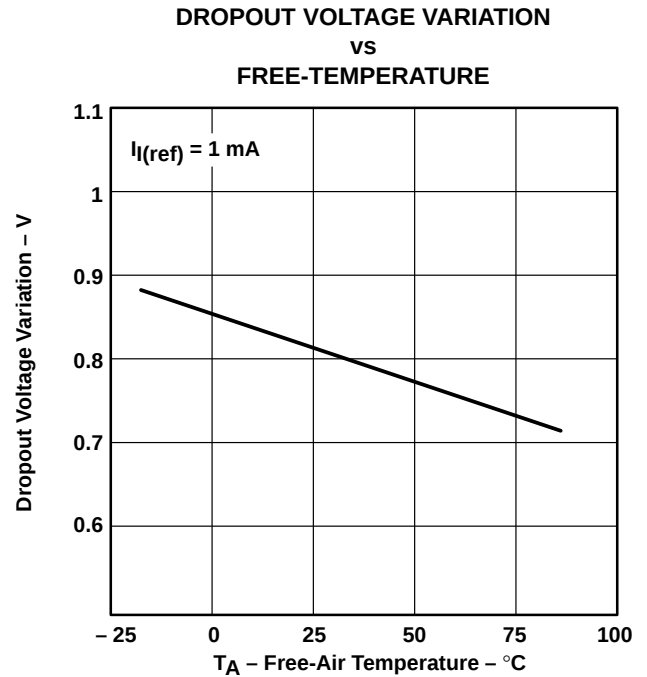


Figure 10

# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### TYPICAL CHARACTERISTICS

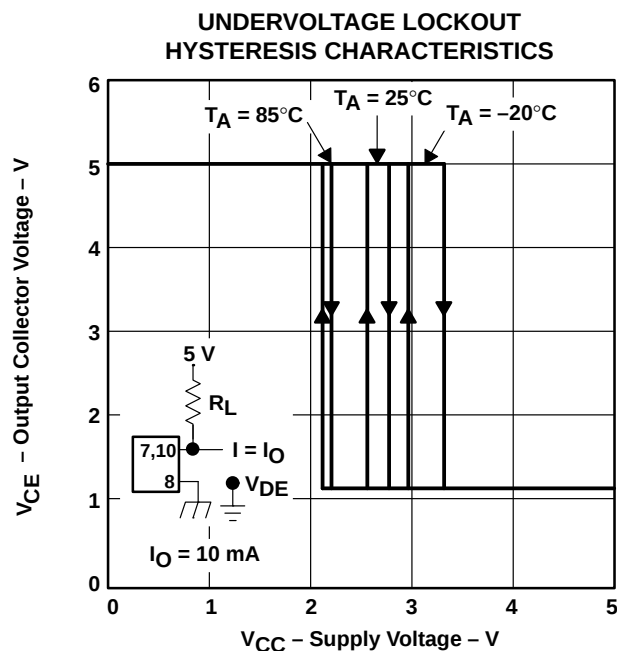


Figure 11

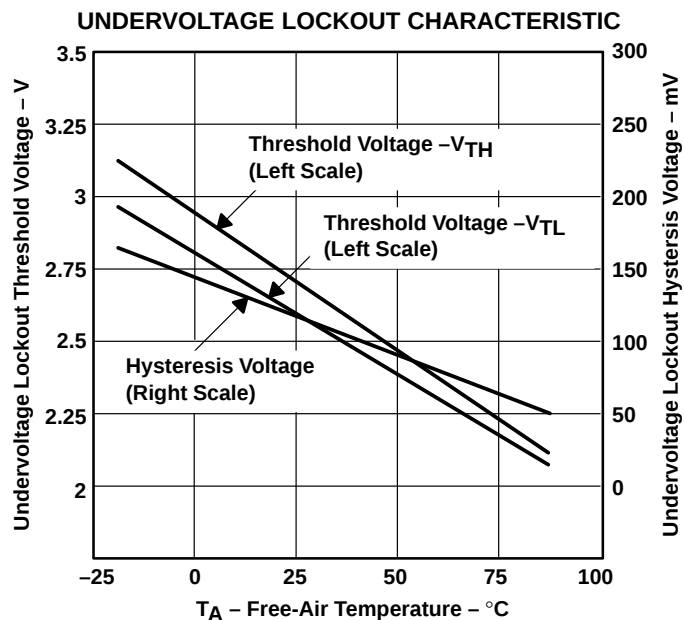


Figure 12

### SHORT-CIRCUIT PROTECTION CHARACTERISTICS

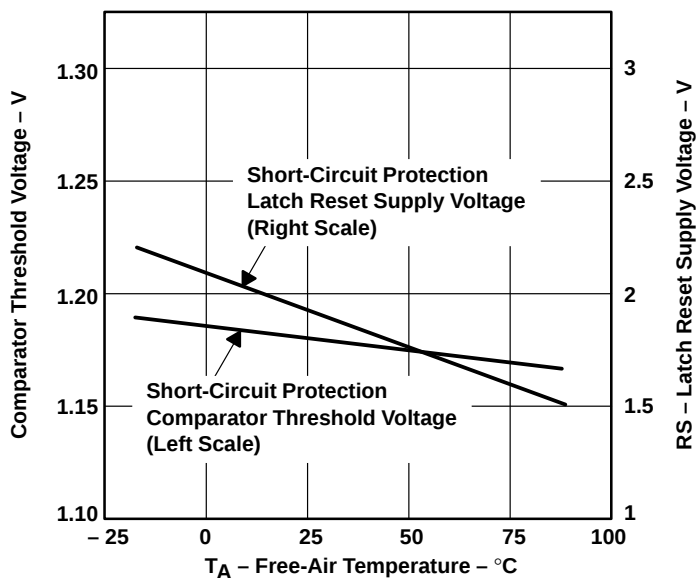


Figure 13

## TYPICAL CHARACTERISTICS

PROTECTION ENABLE TIME  
VS  
PROTECTION ENABLE CAPACITANCE

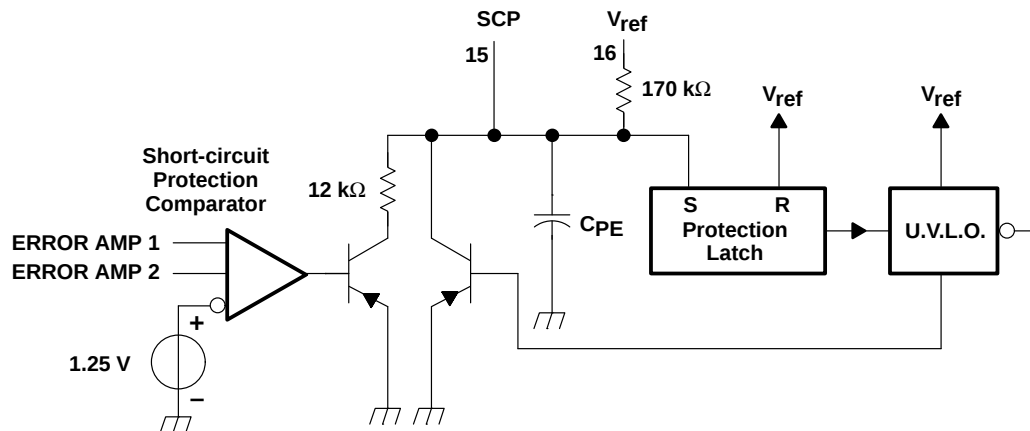
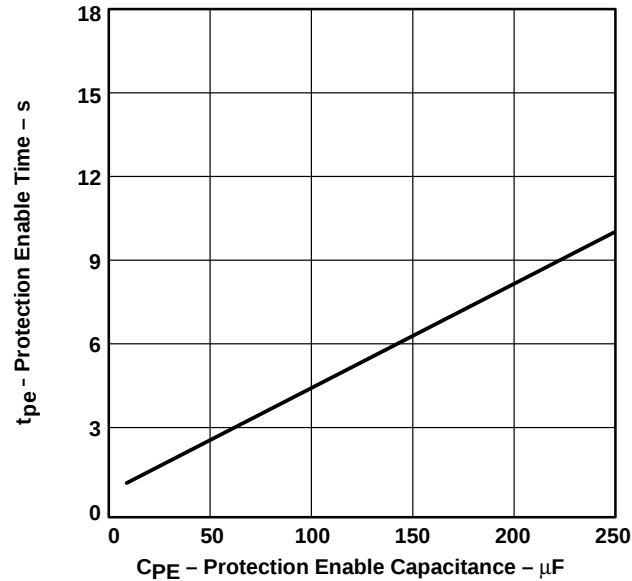


Figure 14

# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### TYPICAL CHARACTERISTICS

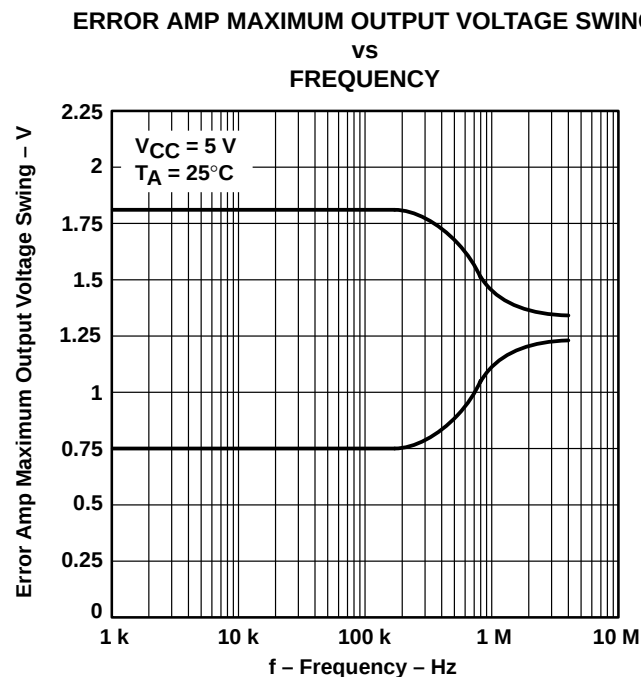


Figure 15

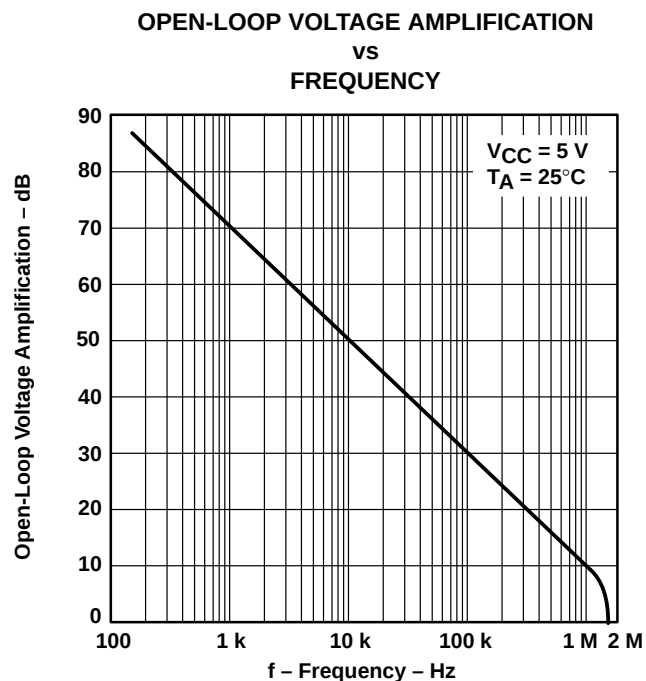


Figure 16

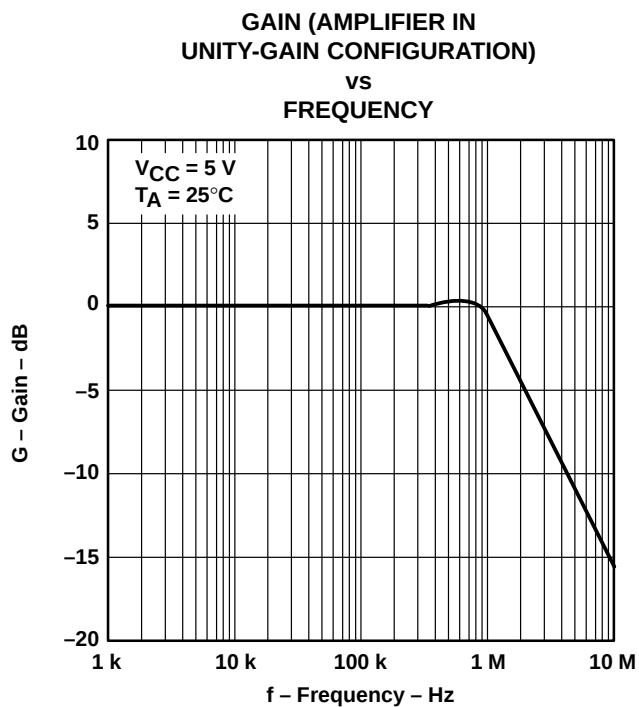
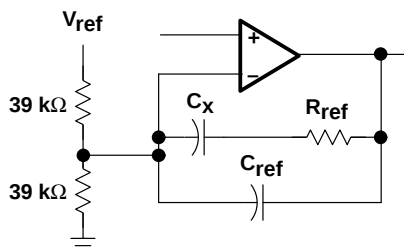
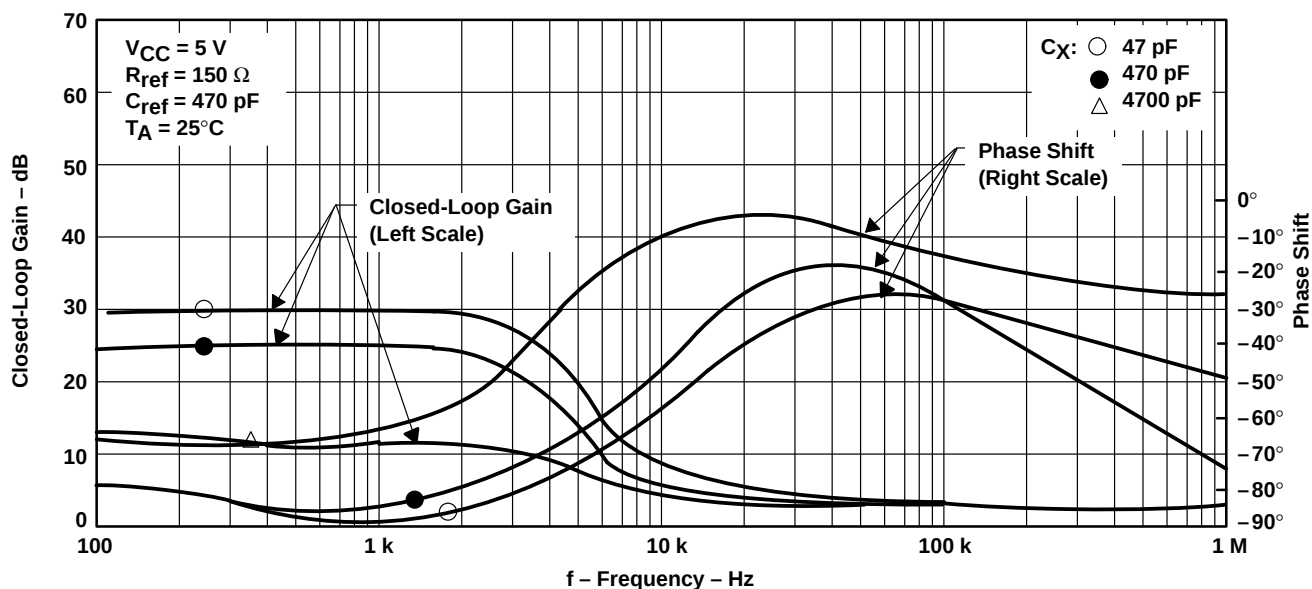


Figure 17

# TYPICAL CHARACTERISTICS

## CLOSED-LOOP GAIN AND PHASE SHIFT VS FREQUENCY



Test Circuit

Figure 18

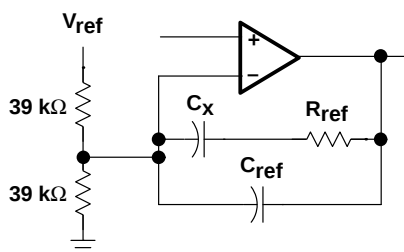
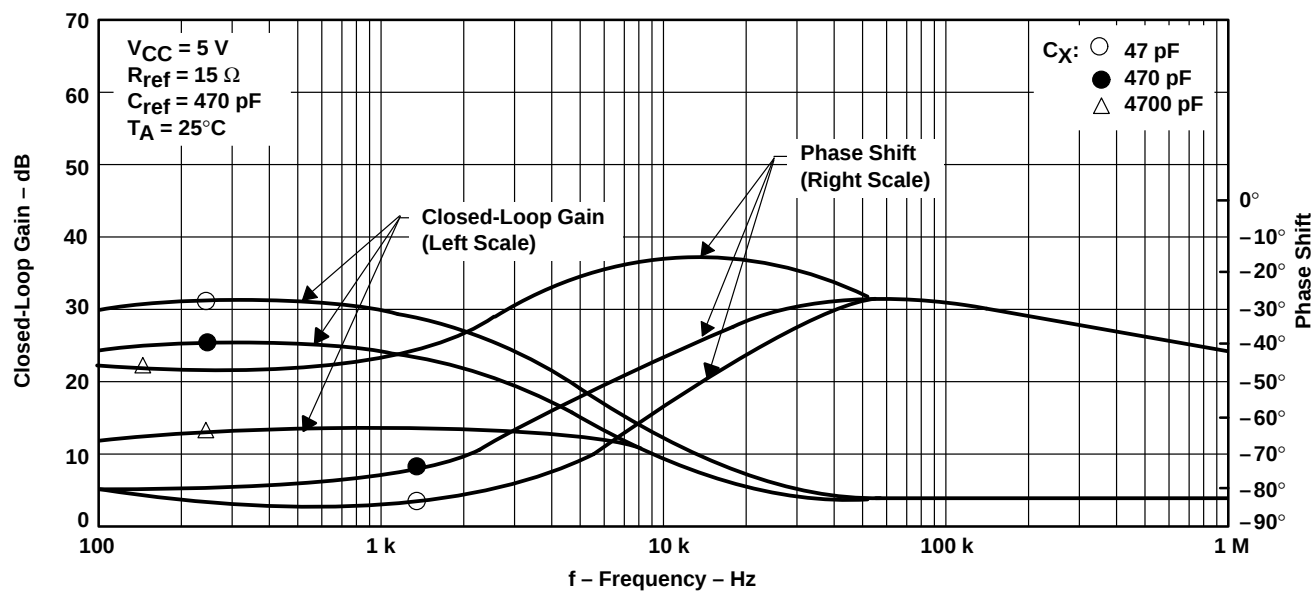
# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### TYPICAL CHARACTERISTICS

#### CLOSED-LOOP GAIN AND PHASE SHIFT VS FREQUENCY

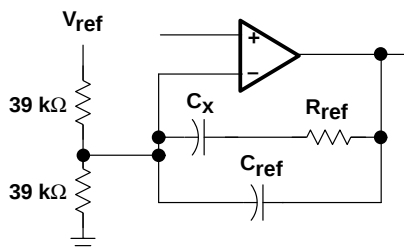
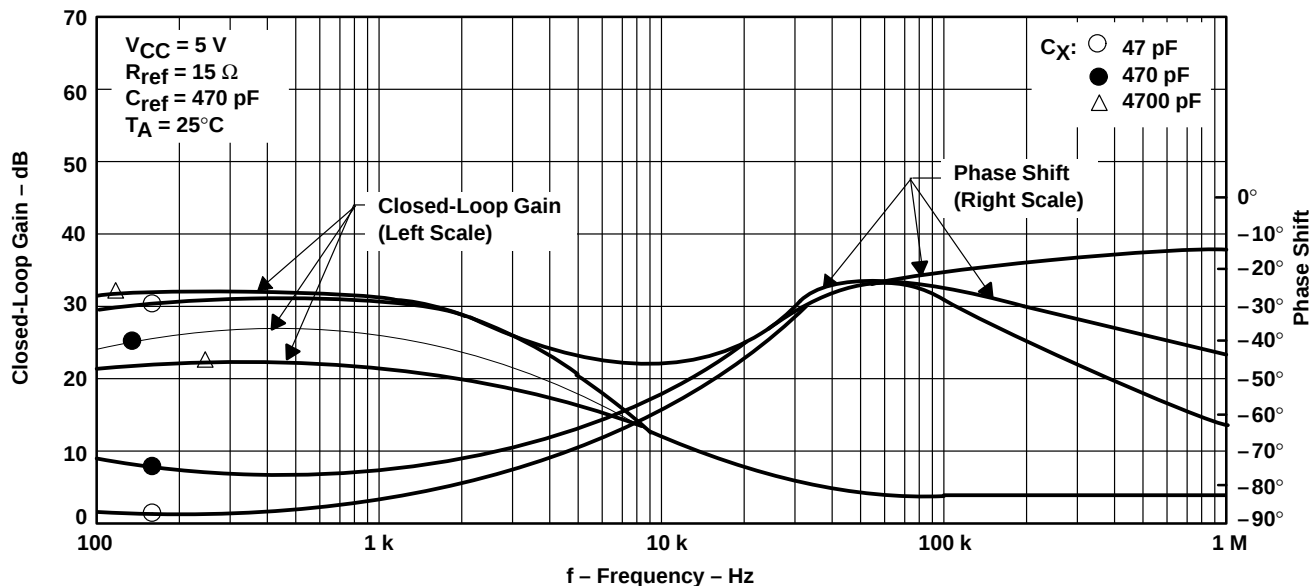


Test Circuit

Figure 19

# TYPICAL CHARACTERISTICS

## CLOSED-LOOP GAIN AND PHASE SHIFT VS FREQUENCY



Test Circuit

Figure 20

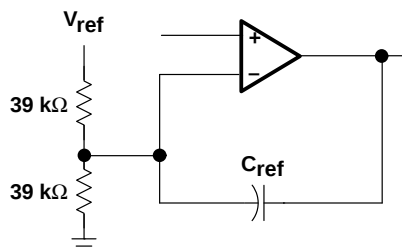
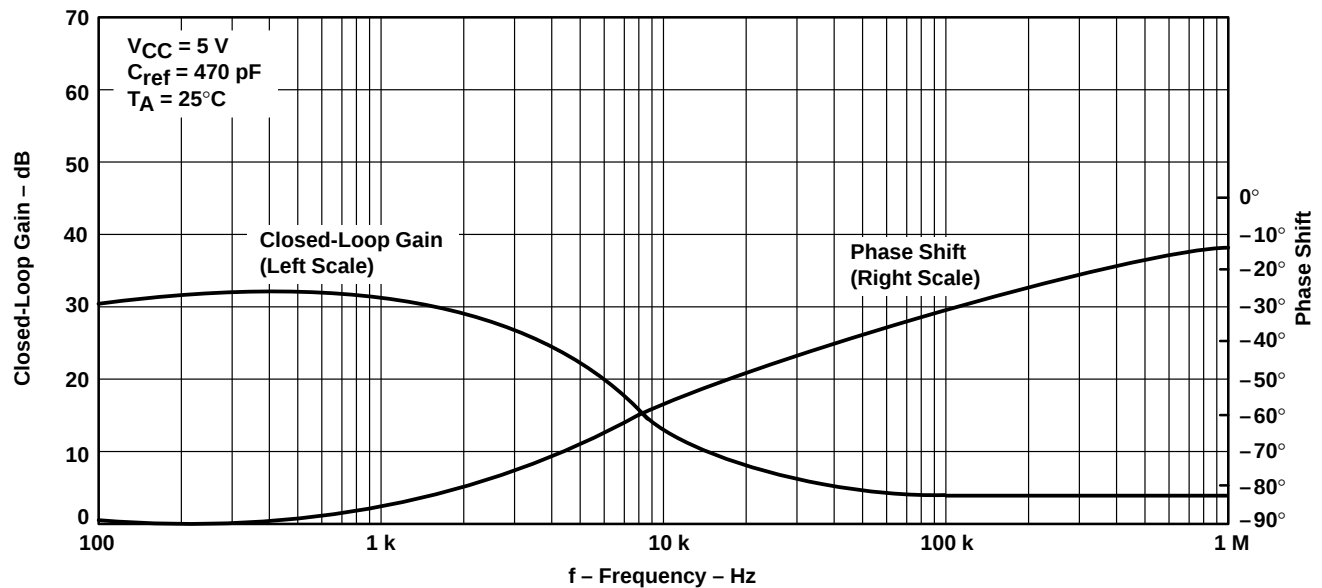
# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### TYPICAL CHARACTERISTICS

#### CLOSED-LOOP GAIN AND PHASE SHIFT VS FREQUENCY



Test Circuit

Figure 21

## TYPICAL CHARACTERISTICS

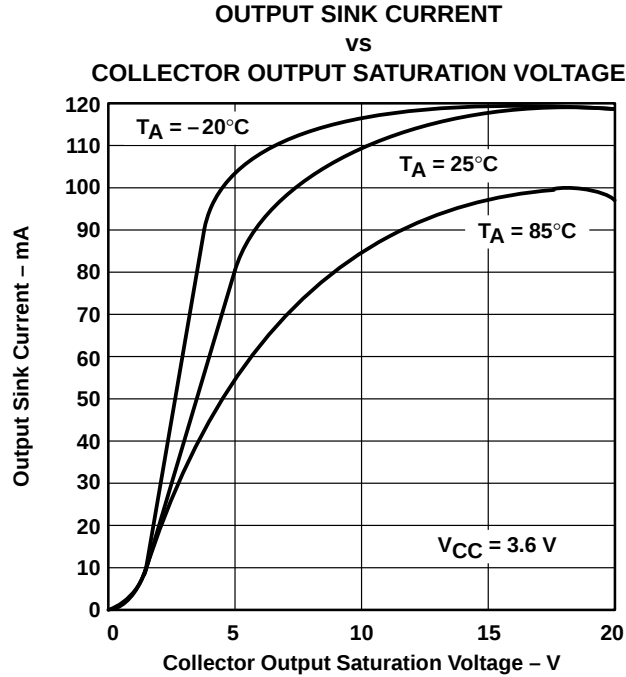


Figure 22

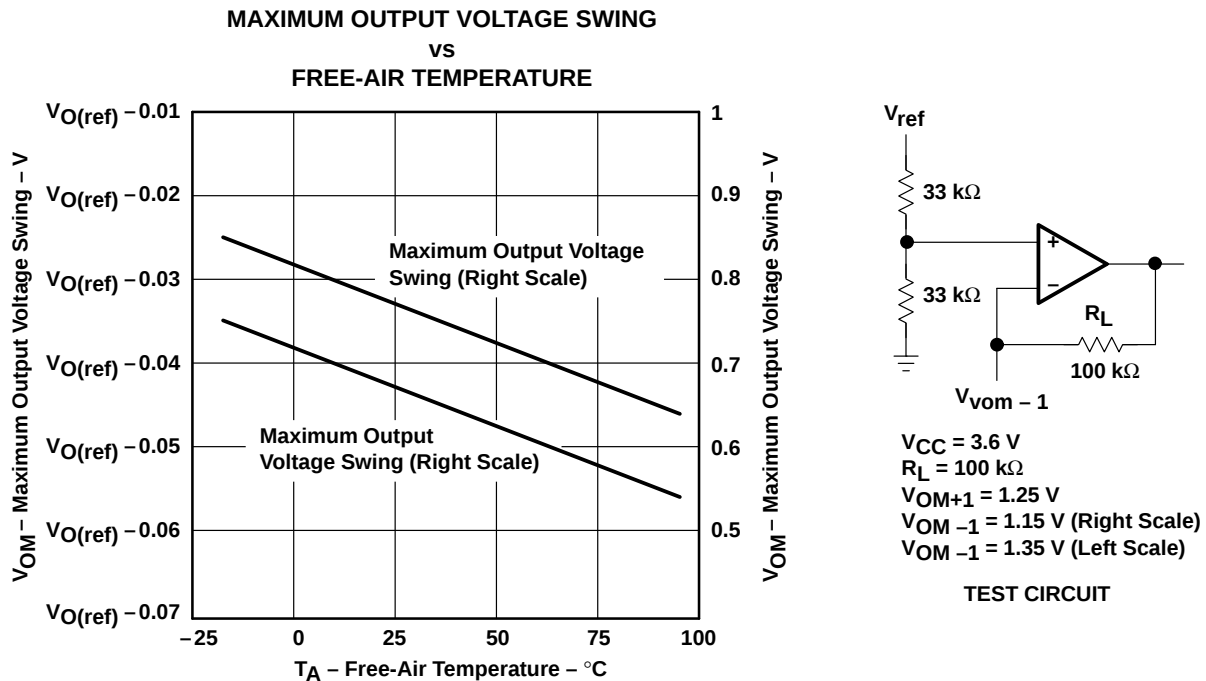


Figure 23

# TL1451AC, TL1451AY

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024C – FEBRUARY 1983 – REVISED OCTOBER 1995

### TYPICAL CHARACTERISTICS

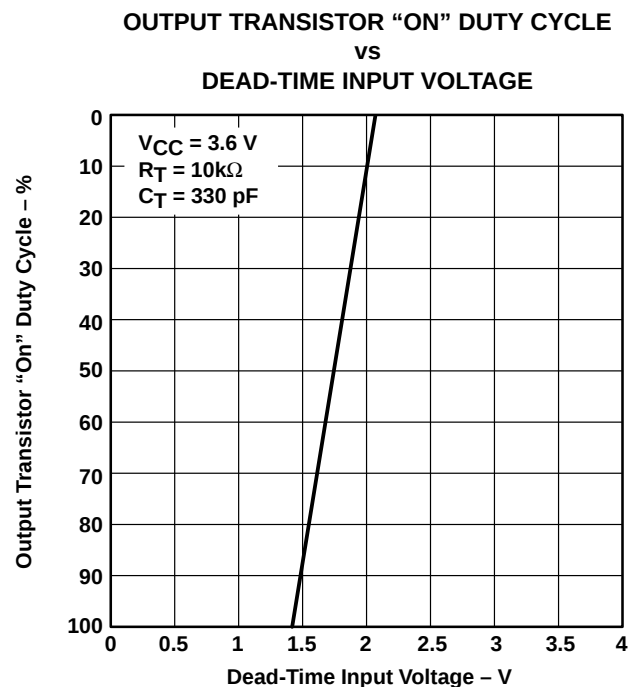


Figure 24

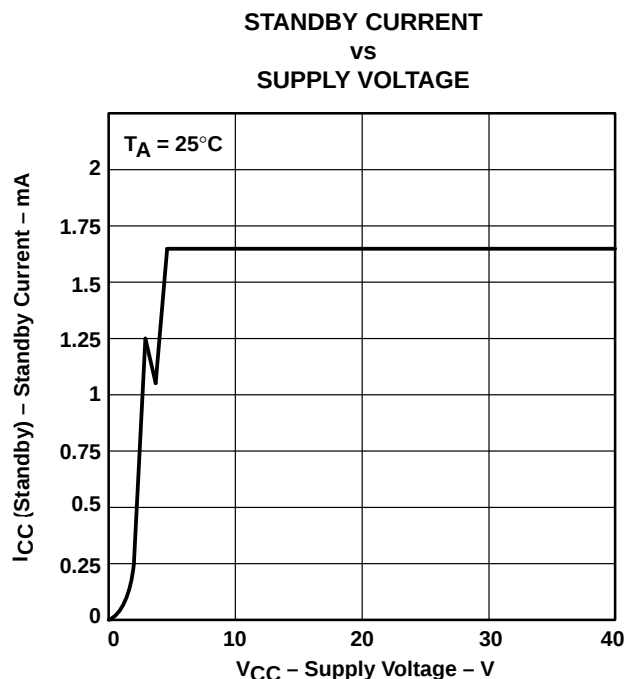


Figure 25

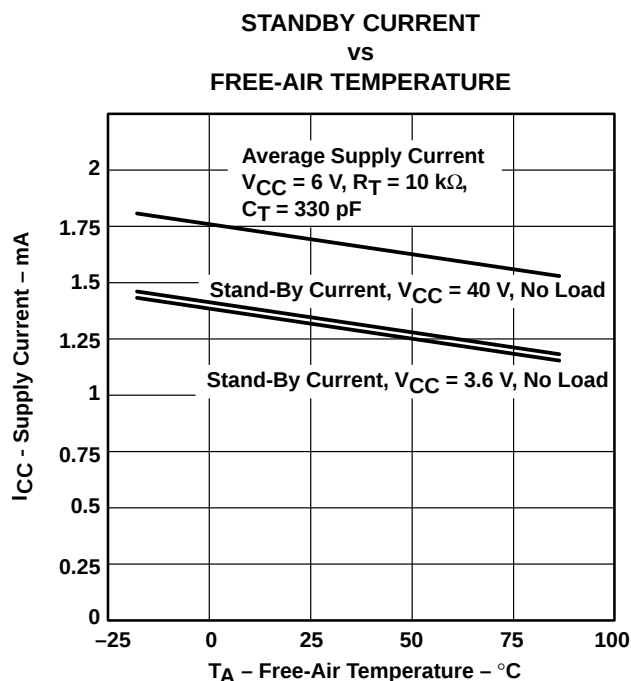


Figure 26

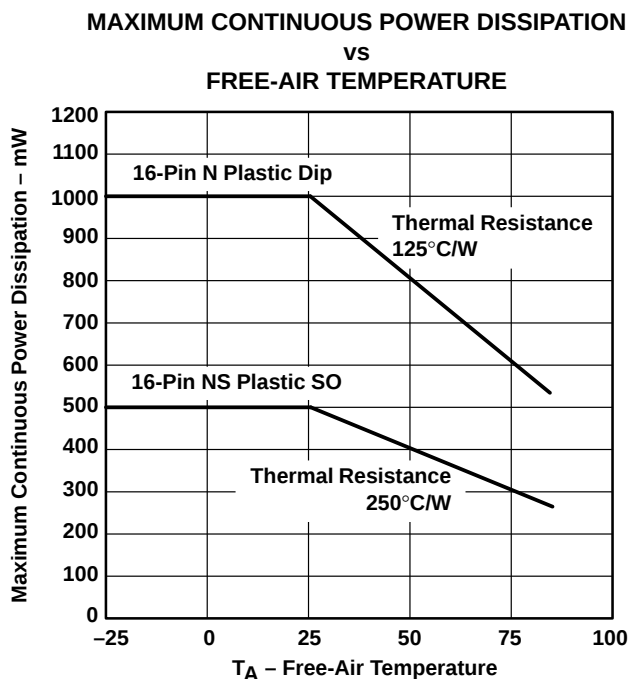
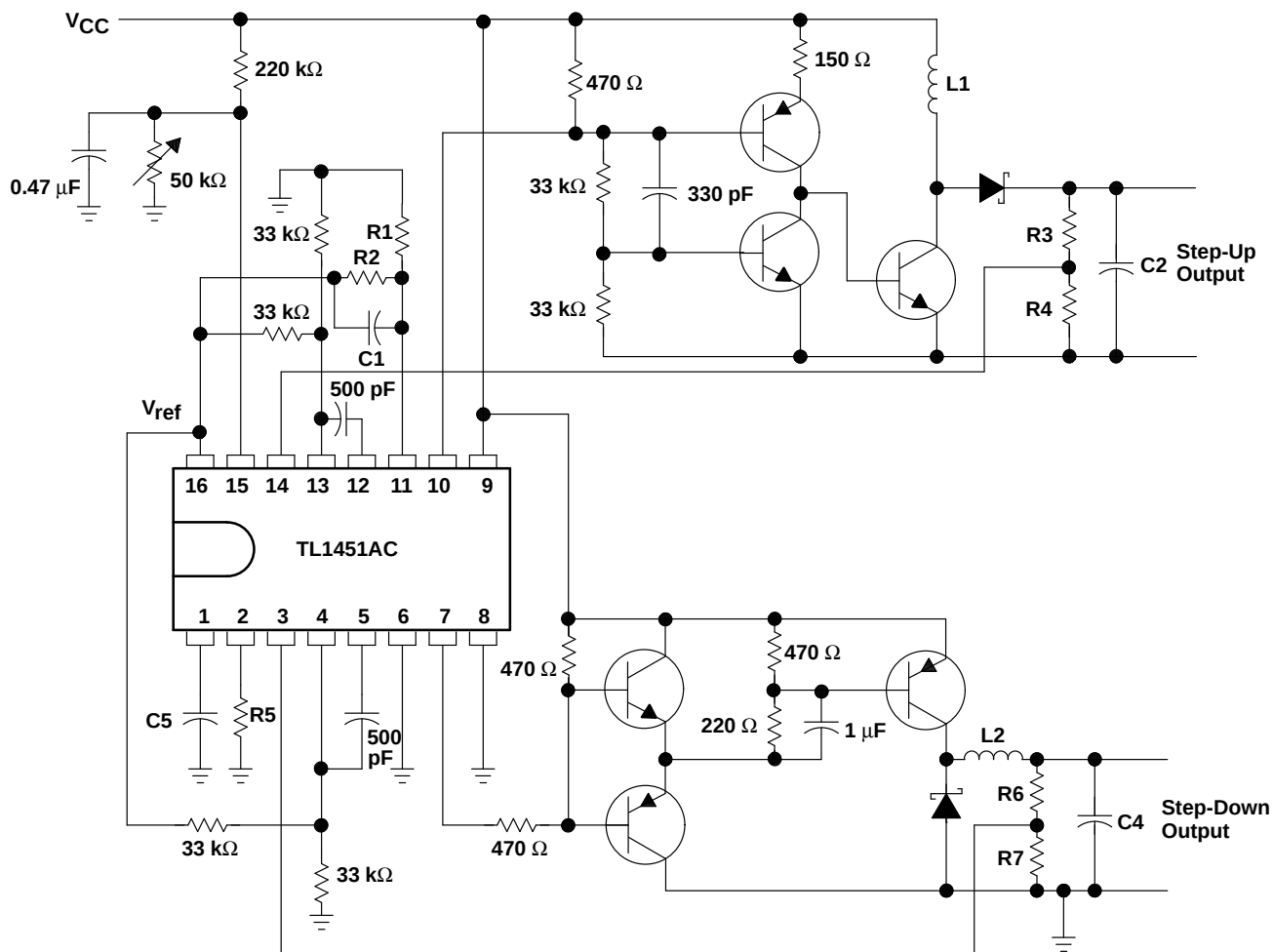


Figure 27

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



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