

# TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

- 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

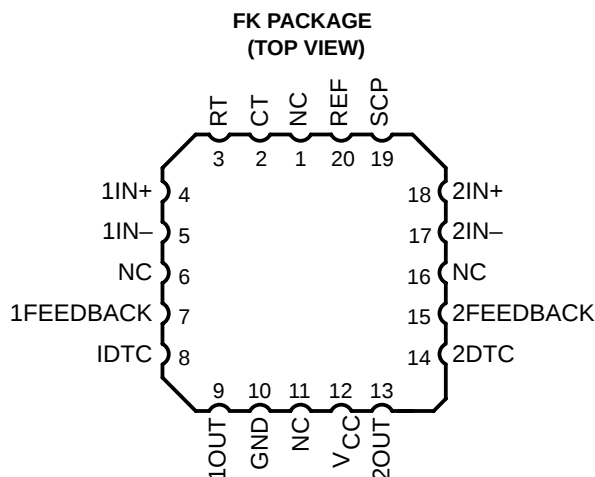
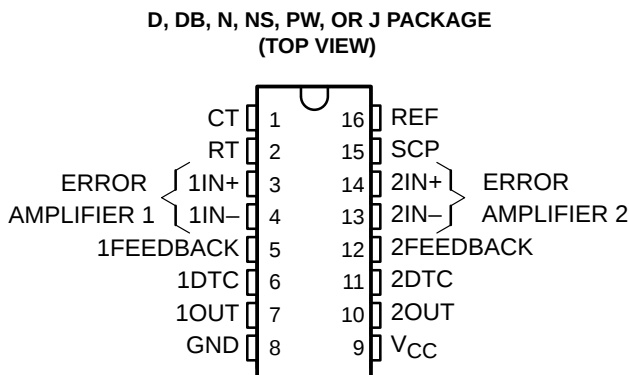
## description

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 TL1451AC is characterized for operation from  $-20^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . The TL1451AQ is characterized for operation from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The TL1451AM is characterized for operation from  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .



## AVAILABLE OPTIONS

| T <sub>A</sub>                                 | PACKAGED DEVICES  |                                 |                 |                    |                         |                   |                 |
|------------------------------------------------|-------------------|---------------------------------|-----------------|--------------------|-------------------------|-------------------|-----------------|
|                                                | SMALL OUTLINE (D) | SMALL OUTLINE (DB) <sup>†</sup> | PLASTIC DIP (N) | SMALL OUTLINE (NS) | TSSOP (PW) <sup>†</sup> | CHIP CARRIER (FK) | CERAMIC DIP (J) |
| $-20^{\circ}\text{C}$ to $85^{\circ}\text{C}$  | TL1451ACD         | TL1451ACDB                      | TL1451ACN       | TL1451ACNS         | TL1451ACPW              | —                 | —               |
| $-40^{\circ}\text{C}$ to $125^{\circ}\text{C}$ | TL1451AQD         | —                               | —               | —                  | —                       | —                 | —               |
| $-55^{\circ}\text{C}$ to $125^{\circ}\text{C}$ | —                 | —                               | —               | —                  | —                       | TL1451AMFK        | TL1451AMJ       |

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



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.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

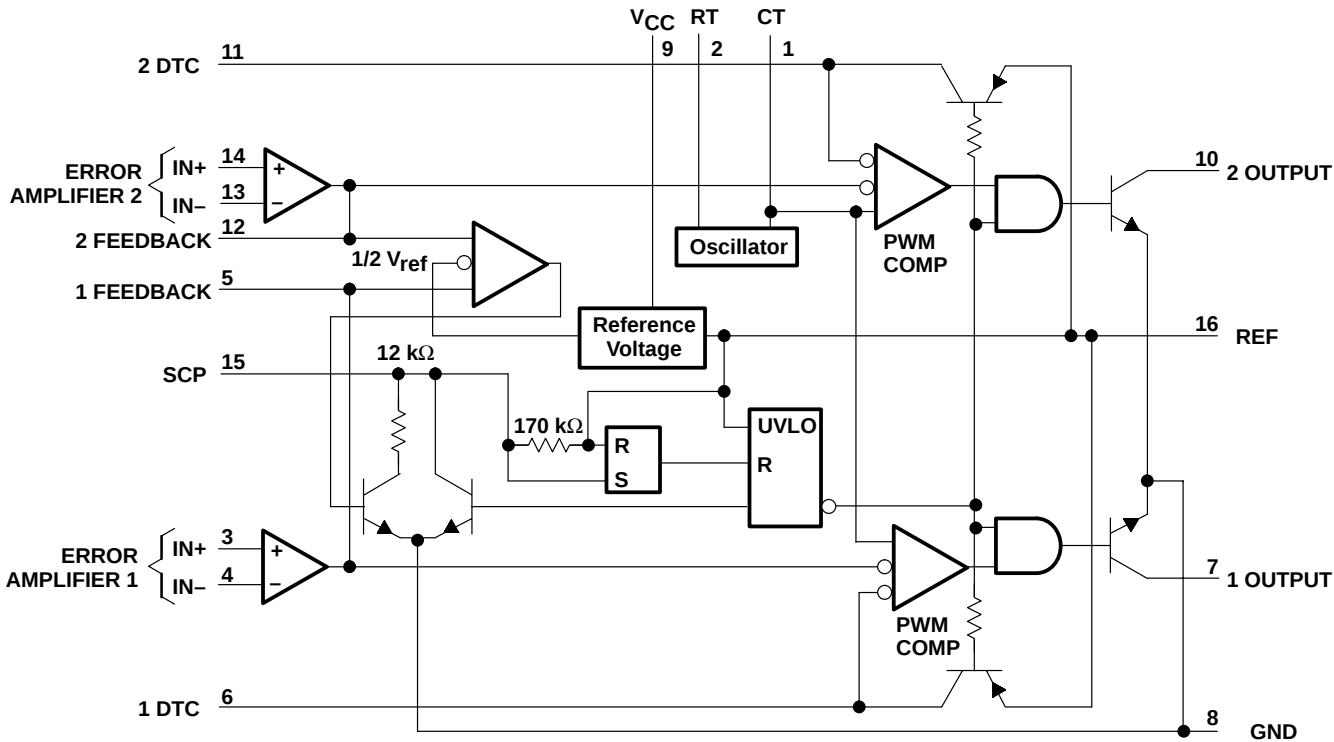
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# TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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functional block diagram



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

# TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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## absolute maximum ratings over operating free-air temperature range<sup>†</sup>

|                                                              |                              |
|--------------------------------------------------------------|------------------------------|
| 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, $T_A$ C suffix         | –20°C to 85°C                |
| Q suffix                                                     | –40°C to 125°C               |
| M suffix                                                     | –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                        |

<sup>†</sup> 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 | $T_A = 125^\circ\text{C}$<br>POWER RATING |
|---------|---------------------------------------------|---------------------------------------------------|------------------------------------------|------------------------------------------|-------------------------------------------|
| D       | 1088 mW                                     | 8.7 mW/°C                                         | 696 mW                                   | 566 mW                                   | 218 mW                                    |
| 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      | 838 mW                                      | 6.7 mW/°C                                         | 536 mW                                   | 436 mW                                   | 168 mW                                    |
| FK      | 1375 mW                                     | 11.0 mW/°C                                        | 880 mW                                   | 715 mW                                   | 275 mW                                    |
| J       | 1375 mW                                     | 11.0 mW/°C                                        | 880 mW                                   | 715 mW                                   | 275 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, $T_A$ | C suffix | –20   | 85   |
|                                       | Q suffix | –40   | 125  |
|                                       | M suffix | –55   | 125  |

# TL1451A

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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

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

### undervoltage lockout section

| PARAMETER                            | TEST CONDITIONS                                                | TL1451AC |      |     | UNIT |
|--------------------------------------|----------------------------------------------------------------|----------|------|-----|------|
|                                      |                                                                | MIN      | TYP† | MAX |      |
| Upper threshold voltage ( $V_{CC}$ ) | $I_{O(\text{ref})} = 0.1\text{ mA}$ , $T_A = 25^\circ\text{C}$ |          | 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    |

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

### short-circuit protection control section

| PARAMETER                               | TEST CONDITIONS                                 | TL1451AC |      |      | UNIT          |
|-----------------------------------------|-------------------------------------------------|----------|------|------|---------------|
|                                         |                                                 | MIN      | TYP† | MAX  |               |
| Input threshold voltage (SCP)           | $T_A = 25^\circ\text{C}$                        | 0.65     | 0.7  | 0.75 | V             |
| Standby voltage (SCP)                   | No pullup                                       | 140      | 185  | 230  | mV            |
| Latched input voltage (SCP)             | No pullup                                       |          | 60   | 120  | mV            |
| Input (source) current                  | $V_I = 0.7\text{ V}$ , $T_A = 25^\circ\text{C}$ | -10      | -15  | -20  | $\mu\text{A}$ |
| Comparator threshold voltage (FEEDBACK) |                                                 |          | 1.18 |      | V             |

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

### oscillator section

| PARAMETER                         | TEST CONDITIONS                                   | TL1451C |       |           | UNIT |
|-----------------------------------|---------------------------------------------------|---------|-------|-----------|------|
|                                   |                                                   | MIN     | TYP†  | MAX       |      |
| Frequency                         | $C_T = 330\text{ pF}$ , $R_T = 10\text{ k}\Omega$ |         | 200   |           | kHz  |
| Standard deviation of frequency   | $C_T = 330\text{ pF}$ , $R_T = 10\text{ k}\Omega$ |         | 10%   |           |      |
| Frequency change with voltage     | $V_{CC} = 3.6\text{ V}$ to $40\text{ V}$          |         | 1%    |           |      |
| Frequency change with temperature | $T_A = -20^\circ\text{C}$ to $25^\circ\text{C}$   |         | -0.4% | $\pm 2\%$ |      |
|                                   | $T_A = 25^\circ\text{C}$ to $85^\circ\text{C}$    |         | -0.2% | $\pm 2\%$ |      |

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

# TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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## dead-time control section

| PARAMETER                                             | TEST CONDITIONS          | TL1451AC |      |      | UNIT |
|-------------------------------------------------------|--------------------------|----------|------|------|------|
|                                                       |                          | MIN      | TYP† | MAX  |      |
| Input bias current (DTC)                              |                          |          |      | 1    | μA   |
| Latch mode (source) current (DTC)                     | $T_A = 25^\circ\text{C}$ | -80      | -145 |      | μA   |
| Latched input voltage (DTC)                           | $I_O = 40\ \mu\text{A}$  | 2.3      |      |      | V    |
| Input threshold voltage at $f = 10\ \text{kHz}$ (DTC) | Zero duty cycle          |          | 2.05 | 2.25 | V    |
|                                                       | Maximum duty cycle       | 1.2      | 1.45 |      |      |

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

## error-amplifier section

| PARAMETER                          | TEST CONDITIONS                                 | TL1451AC           |      |         | UNIT |
|------------------------------------|-------------------------------------------------|--------------------|------|---------|------|
|                                    |                                                 | 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 | nA   |
| Common-mode input voltage range    | $V_{CC} = 3.6\ \text{V to } 40\ \text{V}$       | 1.05<br>to<br>1.45 |      |         | V    |
| Open-loop voltage amplification    | $R_F = 200\ \text{k}\Omega$                     | 70                 | 80   |         | dB   |
| Unity-gain bandwidth               |                                                 |                    | 1.5  |         | MHz  |
| Common-mode rejection ratio        |                                                 | 60                 | 80   |         | dB   |
| Positive output voltage swing      |                                                 | $V_{ref}-0.1$      |      |         | V    |
| Negative output voltage swing      |                                                 |                    |      | 1       | V    |
| Output (sink) current (FEEDBACK)   | $V_{ID} = -0.1\ \text{V}, V_O = 1.25\ \text{V}$ | 0.5                | 1.6  |         | mA   |
| Output (source) current (FEEDBACK) | $V_{ID} = 0.1\ \text{V}, V_O = 1.25\ \text{V}$  | -45                | -70  |         | μA   |

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

## output section

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

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

## pwm comparator section

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

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

## total device

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

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

# TL1451A

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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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                         |                                           | TL1451AQ, TL1451AM |      |      | UNIT |
|----------------------------------------|-----------------------------------------|-------------------------------------------|--------------------|------|------|------|
|                                        |                                         |                                           | MIN                | TYP† | MAX  |      |
| Output voltage (pin 16)                | $I_O = 1\text{ mA}$                     | $T_A = 25^\circ\text{C}$                  | 2.40               | 2.50 | 2.60 | V    |
|                                        |                                         | $T_A = \text{MIN and } 125^\circ\text{C}$ | 2.35               | 2.46 | 2.65 |      |
| Output voltage change with temperature |                                         |                                           | –0.63%    *±4%     |      |      |      |
| Input voltage regulation               | $V_{CC} = 3.6\text{ V to } 40\text{ V}$ | $T_A = 25^\circ\text{C}$                  |                    | 2.0  | 12.5 | mV   |
|                                        |                                         | $T_A = 125^\circ\text{C}$                 |                    | 0.7  | 15   |      |
|                                        |                                         | $T_A = \text{MIN}$                        |                    | 0.3  | 30   |      |
| Output voltage regulation              | $I_O = 0.1\text{ mA to } 1\text{ mA}$   | $T_A = 25^\circ\text{C}$                  |                    | 1.0  | 7.5  | mV   |
|                                        |                                         | $T_A = 125^\circ\text{C}$                 |                    | 0.3  | 14   |      |
|                                        |                                         | $T_A = \text{MIN}$                        |                    | 0.3  | 20   |      |
| Short-circuit output current           | $V_O = 0$                               |                                           | 3                  | 10   | 30   | mA   |

\*These parameters are not production tested.

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

### undervoltage lockout section

| PARAMETER                                  | TEST CONDITIONS |                        | TL1451AQ, TL1451AM |      |     | UNIT |
|--------------------------------------------|-----------------|------------------------|--------------------|------|-----|------|
|                                            |                 |                        | MIN                | TYP† | MAX |      |
| Upper threshold voltage (V <sub>CC</sub> ) |                 | T <sub>A</sub> = 25°C  | 2.72               |      |     | V    |
|                                            |                 | T <sub>A</sub> = 125°C | 1.70               |      |     |      |
|                                            |                 | T <sub>A</sub> = MIN   | 3.15               |      |     |      |
| Lower threshold voltage (V <sub>CC</sub> ) |                 | T <sub>A</sub> = 25°C  | 2.60               |      |     | V    |
|                                            |                 | T <sub>A</sub> = 125°C | 1.65               |      |     |      |
|                                            |                 | T <sub>A</sub> = MIN   | 3.09               |      |     |      |
| Hysteresis (V <sub>CC</sub> )              |                 | T <sub>A</sub> = 25°C  | 80                 | 120  | mV  |      |
|                                            |                 | T <sub>A</sub> = 125°C | 10                 | 50   |     |      |
|                                            |                 | T <sub>A</sub> = MIN   | 10                 | 60   |     |      |
| Reset threshold voltage (V <sub>CC</sub> ) |                 | T <sub>A</sub> = 25°C  | 1.50               |      |     | V    |
|                                            |                 | T <sub>A</sub> = 125°C | 0.95               |      |     |      |
|                                            |                 | T <sub>A</sub> = MIN   | 1.50               |      |     |      |

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

# TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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## short-circuit protection control section

| PARAMETER                               | TEST CONDITIONS           | TL1451AQ, TL1451AM |      |     | UNIT       |
|-----------------------------------------|---------------------------|--------------------|------|-----|------------|
|                                         |                           | MIN                | TYP† | MAX |            |
| Input threshold voltage (SCP)           | $T_A = 25^\circ\text{C}$  | 650                | 700  | 750 | mV         |
|                                         | $T_A = 125^\circ\text{C}$ | 400                | 478  | 550 |            |
|                                         | $T_A = \text{MIN}$        | 800                | 880  | 950 |            |
| Standby voltage (SCP)                   |                           | 140                | 185  | 230 | mV         |
| Latched input voltage (SCP)             | $T_A = 25^\circ\text{C}$  |                    | 60   | 120 | mV         |
|                                         | $T_A = 125^\circ\text{C}$ |                    | 70   | 120 |            |
|                                         | $T_A = \text{MIN}$        |                    | 60   | 120 |            |
| Equivalent timing resistance            |                           |                    | 170  |     | k $\Omega$ |
| Comparator threshold voltage (FEEDBACK) |                           |                    | 1.18 |     | V          |

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

## oscillator section

| PARAMETER                         | TEST CONDITIONS                                      |                           | TL1451AQ, TL1451AM |       |            | UNIT |
|-----------------------------------|------------------------------------------------------|---------------------------|--------------------|-------|------------|------|
|                                   |                                                      |                           | MIN                | TYP†  | MAX        |      |
| Frequency                         | $C_T = 330\text{ pF}$ ,<br>$R_T = 10\text{ k}\Omega$ | $T_A = 25^\circ\text{C}$  |                    | 200   |            | kHz  |
|                                   |                                                      | $T_A = 125^\circ\text{C}$ |                    | 195   |            |      |
|                                   |                                                      | $T_A = \text{MIN}$        |                    | 193   |            |      |
| Standard deviation of frequency   | $C_T = 330\text{ pF}$ , $R_T = 10\text{ k}\Omega$    |                           |                    | 2%    |            |      |
| Frequency change with voltage     | $V_{CC} = 3.6\text{ V to }40\text{ V}$               | $T_A = 25^\circ\text{C}$  |                    | 1%    |            |      |
|                                   |                                                      | $T_A = 125^\circ\text{C}$ |                    | 1%    |            |      |
|                                   |                                                      | $T_A = \text{MIN}$        |                    | 3%    |            |      |
| Frequency change with temperature |                                                      |                           |                    | 1.37% | $\pm 10\%$ |      |

\*These parameters are not production tested.

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

## dead-time control section

| PARAMETER                                            | TEST CONDITIONS                           | TL1451AQ, TL1451AM |      |       | UNIT          |
|------------------------------------------------------|-------------------------------------------|--------------------|------|-------|---------------|
|                                                      |                                           | MIN                | TYP† | MAX   |               |
| Input bias current (DTC)                             | $T_A = 25^\circ\text{C}$                  |                    |      | 1     | $\mu\text{A}$ |
|                                                      | $T_A = \text{MIN and } 125^\circ\text{C}$ |                    |      | 3     |               |
| Latch mode (source) current (DTC)                    |                                           | -80                | -145 |       | $\mu\text{A}$ |
| Latched input voltage (DTC)                          | $T_A = 25^\circ\text{C}$                  | 2.30               |      |       | V             |
|                                                      | $T_A = 125^\circ\text{C}$                 | 2.22               | 2.32 |       |               |
|                                                      | $T_A = \text{MIN}$                        | 2.28               | 2.40 |       |               |
| Input threshold voltage at $f = 10\text{ kHz}$ (DTC) | Zero duty cycle                           |                    | 2.05 | *2.25 | V             |
|                                                      | Maximum duty cycle                        | *1.20              | 1.45 |       |               |

\*These parameters are not production tested.

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

# TL1451A

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### error-amplifier section

| PARAMETER                          | TEST CONDITIONS                                 | TL1451AQ, TL1451AM        |                  |      | UNIT          |
|------------------------------------|-------------------------------------------------|---------------------------|------------------|------|---------------|
|                                    |                                                 | MIN                       | TYP <sup>†</sup> | MAX  |               |
| Input offset voltage               | $V_O$ (FEEDBACK) = 1.25 V                       | $T_A = 25^\circ\text{C}$  |                  | ±6   | mV            |
|                                    |                                                 | $T_A = 125^\circ\text{C}$ |                  | ±10  |               |
|                                    |                                                 | $T_A = \text{MIN}$        |                  | ±12  |               |
| Input offset current               | $V_O$ (FEEDBACK) = 1.25 V                       | $T_A = 25^\circ\text{C}$  |                  | ±100 | nA            |
|                                    |                                                 | $T_A = 125^\circ\text{C}$ |                  | ±100 |               |
|                                    |                                                 | $T_A = \text{MIN}$        |                  | ±200 |               |
| Input bias current                 | $V_O$ (FEEDBACK) = 1.25 V                       | $T_A = 25^\circ\text{C}$  | 160              | 500  | nA            |
|                                    |                                                 | $T_A = 125^\circ\text{C}$ | 100              | 500  |               |
|                                    |                                                 | $T_A = \text{MIN}$        | 142              | 700  |               |
| Common-mode input voltage range    | $V_{CC} = 3.6 \text{ V to } 40 \text{ V}$       | 1.05<br>to<br>1.45        |                  |      | V             |
| Open-loop voltage amplification    | $R_F = 200 \text{ k}\Omega$                     | $T_A = 25^\circ\text{C}$  | 70               | 80   | dB            |
|                                    |                                                 | $T_A = 125^\circ\text{C}$ | 70               | 80   |               |
|                                    |                                                 | $T_A = \text{MIN}$        | 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)   | $V_{ID} = -0.1 \text{ V}, V_O = 1.25 \text{ V}$ | $T_A = 25^\circ\text{C}$  | 0.5              | 1.6  | mA            |
|                                    |                                                 | $T_A = 125^\circ\text{C}$ | 0.4              | 1.8  |               |
|                                    |                                                 | $T_A = \text{MIN}$        | 0.3              | 1.7  |               |
| Output (source) current (FEEDBACK) | $V_{ID} = 0.1 \text{ V}, V_O = 1.25 \text{ V}$  | $T_A = 25^\circ\text{C}$  | -45              | -70  | $\mu\text{A}$ |
|                                    |                                                 | $T_A = 125^\circ\text{C}$ | -25              | -50  |               |
|                                    |                                                 | $T_A = \text{MIN}$        | -15              | -70  |               |

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

### output section

| PARAMETER                    | TEST CONDITIONS           | TL1451AQ, TL1451AM |                  |     | UNIT          |
|------------------------------|---------------------------|--------------------|------------------|-----|---------------|
|                              |                           | MIN                | TYP <sup>†</sup> | MAX |               |
| Collector off-state current  | $V_O = 50 \text{ V}$      |                    |                  | 10  | $\mu\text{A}$ |
| Output saturation voltage    | $T_A = 25^\circ\text{C}$  |                    | 1.20             | 2.0 | V             |
|                              | $T_A = 125^\circ\text{C}$ |                    | 1.60             | 2.4 |               |
|                              | $T_A = \text{MIN}$        |                    | 1.36             | 2.2 |               |
| Short-circuit output current | $V_O = 6 \text{ V}$       |                    | 90               |     | mA            |

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

### pwm comparator section

| PARAMETER                                                  | TEST CONDITIONS    | TL1451AQ, TL1451AM |                  |       | UNIT |
|------------------------------------------------------------|--------------------|--------------------|------------------|-------|------|
|                                                            |                    | MIN                | TYP <sup>†</sup> | MAX   |      |
| Input threshold voltage at $f = 10 \text{ kHz}$ (FEEDBACK) | Zero duty cycle    |                    | 2.05             | *2.25 | V    |
|                                                            | Maximum duty cycle | *1.20              | 1.45             |       |      |

\*These parameters are not production tested.

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

# TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

## total device

| PARAMETER              | TEST CONDITIONS           | TL1451AQ, TL1451AM |                  |     | UNIT |
|------------------------|---------------------------|--------------------|------------------|-----|------|
|                        |                           | MIN                | TYP <sup>†</sup> | MAX |      |
| Standby supply current | Off-state                 |                    | 1.3              | 1.8 | mA   |
| Average supply current | $R_T = 10\text{ k}\Omega$ |                    | 1.7              | 2.4 | mA   |

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

## PARAMETER MEASUREMENT INFORMATION

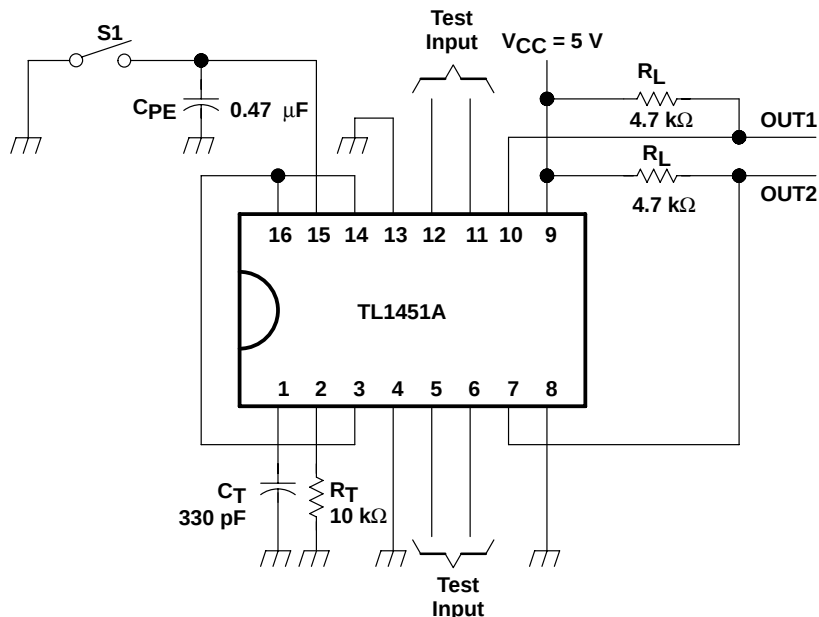
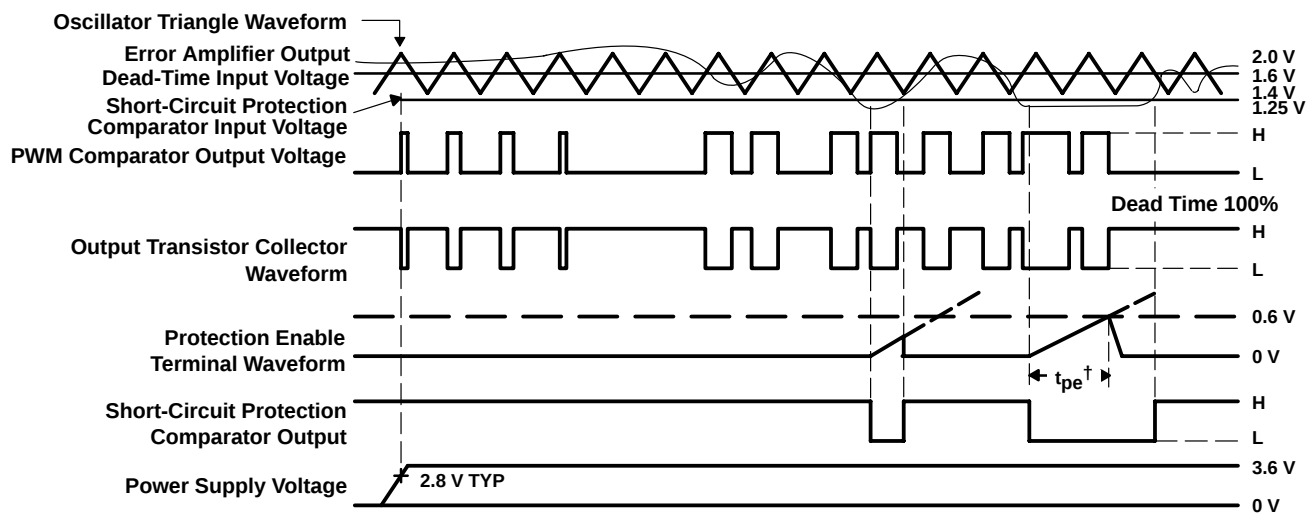


Figure 1. Test Circuit



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

Figure 2. TL1451A Timing Diagram

# TL1451A

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

### TYPICAL CHARACTERISTICS

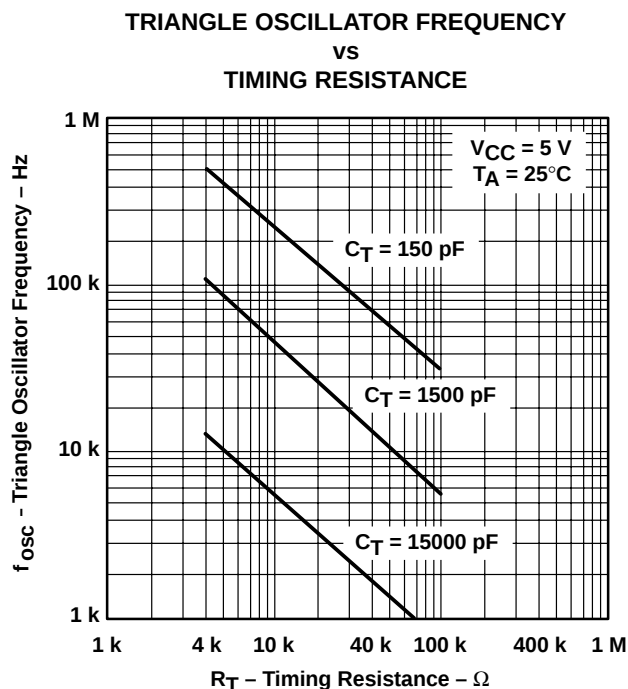


Figure 3

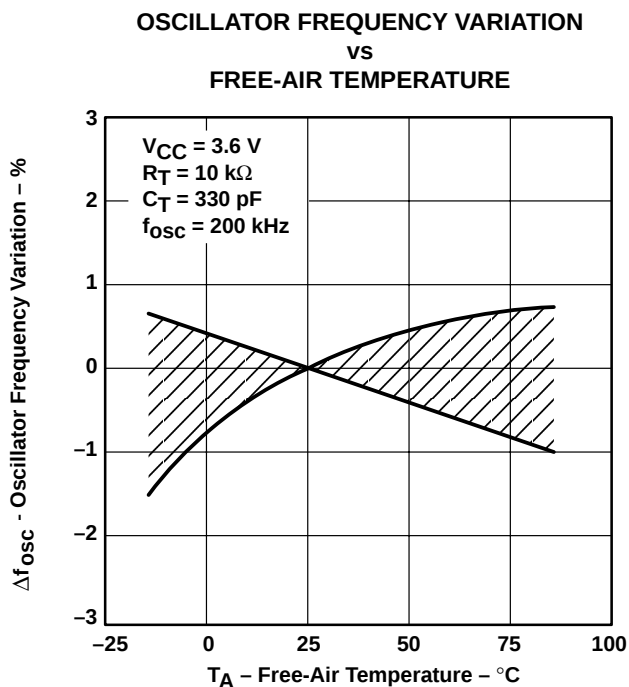


Figure 4

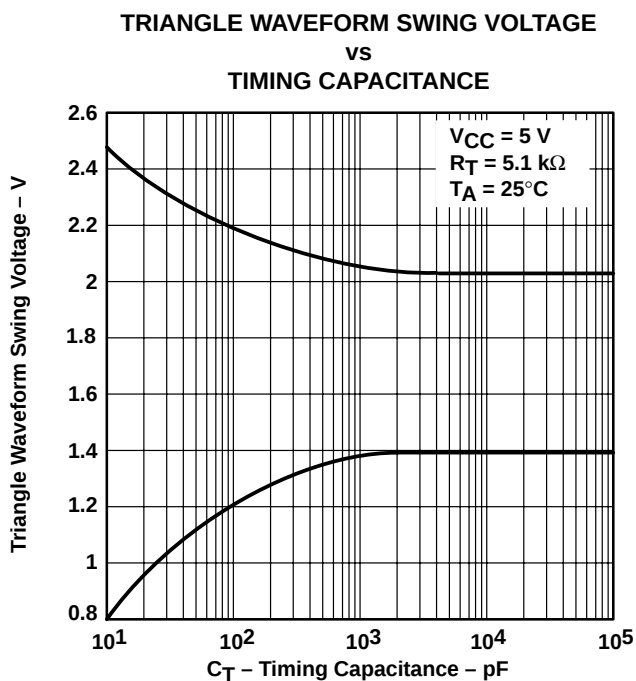


Figure 5

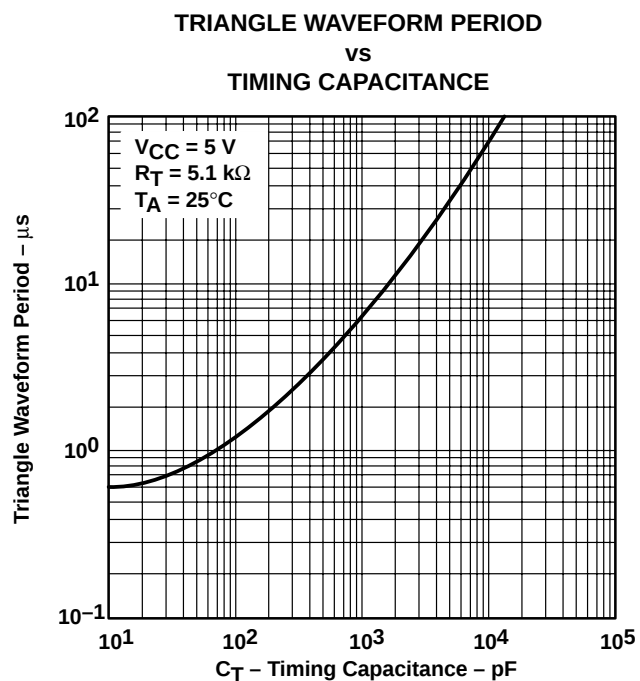


Figure 6

### TYPICAL CHARACTERISTICS

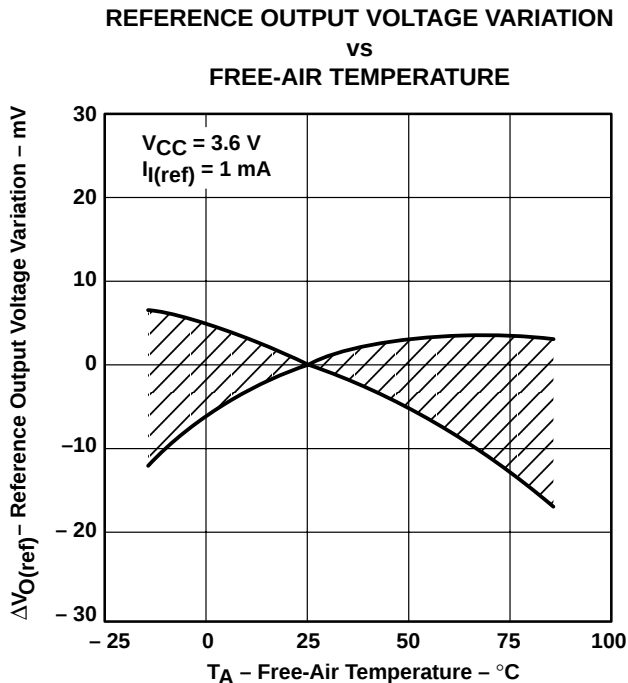


Figure 7

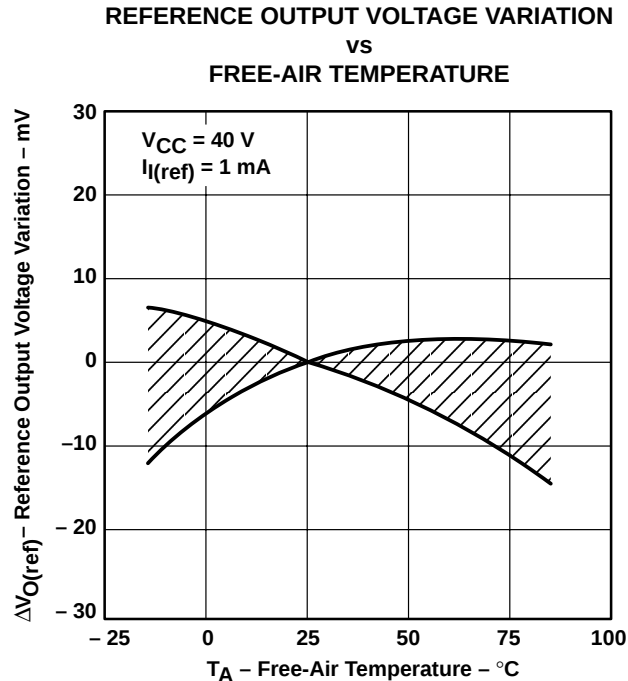


Figure 8

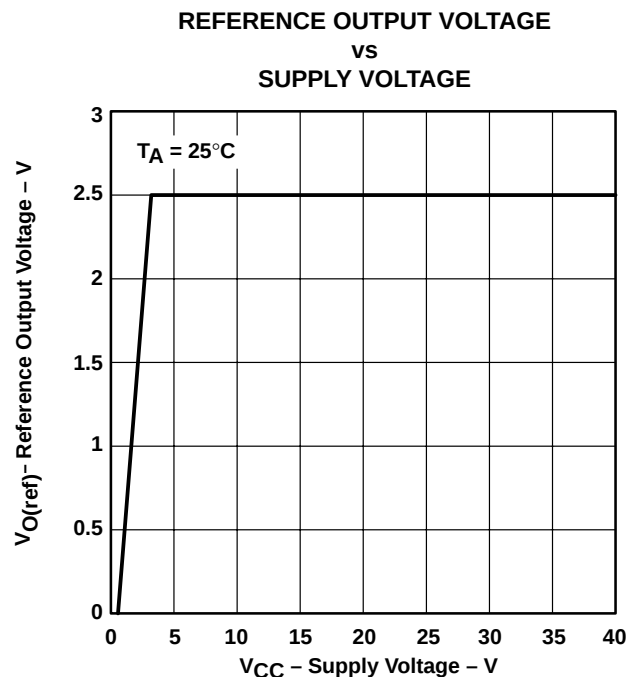


Figure 9

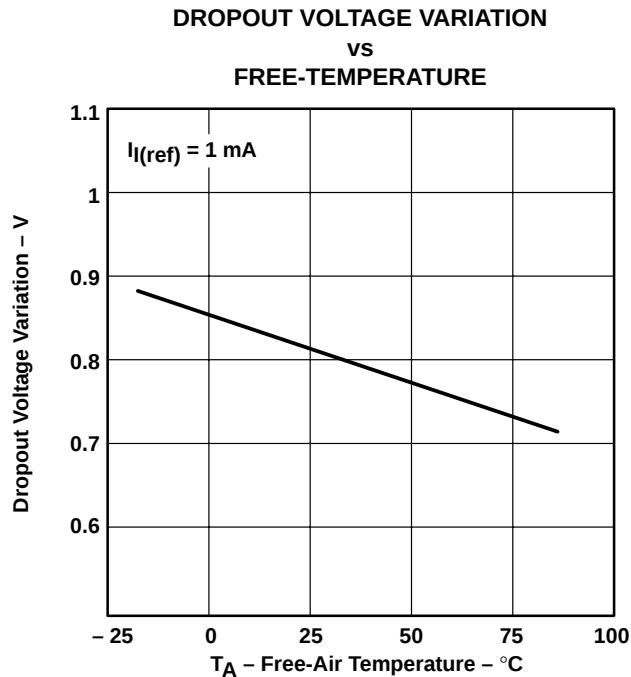


Figure 10

# TL1451A

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

### TYPICAL CHARACTERISTICS

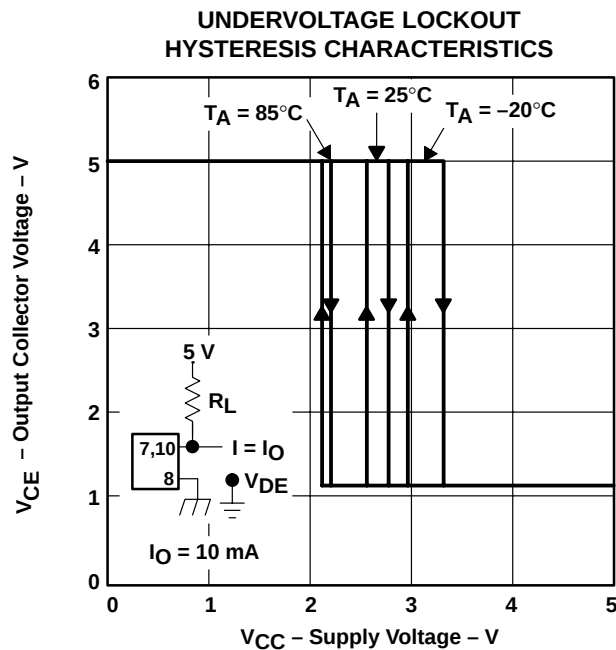


Figure 11

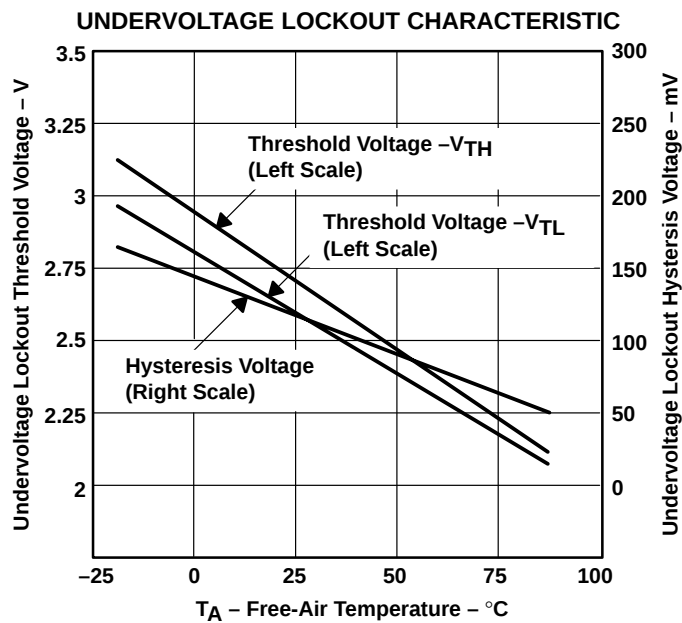


Figure 12

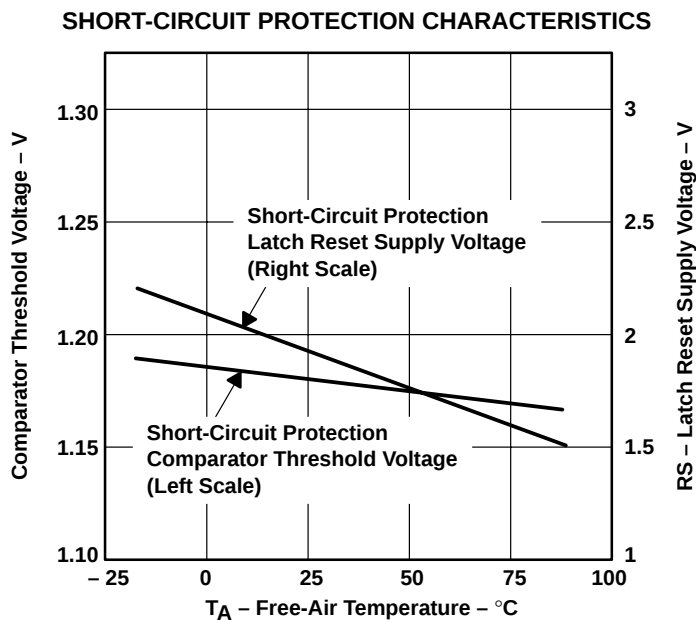


Figure 13

TYPICAL CHARACTERISTICS

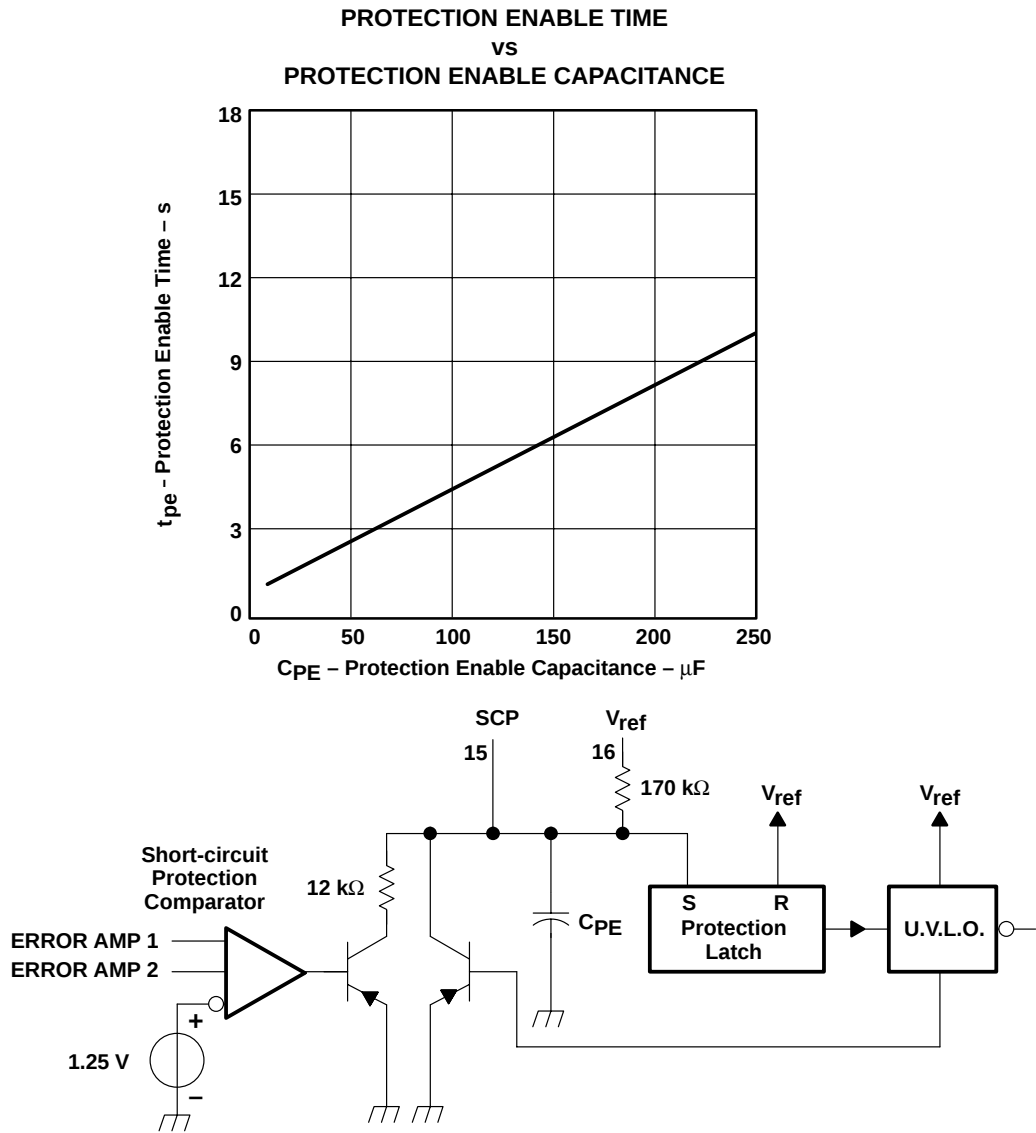


Figure 14

# TL1451A

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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### TYPICAL CHARACTERISTICS

ERROR AMP MAXIMUM OUTPUT VOLTAGE SWING

VS  
FREQUENCY

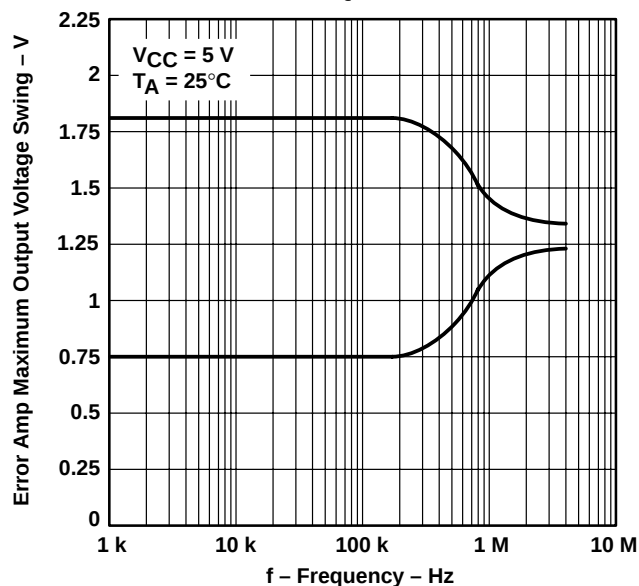


Figure 15

OPEN-LOOP VOLTAGE AMPLIFICATION

VS  
FREQUENCY

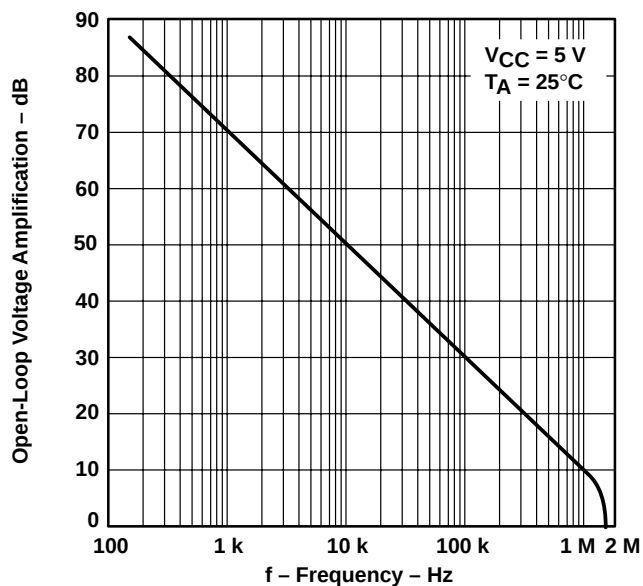


Figure 16

GAIN (AMPLIFIER IN  
UNITY-GAIN CONFIGURATION)

VS  
FREQUENCY

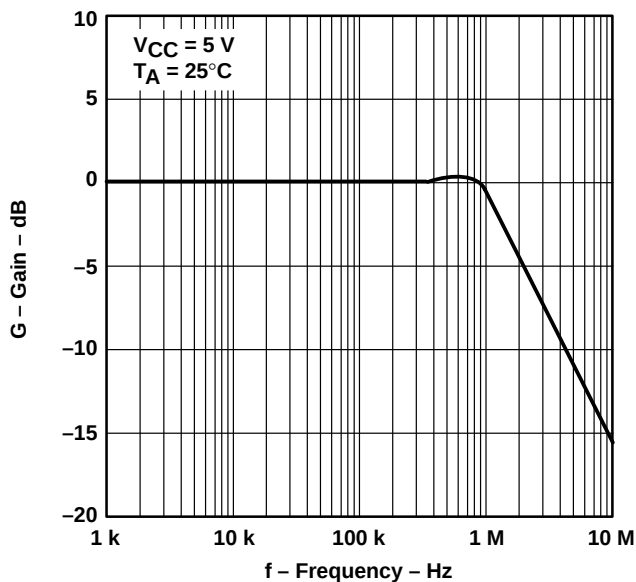
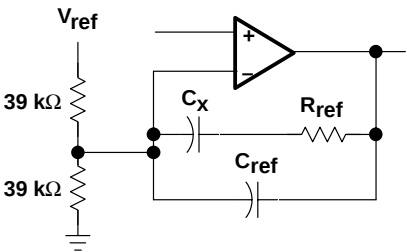
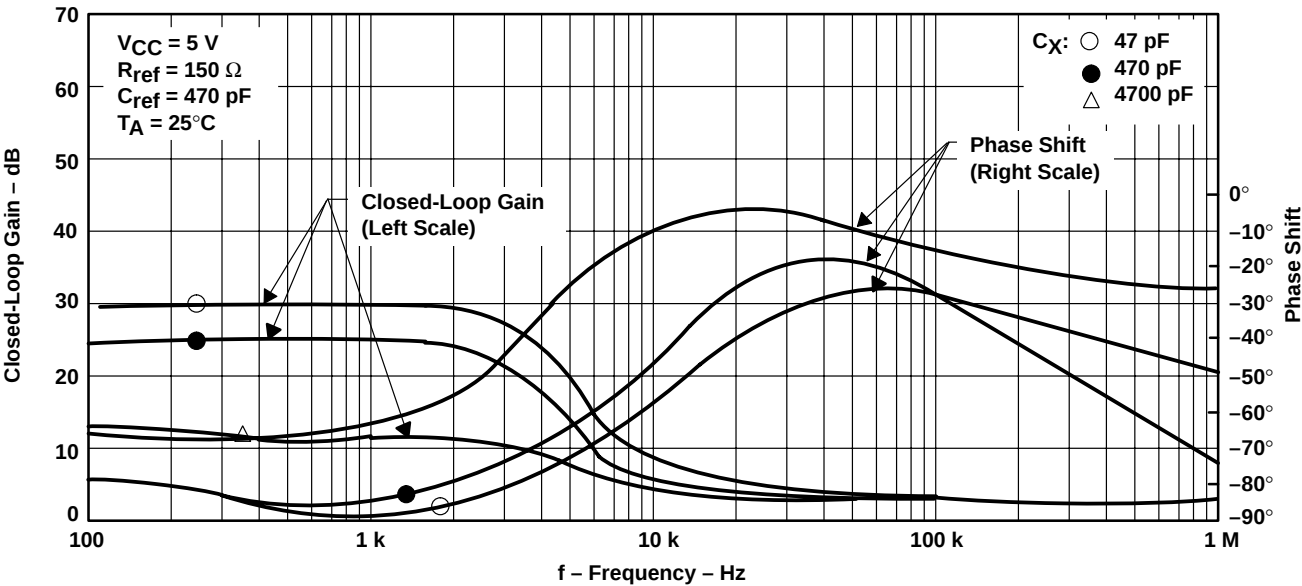


Figure 17

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT  
VS  
FREQUENCY



Test Circuit

Figure 18

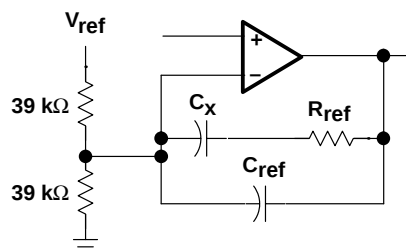
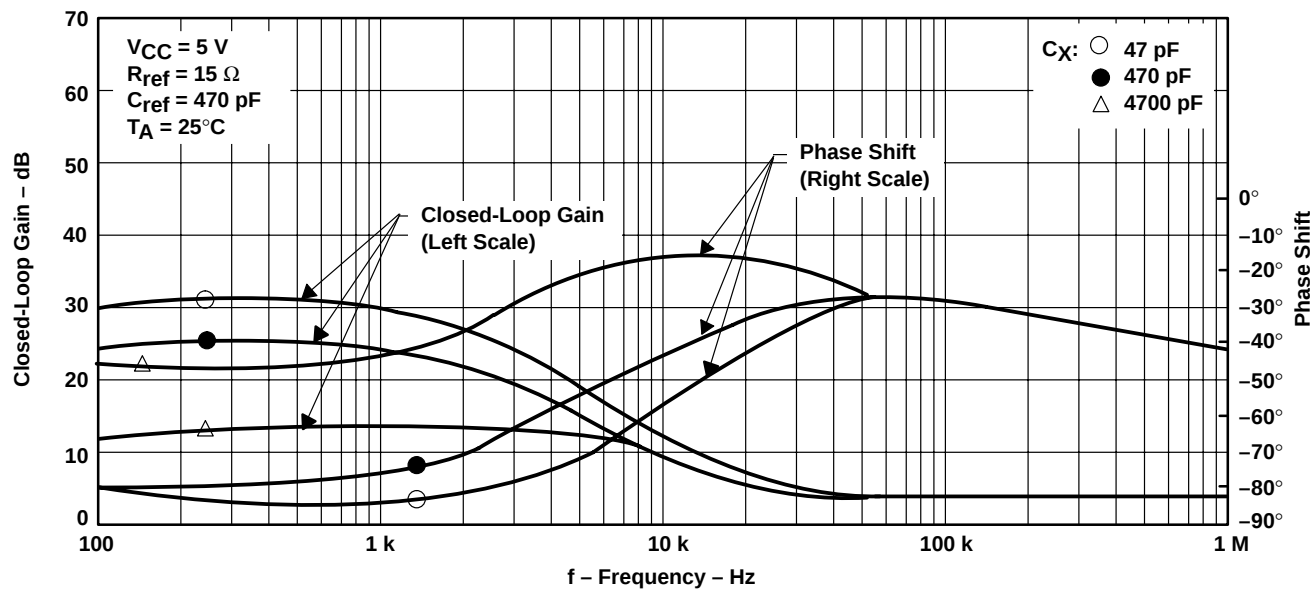
# TL1451A

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

### TYPICAL CHARACTERISTICS

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

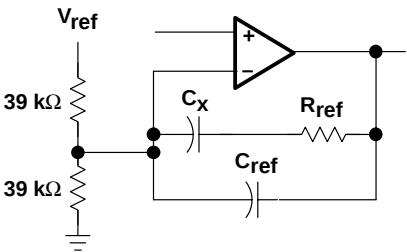
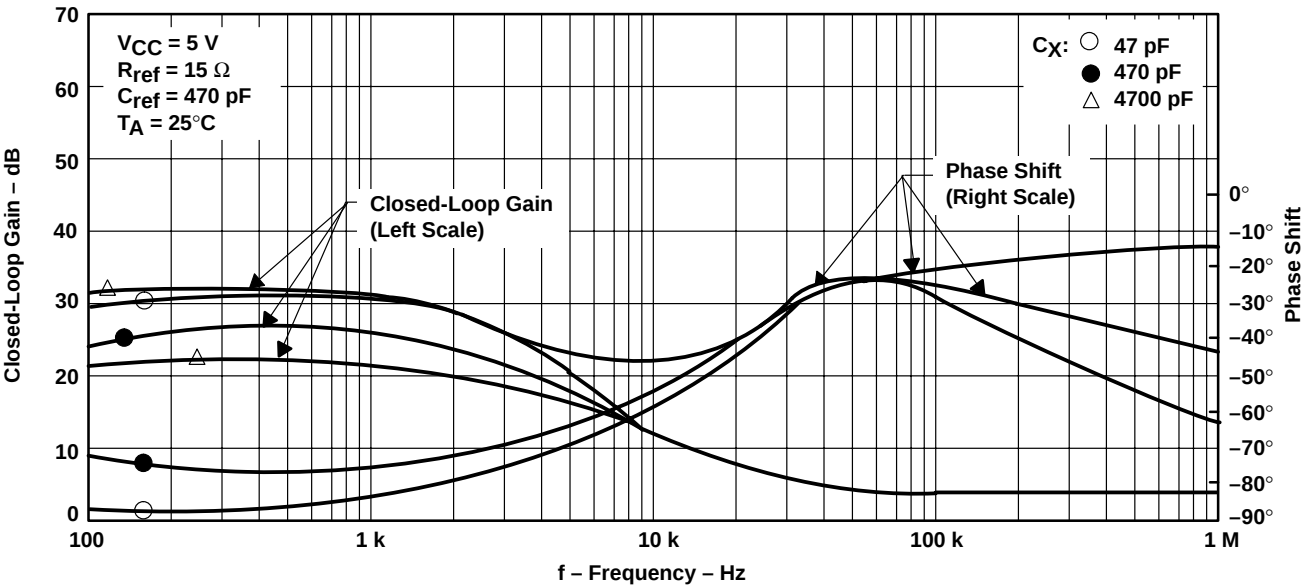


Test Circuit

Figure 19

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT  
VS  
FREQUENCY



Test Circuit

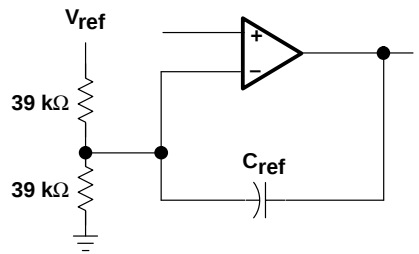
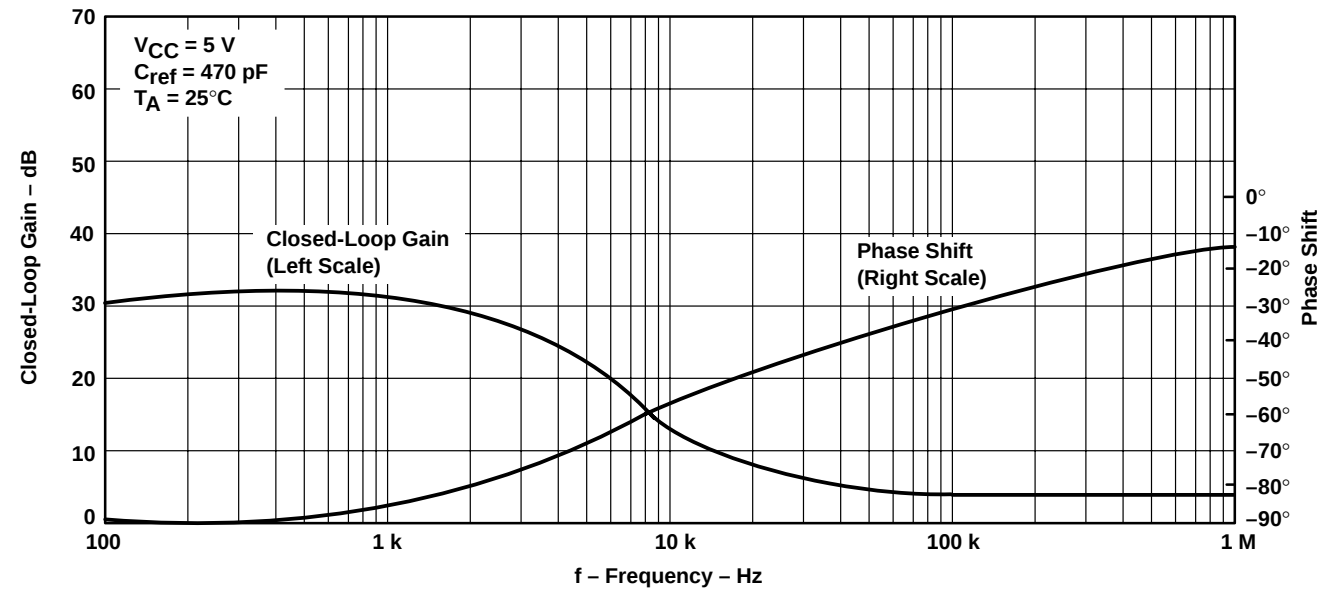
Figure 20

TL1451A  
DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT  
vs  
FREQUENCY



Test Circuit

Figure 21

### TYPICAL CHARACTERISTICS

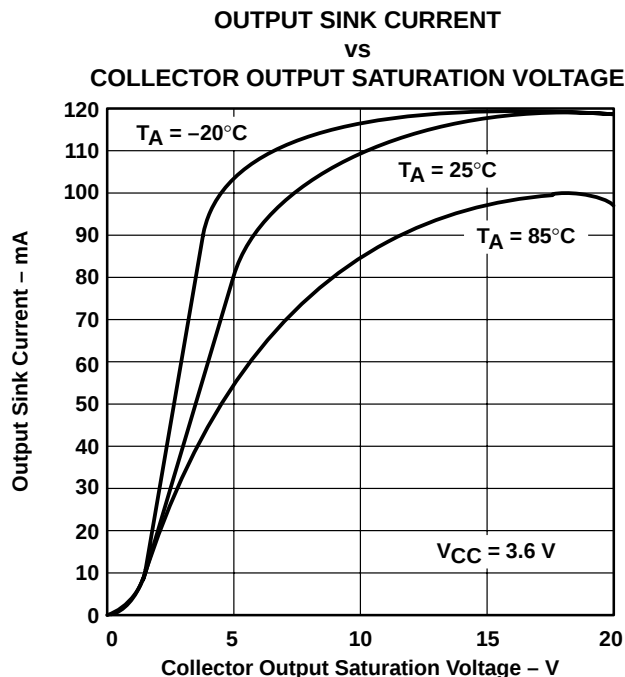


Figure 22

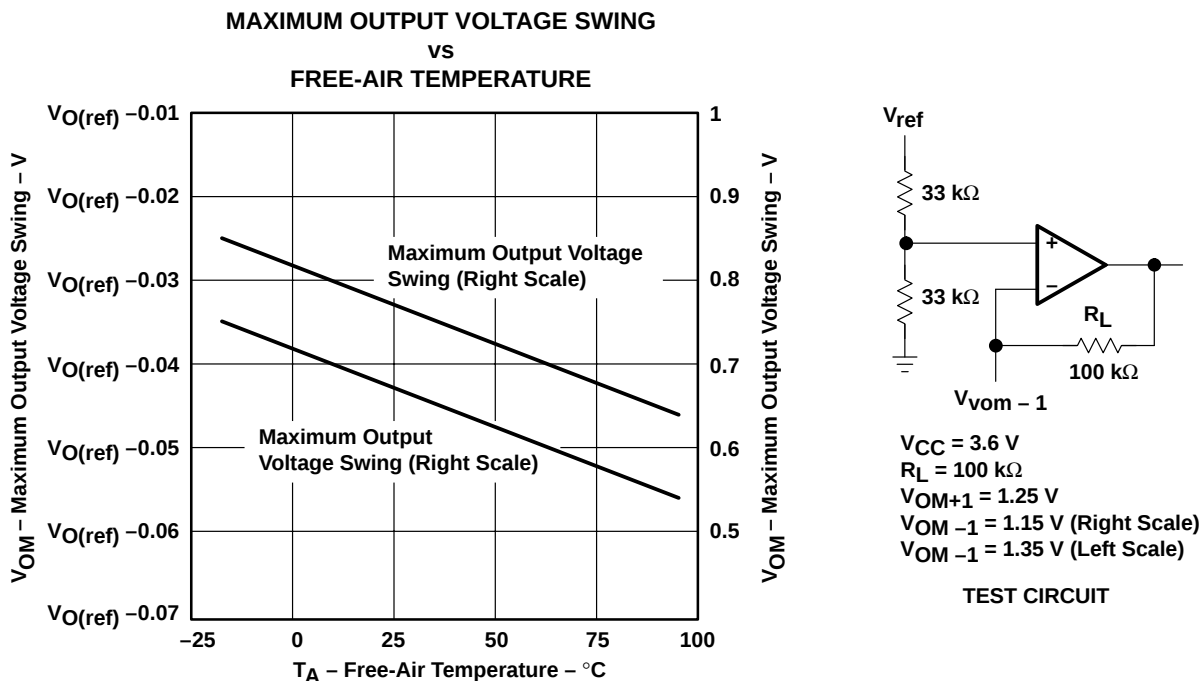


Figure 23

# TL1451A

## DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

### TYPICAL CHARACTERISTICS

OUTPUT TRANSISTOR ON DUTY CYCLE  
vs  
DEAD-TIME INPUT VOLTAGE

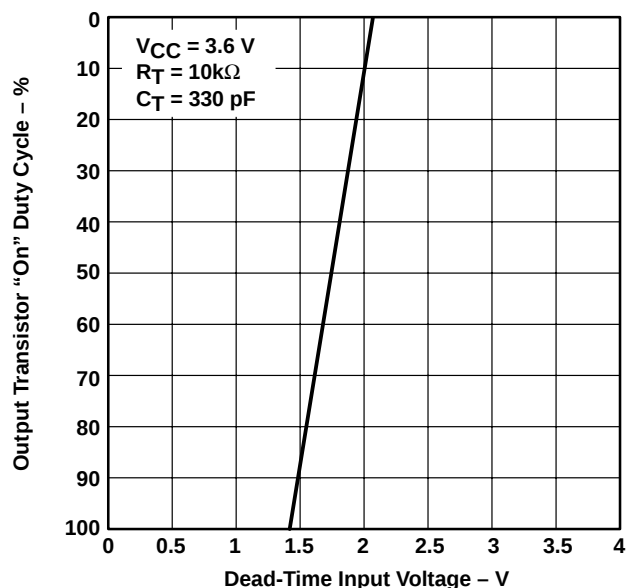


Figure 24

STANDBY CURRENT  
vs  
SUPPLY VOLTAGE

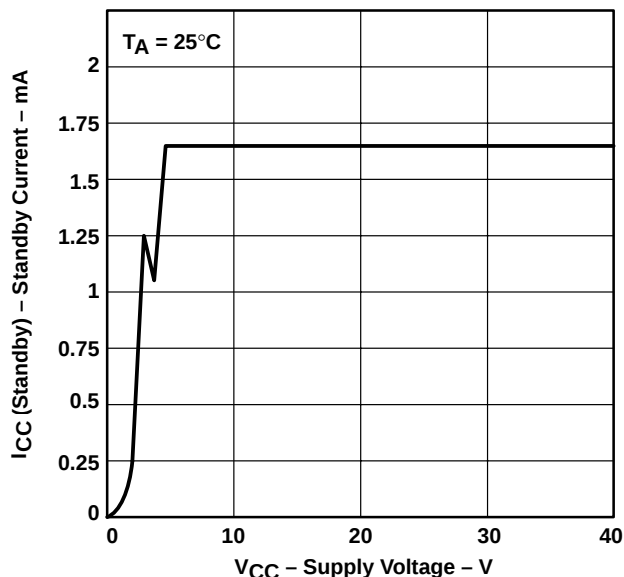


Figure 25

STANDBY CURRENT  
vs  
FREE-AIR TEMPERATURE

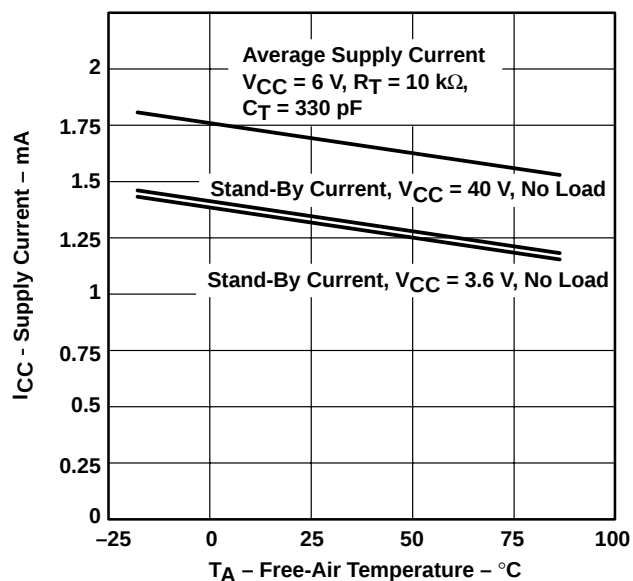


Figure 26

MAXIMUM CONTINUOUS POWER DISSIPATION  
vs  
FREE-AIR TEMPERATURE

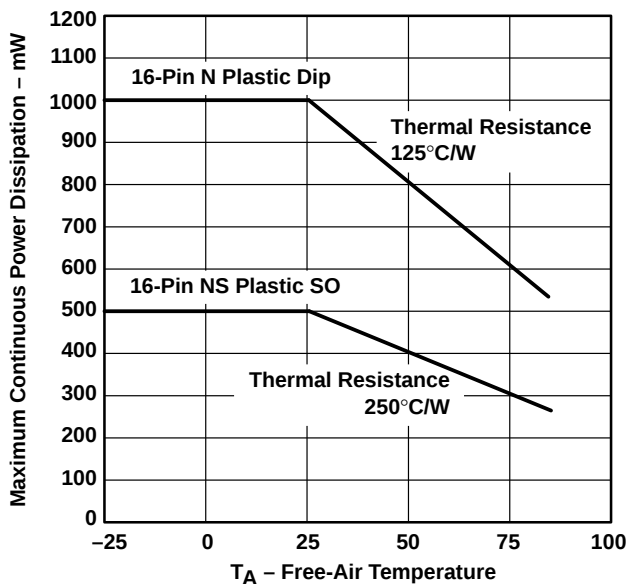
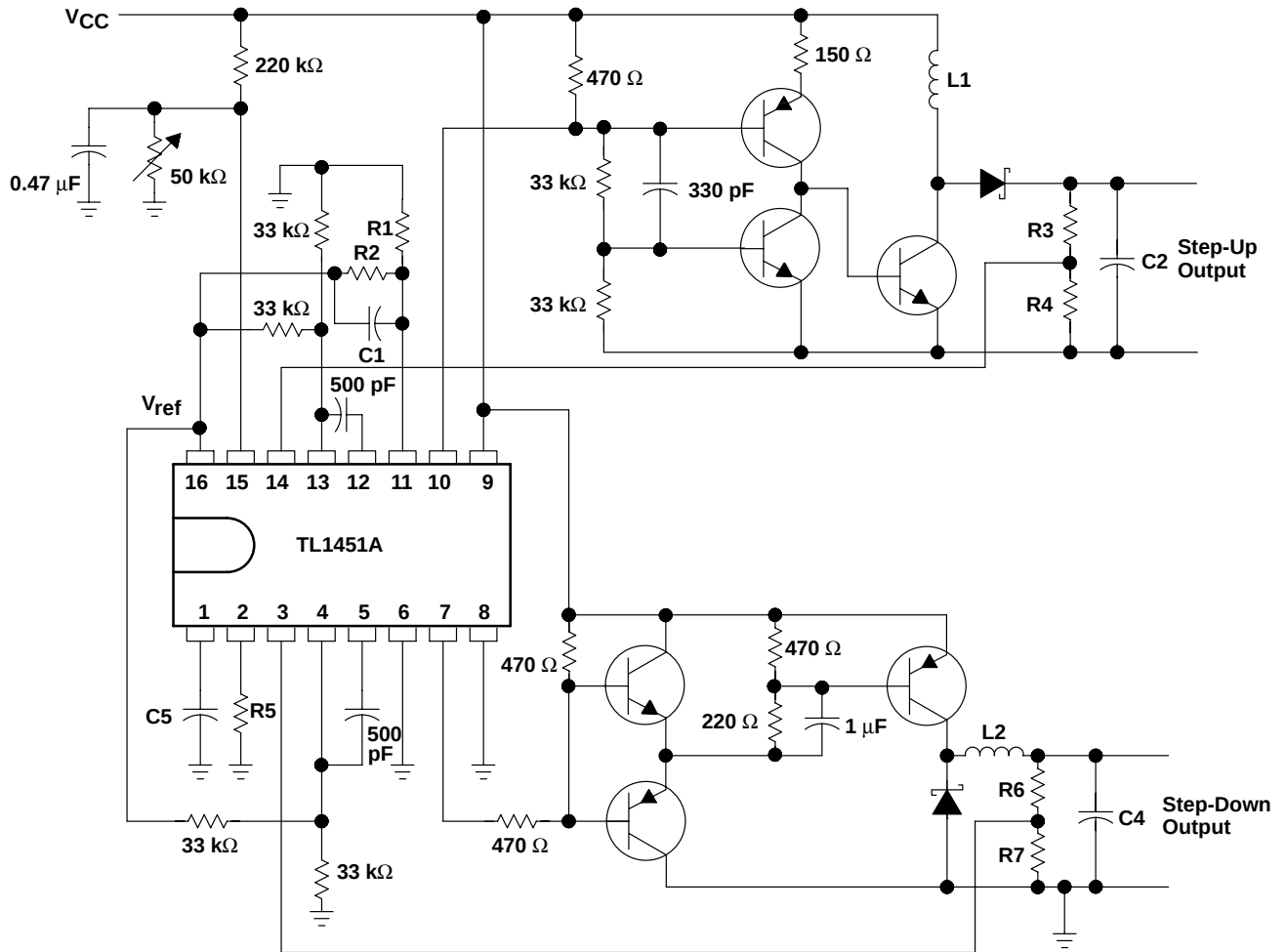


Figure 27

### 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<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| 5962-9958401Q2A  | OBSOLETE      | LCCC         | FK                 | 20   |                | TBD                        | Call TI                 | Call TI              | -55 to 125   |                         |                         |
| 5962-9958401QEA  | OBSOLETE      | CDIP         | J                  | 16   |                | TBD                        | Call TI                 | Call TI              | -55 to 125   |                         |                         |
| TL1451ACD        | ACTIVE        | SOIC         | D                  | 16   | 40             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | TL1451AC                | <a href="#">Samples</a> |
| TL1451ACDBLE     | NRND          | SSOP         | DB                 | 16   |                | TBD                        | Call TI                 | Call TI              | -20 to 85    |                         |                         |
| TL1451ACDBR      | ACTIVE        | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | T1451A                  | <a href="#">Samples</a> |
| TL1451ACDBRG4    | ACTIVE        | SSOP         | DB                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | T1451A                  | <a href="#">Samples</a> |
| TL1451ACDG4      | ACTIVE        | SOIC         | D                  | 16   | 40             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | TL1451AC                | <a href="#">Samples</a> |
| TL1451ACDR       | ACTIVE        | SOIC         | D                  | 16   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | TL1451AC                | <a href="#">Samples</a> |
| TL1451ACDRG4     | ACTIVE        | SOIC         | D                  | 16   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | TL1451AC                | <a href="#">Samples</a> |
| TL1451ACN        | ACTIVE        | PDIP         | N                  | 16   | 25             | Pb-Free<br>(RoHS)          | CU NIPDAU               | N / A for Pkg Type   | -20 to 85    | TL1451ACN               | <a href="#">Samples</a> |
| TL1451ACNSR      | ACTIVE        | SO           | NS                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | TL1451A                 | <a href="#">Samples</a> |
| TL1451ACPW       | ACTIVE        | TSSOP        | PW                 | 16   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | T1451A                  | <a href="#">Samples</a> |
| TL1451ACPWG4     | ACTIVE        | TSSOP        | PW                 | 16   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | T1451A                  | <a href="#">Samples</a> |
| TL1451ACPWLE     | OBSOLETE      | TSSOP        | PW                 | 16   |                | TBD                        | Call TI                 | Call TI              | -20 to 85    |                         |                         |
| TL1451ACPWR      | ACTIVE        | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | T1451A                  | <a href="#">Samples</a> |
| TL1451ACPWRG4    | ACTIVE        | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -20 to 85    | T1451A                  | <a href="#">Samples</a> |
| TL1451AMFKB      | OBSOLETE      | LCCC         | FK                 | 20   |                | TBD                        | Call TI                 | Call TI              | -55 to 125   |                         |                         |
| TL1451AMJB       | OBSOLETE      | CDIP         | J                  | 16   |                | TBD                        | Call TI                 | Call TI              | -55 to 125   |                         |                         |
| TL1451AQD        | ACTIVE        | SOIC         | D                  | 16   | 40             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TL1451AQ                | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2)         | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TL1451AQDG4      | ACTIVE        | SOIC         | D               | 16   | 40          | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   |              | 1451AQ                  | <a href="#">Samples</a> |
| TL1451AQDR       | ACTIVE        | SOIC         | D               | 16   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TL1451AQ                | <a href="#">Samples</a> |
| TL1451AQDRG4     | ACTIVE        | SOIC         | D               | 16   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   |              | 1451AQ                  | <a href="#">Samples</a> |
| TL1451CDBR       | ACTIVE        | SSOP         | DB              | 16   | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   |              | T1451                   | <a href="#">Samples</a> |
| TL1451CN         | ACTIVE        | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)          | CU NIPDAU               | N / A for Pkg Type   |              | TL1451CN                | <a href="#">Samples</a> |
| TL1451CNS        | ACTIVE        | SO           | NS              | 16   | 50          | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   |              | TL1451                  | <a href="#">Samples</a> |
| TL1451CNSG4      | ACTIVE        | SO           | NS              | 16   | 50          | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   |              | TL1451                  | <a href="#">Samples</a> |
| TL1451CNSR       | ACTIVE        | SO           | NS              | 16   | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   |              | TL1451                  | <a href="#">Samples</a> |
| TL1451INSR       | ACTIVE        | SO           | NS              | 16   | 2000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   |              | TL1451I                 | <a href="#">Samples</a> |

(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.

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**OTHER QUALIFIED VERSIONS OF TL1451A, TL1451AM :**

- Catalog: [TL1451A](#)
- Automotive: [TL1451A-Q1](#), [TL1451A-Q1](#)
- Enhanced Product: [TL1451A-EP](#), [TL1451A-EP](#)
- Military: [TL1451AM](#)

**NOTE: Qualified Version Definitions:**

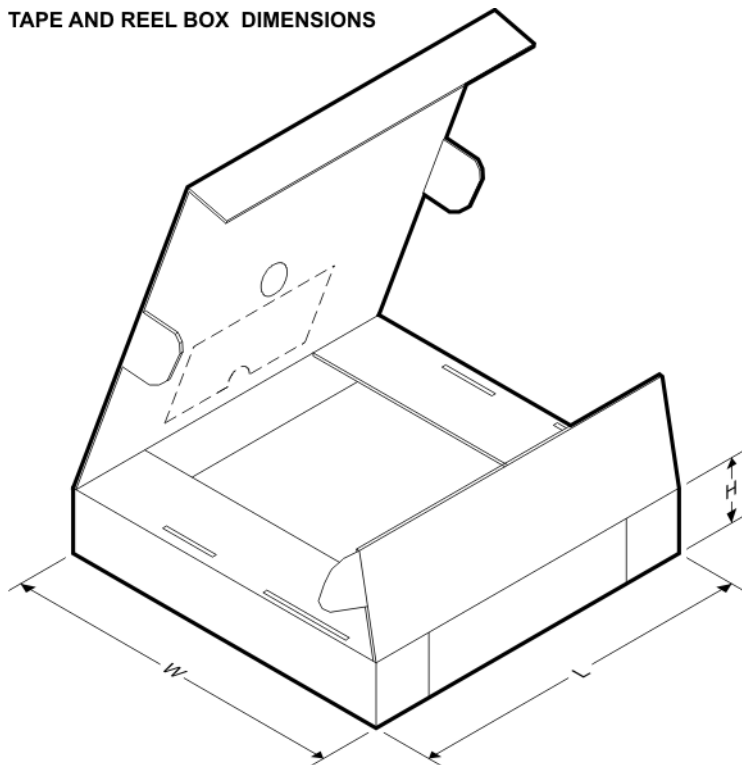
- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications

**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TL1451ACDBR  | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 6.6     | 2.5     | 12.0    | 16.0   | Q1            |
| TL1451ACDR   | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |
| TL1451ACDR   | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |
| TL1451ACNSR  | SO           | NS              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 10.5    | 2.5     | 12.0    | 16.0   | Q1            |
| TL1451ACPWR  | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| TL1451AQDR   | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |
| TL1451AQDRG4 | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |
| TL1451CDBR   | SSOP         | DB              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 6.6     | 2.5     | 12.0    | 16.0   | Q1            |
| TL1451CNSR   | SO           | NS              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 10.5    | 2.5     | 12.0    | 16.0   | Q1            |
| TL1451INSR   | SO           | NS              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 10.5    | 2.5     | 12.0    | 16.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



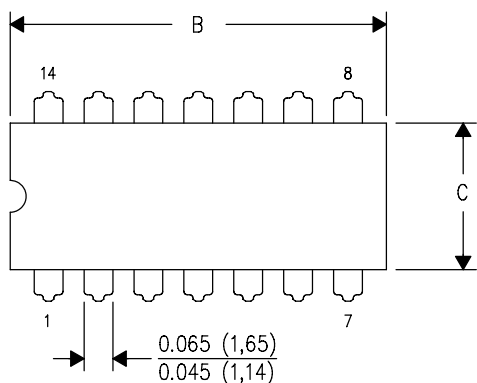
\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TL1451ACDBR  | SSOP         | DB              | 16   | 2000 | 367.0       | 367.0      | 38.0        |
| TL1451ACDR   | SOIC         | D               | 16   | 2500 | 333.2       | 345.9      | 28.6        |
| TL1451ACDR   | SOIC         | D               | 16   | 2500 | 367.0       | 367.0      | 38.0        |
| TL1451ACNSR  | SO           | NS              | 16   | 2000 | 367.0       | 367.0      | 38.0        |
| TL1451ACPWR  | TSSOP        | PW              | 16   | 2000 | 367.0       | 367.0      | 35.0        |
| TL1451AQDR   | SOIC         | D               | 16   | 2500 | 367.0       | 367.0      | 38.0        |
| TL1451AQDRG4 | SOIC         | D               | 16   | 2500 | 367.0       | 367.0      | 38.0        |
| TL1451CDBR   | SSOP         | DB              | 16   | 2000 | 367.0       | 367.0      | 38.0        |
| TL1451CNSR   | SO           | NS              | 16   | 2000 | 367.0       | 367.0      | 38.0        |
| TL1451INSR   | SO           | NS              | 16   | 2000 | 367.0       | 367.0      | 38.0        |

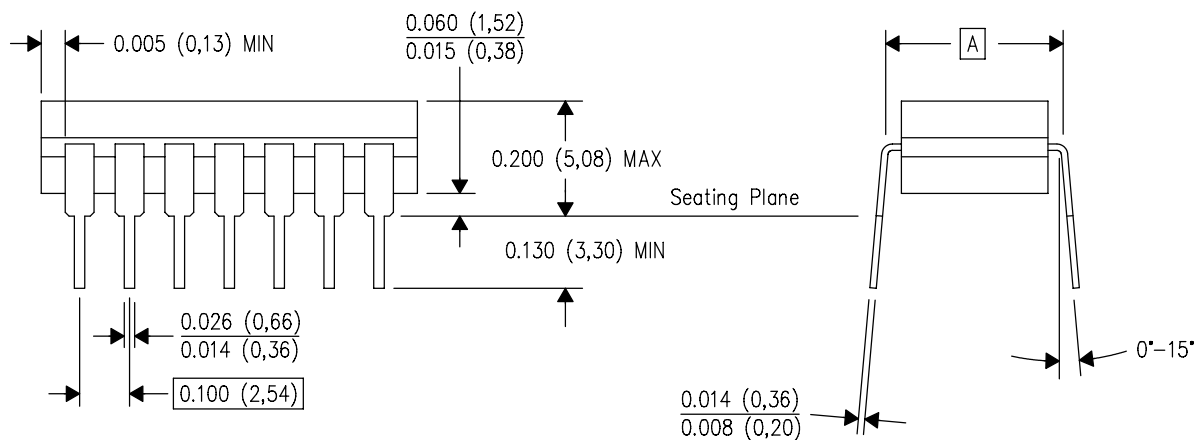
J (R-GDIP-T\*\*)

14 LEADS SHOWN

# CERAMIC DUAL IN-LINE PACKAGE



| PINS **<br>DIM | 14                     | 16                     | 18                     | 20                     |
|----------------|------------------------|------------------------|------------------------|------------------------|
| A              | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC |
| B MAX          | 0.785<br>(19,94)       | .840<br>(21,34)        | 0.960<br>(24,38)       | 1.060<br>(26,92)       |
| B MIN          | —                      | —                      | —                      | —                      |
| C MAX          | 0.300<br>(7,62)        | 0.300<br>(7,62)        | 0.310<br>(7,87)        | 0.300<br>(7,62)        |
| C MIN          | 0.245<br>(6,22)        | 0.245<br>(6,22)        | 0.220<br>(5,59)        | 0.245<br>(6,22)        |



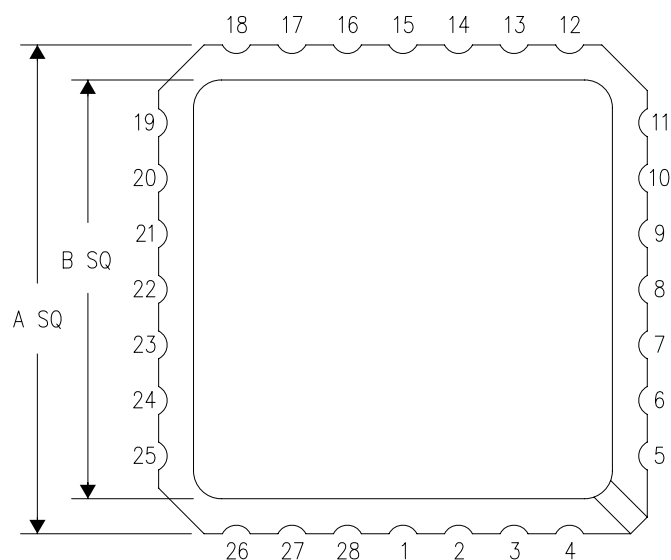
4040083/F 03/03

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package is hermetically sealed with a ceramic lid using glass frit.
  - D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
  - E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

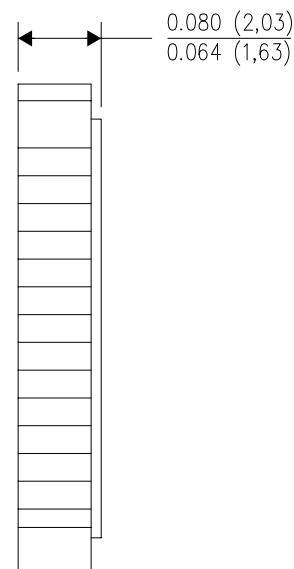
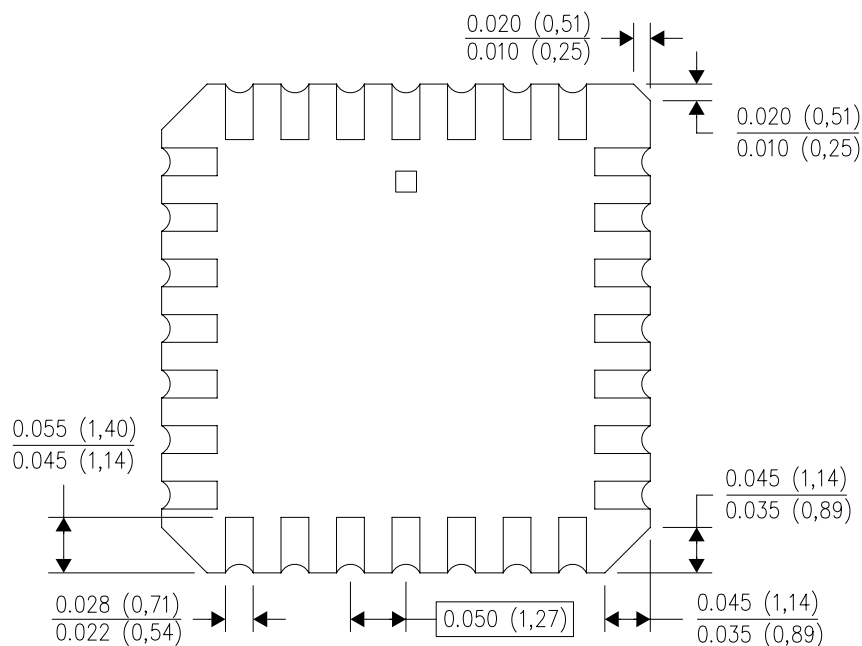
FK (S-CQCC-N\*\*)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



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



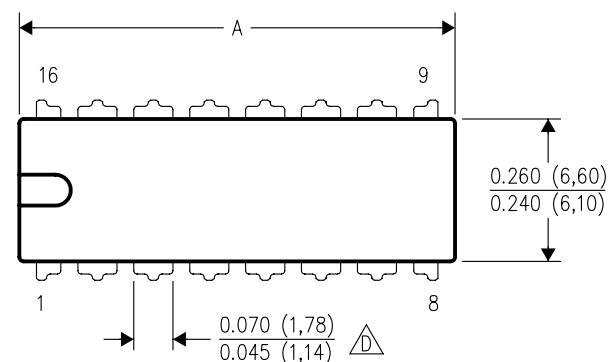
4040140/D 01/11

- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - This package can be hermetically sealed with a metal lid.
  - Falls within JEDEC MS-004

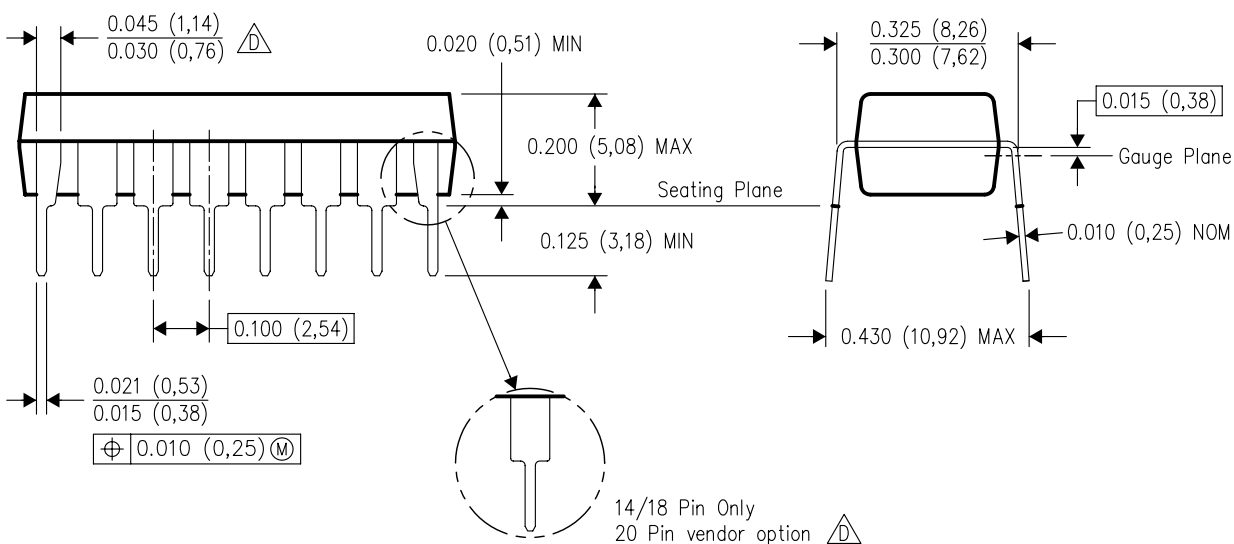
N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE



| PINS **<br>DIM      | 14               | 16               | 18               | 20               |
|---------------------|------------------|------------------|------------------|------------------|
| A MAX               | 0.775<br>(19,69) | 0.775<br>(19,69) | 0.920<br>(23,37) | 1.060<br>(26,92) |
| A MIN               | 0.745<br>(18,92) | 0.745<br>(18,92) | 0.850<br>(21,59) | 0.940<br>(23,88) |
| MS-001<br>VARIATION | AA               | BB               | AC               | AD               |



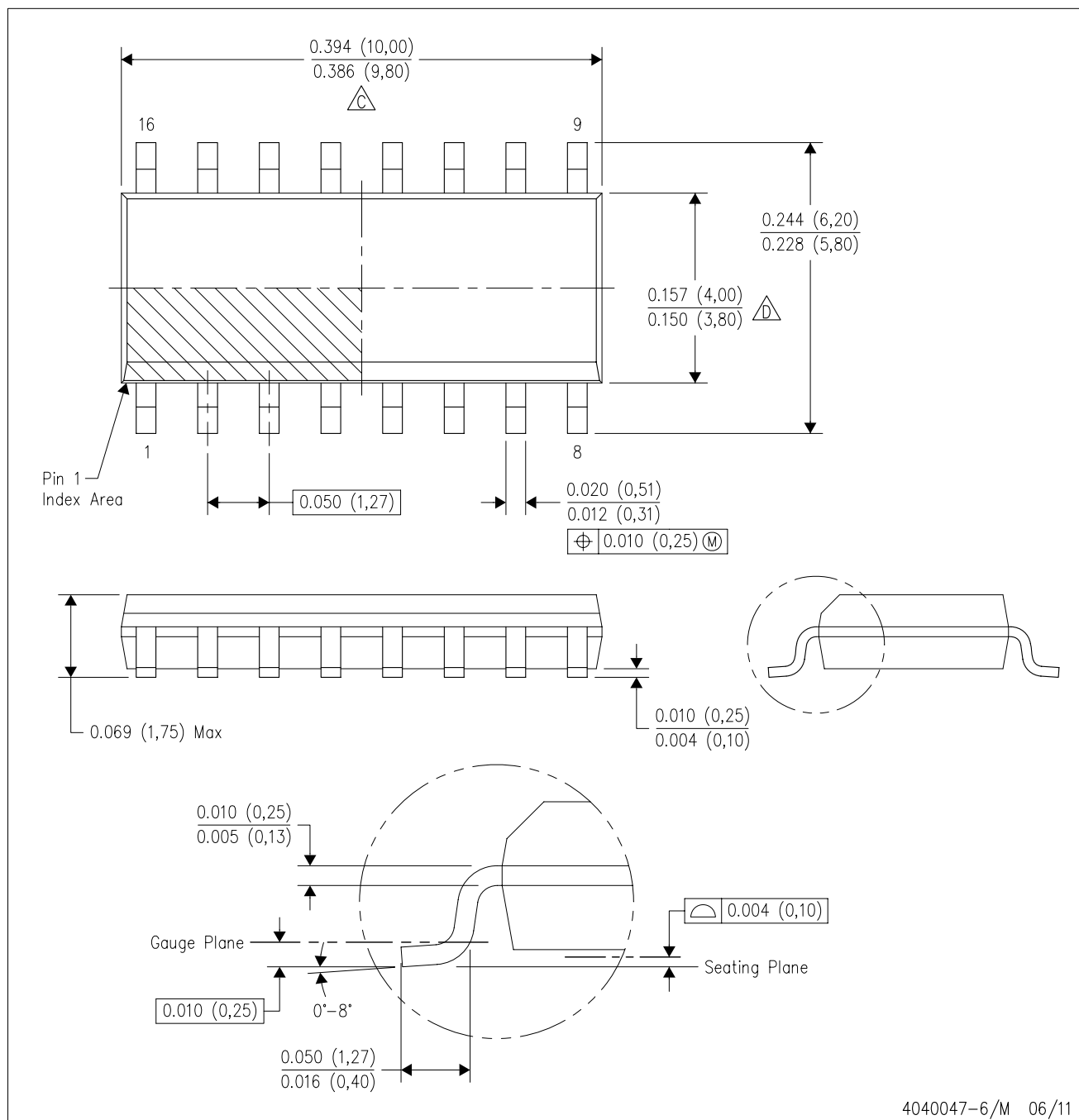
4040049/E 12/2002

NOTES:

- A. All linear dimensions are in inches (millimeters).  
B. This drawing is subject to change without notice.
-  Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).  
 The 20 pin end lead shoulder width is a vendor option, either half or full width.

## D (R-PDSO-G16)

## PLASTIC SMALL OUTLINE

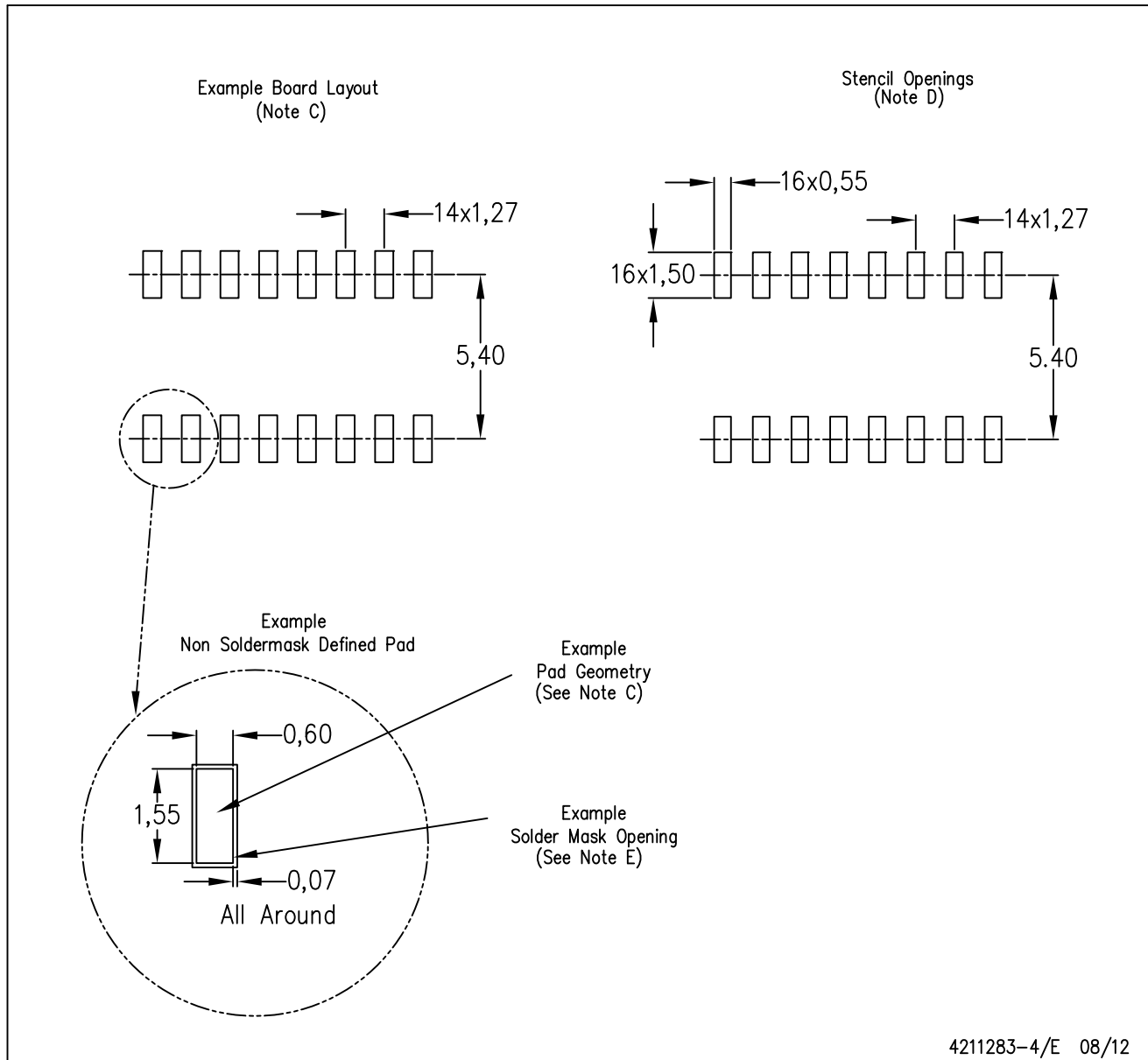


NOTES:

- 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 0.006 (0,15) each side.  
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.  
E. Reference JEDEC MS-012 variation AC.

D (R-PDSO-G16)

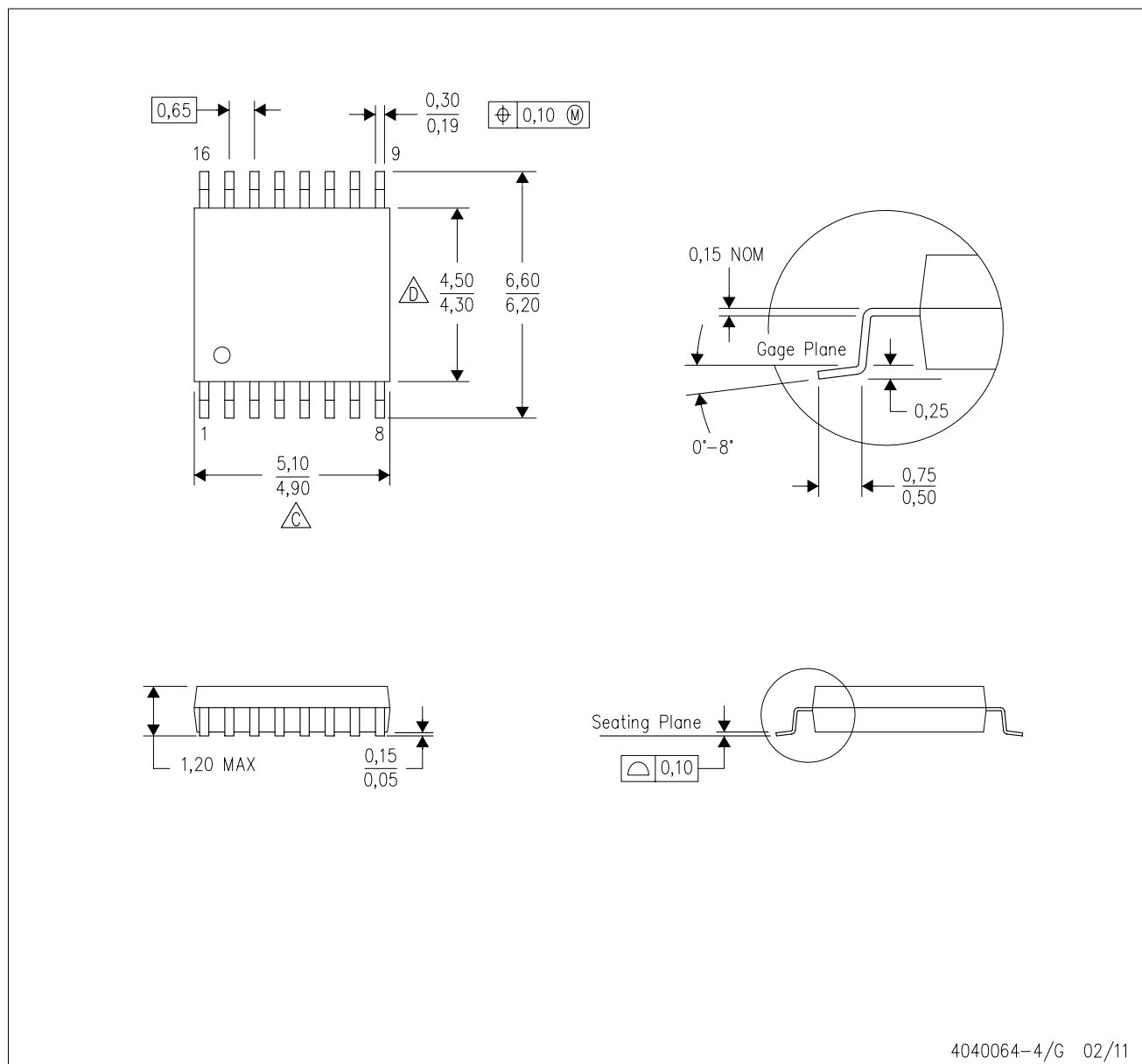
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. 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.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R-PDSO-G16)

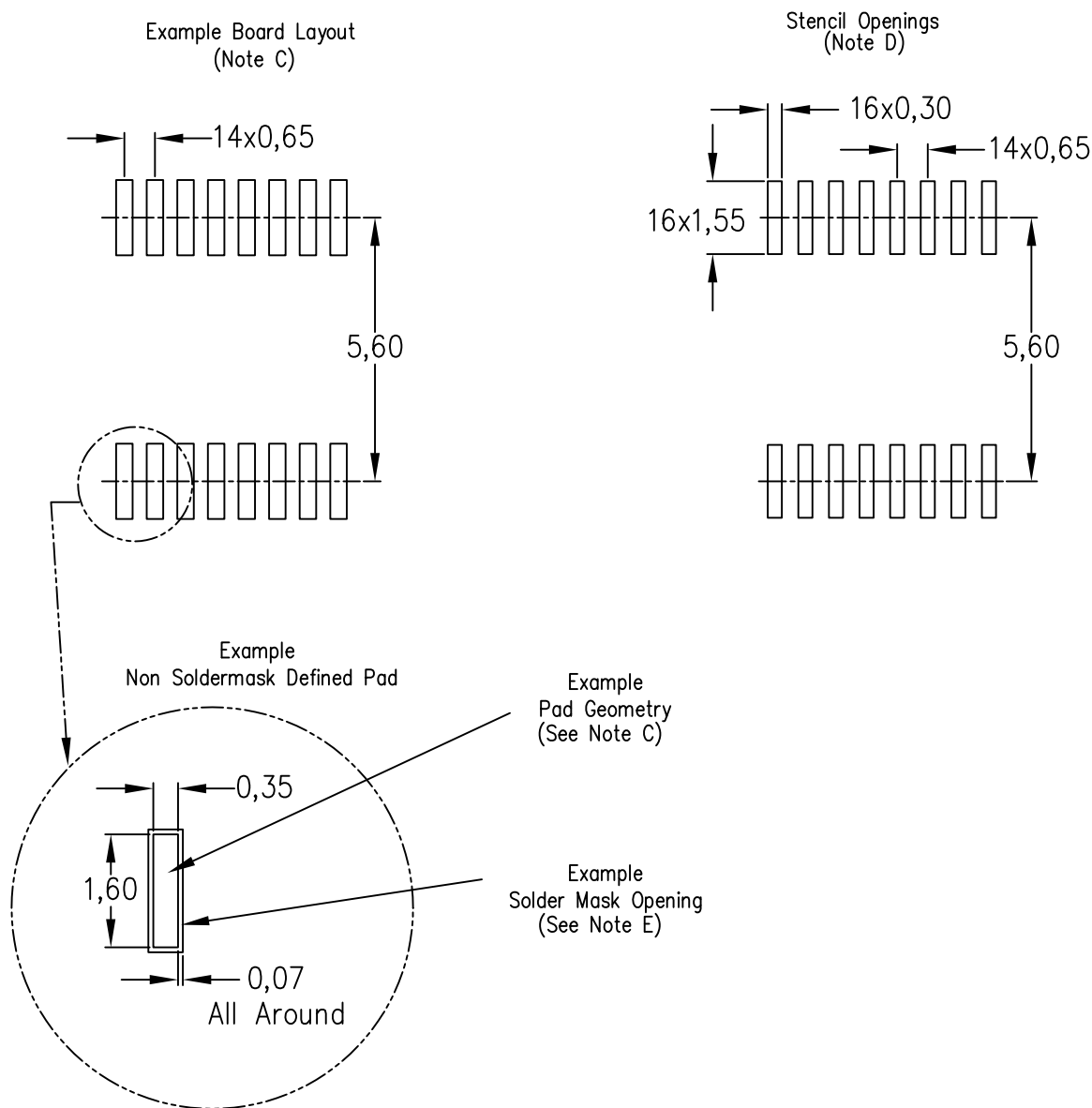
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - 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 0,15 each side.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE



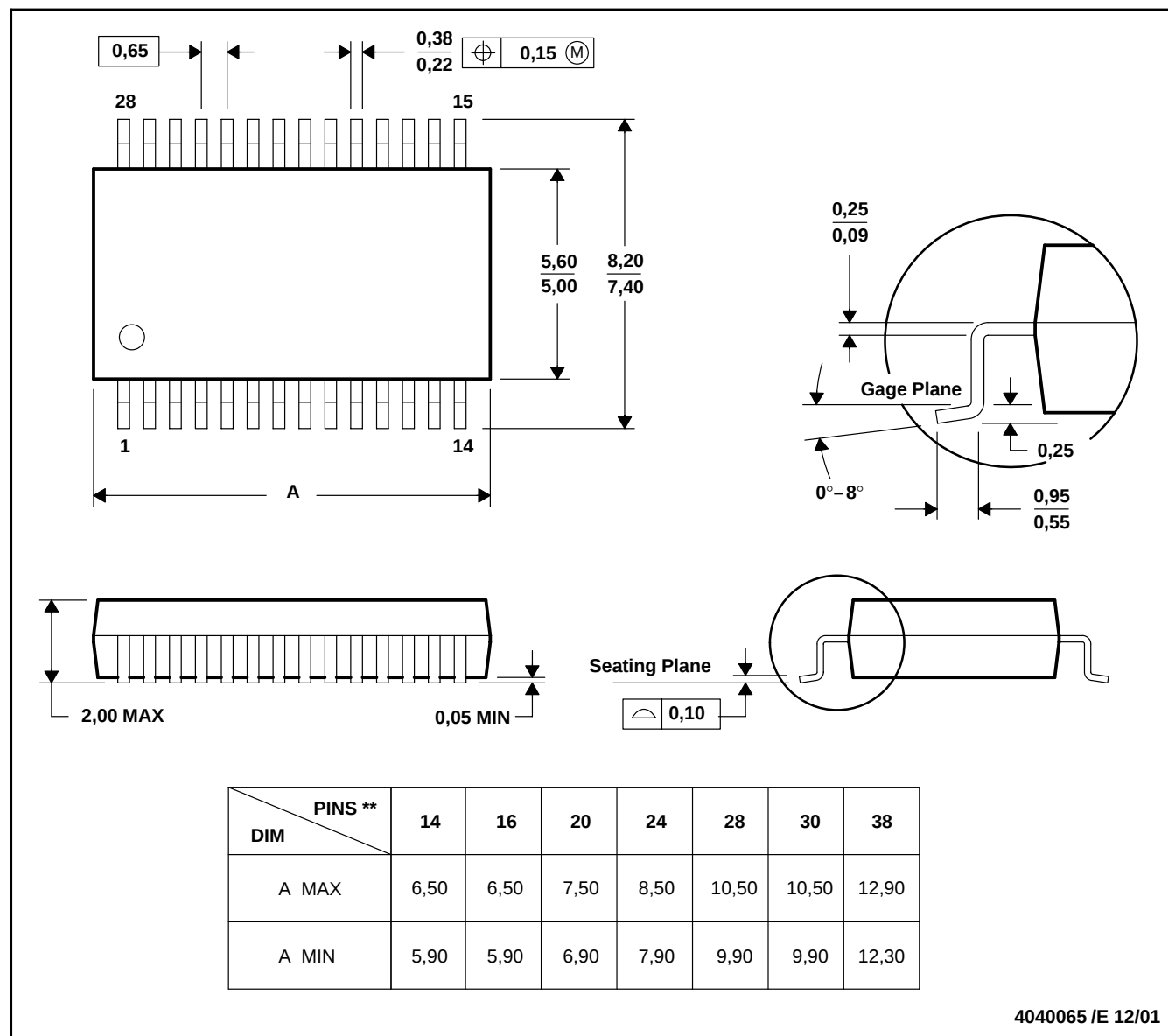
4211284-3/F 12/12

- 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.

## DB (R-PDSO-G\*\*)

## PLASTIC SMALL-OUTLINE

28 PINS SHOWN



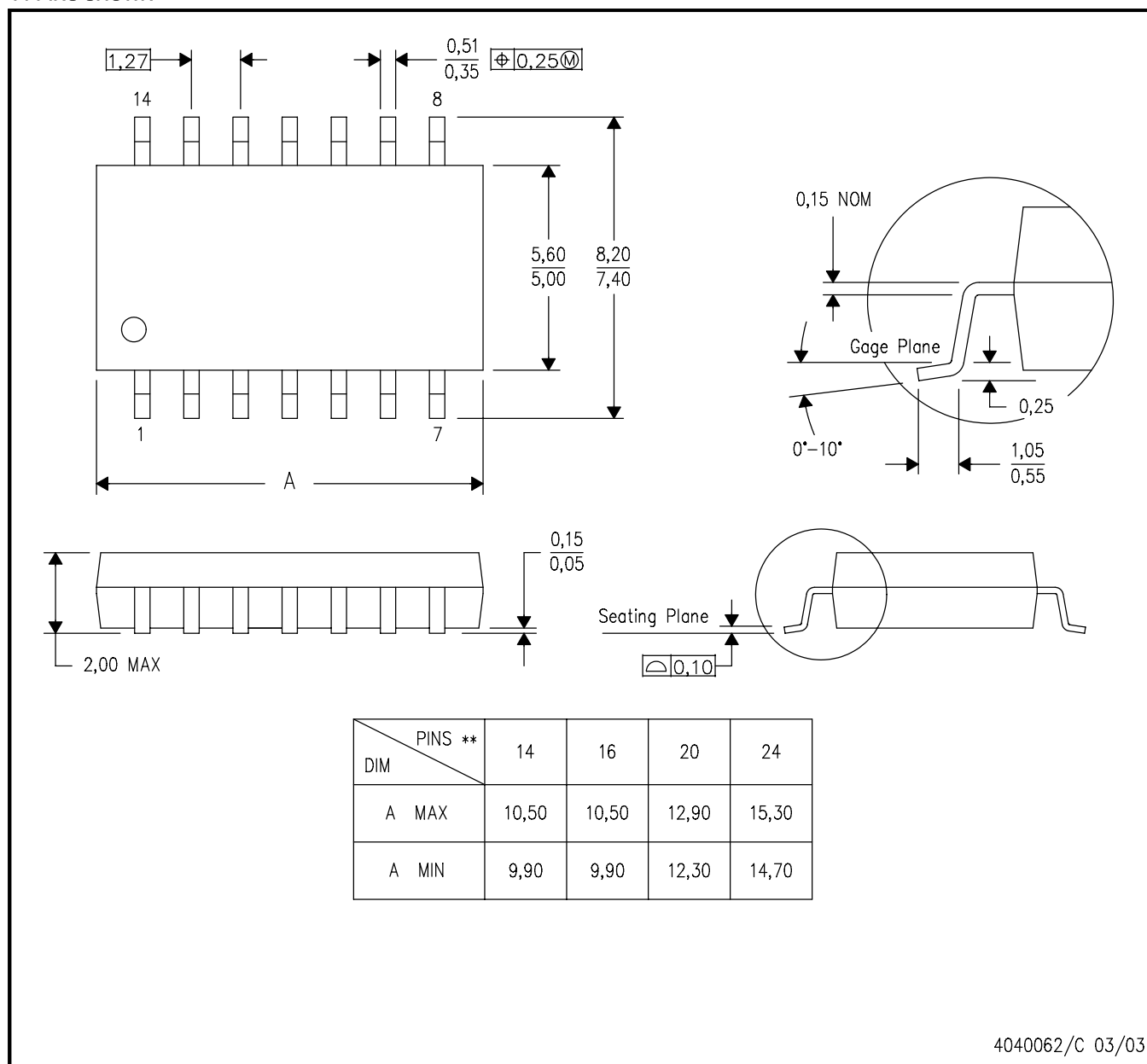
- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion not to exceed 0,15.
  - Falls within JEDEC MO-150

# MECHANICAL DATA

NS (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

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