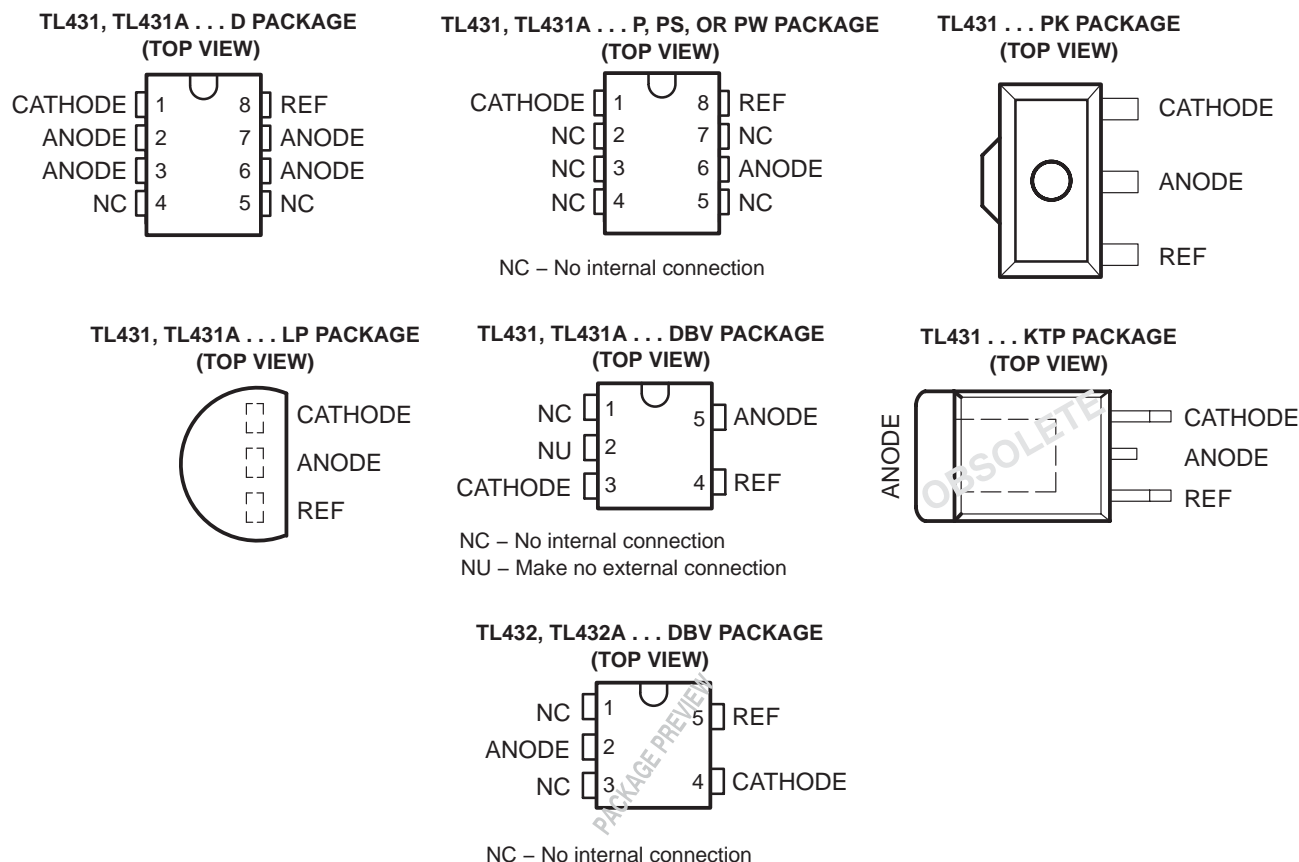


# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

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- Equivalent Full-Range Temperature Coefficient . . . 30 ppm/°C
- 0.2-Ω Typical Output Impedance
- Sink-Current Capability . . . 1 mA to 100 mA
- Low Output Noise
- Adjustable Output Voltage . . .  $V_{ref}$  to 36 V



## description/ordering information

The TL431, TL431A, TL432, and TL432A are three-terminal adjustable shunt regulators, with specified thermal stability over applicable automotive, commercial, and military temperature ranges. The output voltage can be set to any value between  $V_{ref}$  (approximately 2.5 V) and 36 V, with two external resistors (see Figure 17). These devices have a typical output impedance of 0.2 Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for Zener diodes in many applications, such as onboard regulation, adjustable power supplies, and switching power supplies.

The TL431C, TL431AC, TL432C, and TL432AC are characterized for operation from 0°C to 70°C, and the TL431I, TL431AI, TL432I, and TL432AI are characterized for operation from –40°C to 85°C.



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.

**TEXAS  
INSTRUMENTS**

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# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

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## description/ordering information (continued)

### TL431, TL432 ORDERING INFORMATION V<sub>ref</sub> TOLERANCE (25°C) = 2%

TA	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING‡
0°C to 70°C	PDIP (P)	Tube of 50	TL431CP	TL431CP
	SOIC (D)	Tube of 75	TL431CD	TL431C
		Reel of 2500	TL431CDR	
	SOP (PS)	Reel of 2000	TL431CPSR	T431
	SOT-23 (DBV)	Reel of 3000	TL431CDBVR	T3C_
		Reel of 250	TL431CDBVT	
		Reel of 3000	TL432CDBVR§	TBD
	SOT-89 (PK)	Reel of 1000	TL431CPK	43
	TO-226/TO-92 (LP)	Ammo of 2000	TL431CLPM	TL431C
		Reel of 2000	TL431CLPR	
TSSOP (PW)	Tube of 150	TL431CPW	T431	
	Reel of 2000	TL431CPWR		
-40°C to 85°C	PDIP (P)	Tube of 50	TL431IP	TL431IP
	SOIC (D)	Tube of 75	TL431ID	TL431I
		Reel of 2500	TL431IDR	
	SOT-23 (DBV)	Reel of 3000	TL431IDBVR	T3I_
		Reel of 250	TL431IDBVT	
		Reel of 3000	TL432IDBVR§	TBD
	SOT-89 (PK)	Reel of 1000	TL431IPK	3I
	TO-226/TO-92 (LP)	Bulk of 1000	TL431ILP	TL431I
		Reel of 2000	TL431ILPR	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

‡ DBV: The actual top-side marking has one additional character that designates the assembly/test site.

§ Product preview



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# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

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## description/ordering information (continued)

### TL431A, TL432A ORDERING INFORMATION $V_{ref}$ TOLERANCE (25°C) = 1%

$T_A$	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING‡
0°C to 70°C	PDIP (P)	Tube of 50	TL431ACP	TL431ACP
	SOIC (D)	Tube of 75	TL431ACD	431AC
		Reel of 2500	TL431ACDR	
	SOP (PS)	Reel of 2000	TL431ACPSR	T431A
	SOT-23 (DBV)	Reel of 3000	TL431ACDBVR	TAC_
		Reel of 250	TL431ACDBVT	
		Reel of 3000	TL432ACDBVR§	TBD
	TO-226/TO-92 (LP)	Bulk of 1000	TL431ACLPM	TL431AC
		Ammo of 2000	TL431ACLPM	
		Reel of 2000	TL431ACLPR	
TSSOP (PW)	Tube of 150	TL431ACPW	T431A	
	Reel of 2000	TL431ACPWR		
-40°C to 85°C	PDIP (P)	Tube of 50	TL431AIP	TL431AIP
	SOIC (D)	Tube of 75	TL431AID	431AI
		Reel of 2500	TL431AIDR	
	SOT-23 (DBV)	Reel of 3000	TL431AIDBVR	TAI_
		Reel of 250	TL431AIDBVT	
		Reel of 3000	TL432AIDBVR§	TBD
	TO-226/TO-92 (LP)	Bulk of 1000	TL431AILP	TL431AI
		Reel of 2000	TL431AILPR	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

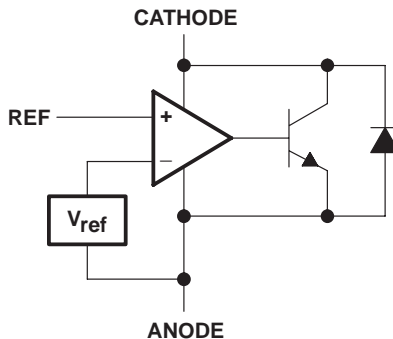
‡ DBV: The actual top-side marking has one additional character that designates the assembly/test site.

§ Product preview

## symbol



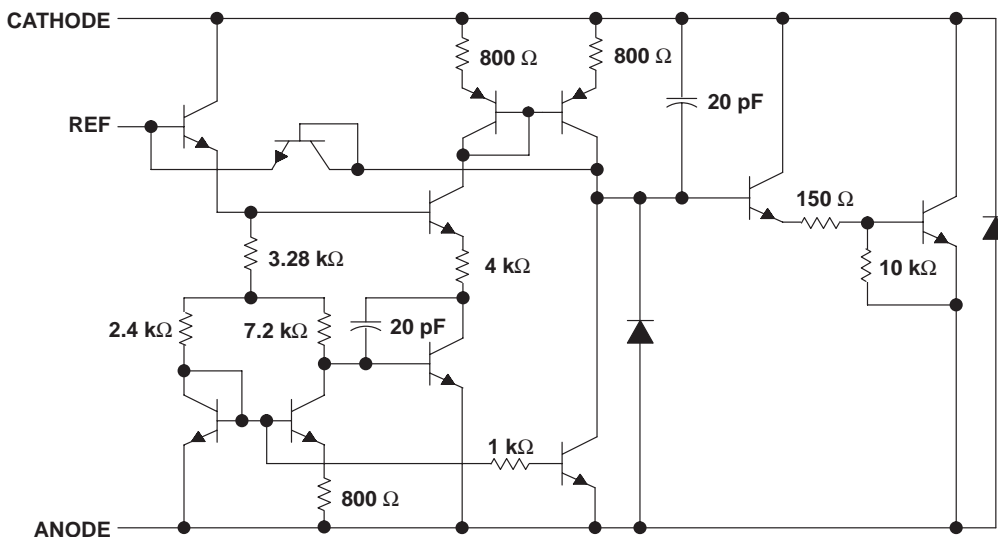
## functional block diagram



# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

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## equivalent schematic†



† All component values are nominal.

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

Cathode voltage, $V_{KA}$ (see Note 1)	37 V
Continuous cathode current range, $I_{KA}$	-100 mA to 150 mA
Reference input current range	-50 $\mu$ A to 10 mA
Operating virtual junction temperature, $T_J$	150°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds	260°C
Storage temperature range, $T_{stg}$	-65°C to 150°C

‡ Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: Voltage values are with respect to the ANODE terminal unless otherwise noted.

## package thermal data (see Note 2)

PACKAGE	BOARD	$\theta_{JC}$	$\theta_{JA}$
PDIP (P)	High K, JESD 51-7	57°C/W	85°C/W
POWER-FLEX (KTP)	High K, JESD 51-5	19°C/W	28°C/W
SOIC (D)	High K, JESD 51-7	39°C/W	97°C/W
SOT-89 (PK)	High K, JESD 51-7	9°C/W	52°C/W
SOT-23 (DBV)	High K, JESD 51-7	131°C/W	206°C/W
TO-92 (LP)	High K, JESD 51-7	55°C/W	140°C/W
TSSOP (PW)	High K, JESD 51-7	65°C/W	149°C/W

NOTE 2: Maximum power dissipation is a function of  $T_J(\max)$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\max) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.



# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

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## recommended operating conditions

		MIN	MAX	UNIT	
$V_{KA}$	Cathode voltage	$V_{ref}$	36	V	
$I_{KA}$	Cathode current	1	100	mA	
$T_A$	Operating free-air temperature range	TL431C, TL431AC, TL432C, TL432AC	0	70	°C
		TL431I, TL431AI, TL432I, TL432AI	-40	85	



# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

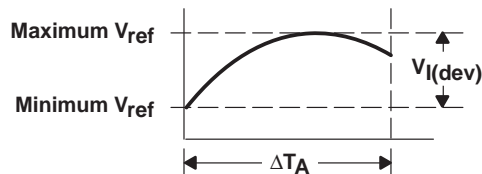
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electrical characteristics over recommended operating conditions,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CIRCUIT	TEST CONDITIONS	TL431C, TL432C			UNIT
			MIN	TYP	MAX	
$V_{\text{ref}}$ Reference voltage	2	$V_{\text{KA}} = V_{\text{ref}}, I_{\text{KA}} = 10 \text{ mA}$	2440	2495	2550	mV
$V_{\text{I(dev)}}$ Deviation of reference voltage over full temperature range (see Figure 1)	2	$V_{\text{KA}} = V_{\text{ref}}, I_{\text{KA}} = 10 \text{ mA}, T_A = 0^\circ\text{C to } 70^\circ\text{C}$		4	25	mV
$\frac{\Delta V_{\text{ref}}}{\Delta V_{\text{KA}}}$ Ratio of change in reference voltage to the change in cathode voltage	3	$I_{\text{KA}} = 10 \text{ mA}$	$\Delta V_{\text{KA}} = 10 \text{ V} - V_{\text{ref}}$	-1.4	-2.7	$\frac{\text{mV}}{\text{V}}$
			$\Delta V_{\text{KA}} = 36 \text{ V} - 10 \text{ V}$	-1	-2	
$I_{\text{ref}}$ Reference current	3	$I_{\text{KA}} = 10 \text{ mA}, R_1 = 10 \text{ k}\Omega, R_2 = \infty$		2	4	$\mu\text{A}$
$I_{\text{I(dev)}}$ Deviation of reference current over full temperature range (see Figure 1)	3	$I_{\text{KA}} = 10 \text{ mA}, R_1 = 10 \text{ k}\Omega, R_2 = \infty, T_A = 0^\circ\text{C to } 70^\circ\text{C}$		0.4	1.2	$\mu\text{A}$
$I_{\text{min}}$ Minimum cathode current for regulation	2	$V_{\text{KA}} = V_{\text{ref}}$		0.4	1	mA
$I_{\text{off}}$ Off-state cathode current	4	$V_{\text{KA}} = 36 \text{ V}, V_{\text{ref}} = 0$		0.1	1	$\mu\text{A}$
$ z_{\text{KA}} $ Dynamic impedance (see Figure 1)	1	$I_{\text{KA}} = 1 \text{ mA to } 100 \text{ mA}, V_{\text{KA}} = V_{\text{ref}}, f \leq 1 \text{ kHz}$		0.2	0.5	$\Omega$

The deviation parameters  $V_{\text{ref(dev)}}$  and  $I_{\text{ref(dev)}}$  are defined as the differences between the maximum and minimum values obtained over the recommended temperature range. The average full-range temperature coefficient of the reference voltage,  $\alpha_{V_{\text{ref}}}$ , is defined as:

$$|\alpha_{V_{\text{ref}}}| \left( \frac{\text{ppm}}{^\circ\text{C}} \right) = \frac{\left( \frac{V_{\text{I(dev)}}}{V_{\text{ref at } 25^\circ\text{C}}} \right) \times 10^6}{\Delta T_A}$$



where:

$\Delta T_A$  is the recommended operating free-air temperature range of the device.

$\alpha_{V_{\text{ref}}}$  can be positive or negative, depending on whether minimum  $V_{\text{ref}}$  or maximum  $V_{\text{ref}}$ , respectively, occurs at the lower temperature.

Example: maximum  $V_{\text{ref}} = 2496 \text{ mV}$  at  $30^\circ\text{C}$ , minimum  $V_{\text{ref}} = 2492 \text{ mV}$  at  $0^\circ\text{C}$ ,  $V_{\text{ref}} = 2495 \text{ mV}$  at  $25^\circ\text{C}$ ,  $\Delta T_A = 70^\circ\text{C}$  for TL431C

$$|\alpha_{V_{\text{ref}}}| = \frac{\left( \frac{4 \text{ mV}}{2495 \text{ mV}} \right) \times 10^6}{70^\circ\text{C}} \approx 23 \text{ ppm}/^\circ\text{C}$$

Because minimum  $V_{\text{ref}}$  occurs at the lower temperature, the coefficient is positive.

### Calculating Dynamic Impedance

The dynamic impedance is defined as:  $|z_{\text{KA}}| = \frac{\Delta V_{\text{KA}}}{\Delta I_{\text{KA}}}$

When the device is operating with two external resistors (see Figure 3), the total dynamic impedance of the circuit is given by:

$$|z'| = \frac{\Delta V}{\Delta I} \approx |z_{\text{KA}}| \left( 1 + \frac{R_1}{R_2} \right)$$

Figure 1. Calculating Deviation Parameters and Dynamic Impedance

# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

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electrical characteristics over recommended operating conditions,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CIRCUIT	TEST CONDITIONS	TL431, TL432I			UNIT
			MIN	TYP	MAX	
$V_{\text{ref}}$ Reference voltage	2	$V_{\text{KA}} = V_{\text{ref}}, I_{\text{KA}} = 10 \text{ mA}$	2440	2495	2550	mV
$V_{\text{I(dev)}}$ Deviation of reference voltage over full temperature range (see Figure 1)	2	$V_{\text{KA}} = V_{\text{ref}}, I_{\text{KA}} = 10 \text{ mA}, T_A = -40^\circ\text{C to } 85^\circ\text{C}$		5	50	mV
$\frac{\Delta V_{\text{ref}}}{\Delta V_{\text{KA}}}$ Ratio of change in reference voltage to the change in cathode voltage	3	$I_{\text{KA}} = 10 \text{ mA}$	$\Delta V_{\text{KA}} = 10 \text{ V} - V_{\text{ref}}$	-1.4	-2.7	$\frac{\text{mV}}{\text{V}}$
			$\Delta V_{\text{KA}} = 36 \text{ V} - 10 \text{ V}$	-1	-2	
$I_{\text{ref}}$ Reference current	3	$I_{\text{KA}} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty$		2	4	$\mu\text{A}$
$I_{\text{I(dev)}}$ Deviation of reference current over full temperature range (see Figure 1)	3	$I_{\text{KA}} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty, T_A = -40^\circ\text{C to } 85^\circ\text{C}$		0.8	2.5	$\mu\text{A}$
$I_{\text{min}}$ Minimum cathode current for regulation	2	$V_{\text{KA}} = V_{\text{ref}}$		0.4	1	mA
$I_{\text{off}}$ Off-state cathode current	4	$V_{\text{KA}} = 36 \text{ V}, V_{\text{ref}} = 0$		0.1	1	$\mu\text{A}$
$ z_{\text{KA}} $ Dynamic impedance (see Figure 1)	2	$I_{\text{KA}} = 1 \text{ mA to } 100 \text{ mA}, V_{\text{KA}} = V_{\text{ref}}, f \leq 1 \text{ kHz}$		0.2	0.5	$\Omega$

# TL431, TL431A, TL432, TL432A

## ADJUSTABLE PRECISION SHUNT REGULATORS

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electrical characteristics over recommended operating conditions,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CIRCUIT	TEST CONDITIONS	TL431AC, TL432AC			UNIT
			MIN	TYP	MAX	
$V_{\text{ref}}$ Reference voltage	2	$V_{KA} = V_{\text{ref}}, I_{KA} = 10 \text{ mA}$	2470	2495	2520	mV
$V_{I(\text{dev})}$ Deviation of reference voltage over full temperature range (see Figure 1)	2	$V_{KA} = V_{\text{ref}}, I_{KA} = 10 \text{ mA}, T_A = 0^\circ\text{C to } 70^\circ\text{C}$		4	25	mV
$\frac{\Delta V_{\text{ref}}}{\Delta V_{KA}}$ Ratio of change in reference voltage to the change in cathode voltage	3	$I_{KA} = 10 \text{ mA}$	$\Delta V_{KA} = 10 \text{ V} - V_{\text{ref}}$	-1.4	-2.7	$\frac{\text{mV}}{\text{V}}$
			$\Delta V_{KA} = 36 \text{ V} - 10 \text{ V}$	-1	-2	
$I_{\text{ref}}$ Reference current	3	$I_{KA} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty$		2	4	$\mu\text{A}$
$I_{I(\text{dev})}$ Deviation of reference current over full temperature range (see Figure 1)	3	$I_{KA} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty, T_A = 0^\circ\text{C to } 70^\circ\text{C}$		0.8	1.2	$\mu\text{A}$
$I_{\text{min}}$ Minimum cathode current for regulation	2	$V_{KA} = V_{\text{ref}}$		0.4	0.6	mA
$I_{\text{off}}$ Off-state cathode current	4	$V_{KA} = 36 \text{ V}, V_{\text{ref}} = 0$		0.1	0.5	$\mu\text{A}$
$ z_{KA} $ Dynamic impedance (see Figure 1)	1	$I_{KA} = 1 \text{ mA to } 100 \text{ mA}, V_{KA} = V_{\text{ref}}, f \leq 1 \text{ kHz}$		0.2	0.5	$\Omega$

electrical characteristics over recommended operating conditions,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CIRCUIT	TEST CONDITIONS	TL431AI, TL432AI			UNIT
			MIN	TYP	MAX	
$V_{\text{ref}}$ Reference voltage	2	$V_{KA} = V_{\text{ref}}, I_{KA} = 10 \text{ mA}$	2470	2495	2520	mV
$V_{I(\text{dev})}$ Deviation of reference voltage over full temperature range (see Figure 1)	2	$V_{KA} = V_{\text{ref}}, I_{KA} = 10 \text{ mA}, T_A = -40^\circ\text{C to } 85^\circ\text{C}$		5	50	mV
$\frac{\Delta V_{\text{ref}}}{\Delta V_{KA}}$ Ratio of change in reference voltage to the change in cathode voltage	3	$I_{KA} = 10 \text{ mA}$	$\Delta V_{KA} = 10 \text{ V} - V_{\text{ref}}$	-1.4	-2.7	$\frac{\text{mV}}{\text{V}}$
			$\Delta V_{KA} = 36 \text{ V} - 10 \text{ V}$	-1	-2	
$I_{\text{ref}}$ Reference current	3	$I_{KA} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty$		2	4	$\mu\text{A}$
$I_{I(\text{dev})}$ Deviation of reference current over full temperature range (see Figure 1)	3	$I_{KA} = 10 \text{ mA}, R1 = 10 \text{ k}\Omega, R2 = \infty, T_A = -40^\circ\text{C to } 85^\circ\text{C}$		0.8	2.5	$\mu\text{A}$
$I_{\text{min}}$ Minimum cathode current for regulation	2	$V_{KA} = V_{\text{ref}}$		0.4	0.7	mA
$I_{\text{off}}$ Off-state cathode current	4	$V_{KA} = 36 \text{ V}, V_{\text{ref}} = 0$		0.1	0.5	$\mu\text{A}$
$ z_{KA} $ Dynamic impedance (see Figure 1)	2	$I_{KA} = 1 \text{ mA to } 100 \text{ mA}, V_{KA} = V_{\text{ref}}, f \leq 1 \text{ kHz}$		0.2	0.5	$\Omega$





PARAMETER MEASUREMENT INFORMATION

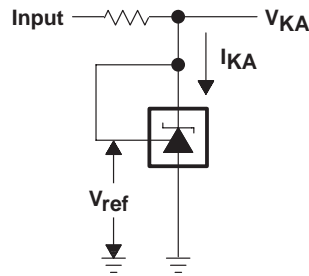


Figure 2. Test Circuit for  $V_{KA} = V_{ref}$

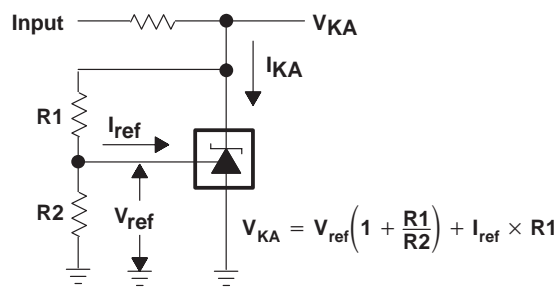


Figure 3. Test Circuit for  $V_{KA} > V_{ref}$

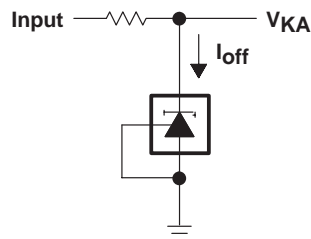


Figure 4. Test Circuit for  $I_{off}$

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## TYPICAL CHARACTERISTICS

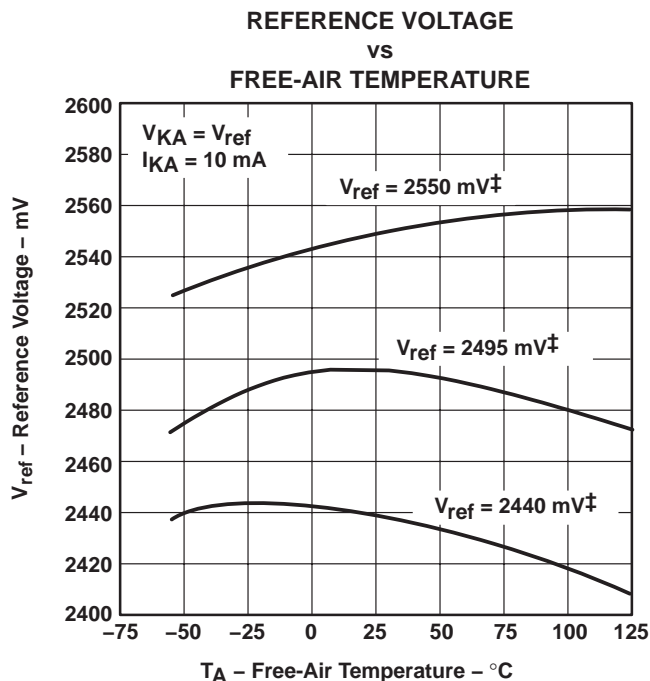
**Table 1. Graphs**

	FIGURE
Reference input voltage vs Free-air temperature	5
Reference input current vs Free-air temperature	6
Cathode current vs Cathode voltage	7, 8
Off-state cathode current vs Free-air temperature	9
Ratio of delta reference voltage to change in cathode voltage vs Free-air temperature	10
Equivalent input noise voltage vs Frequency	11
Equivalent input noise voltage over a 10-second period	12
Small-signal voltage amplification vs Frequency	13
Reference impedance vs Frequency	14
Pulse response	15
Stability boundary conditions	16

**Table 2. Application Circuits**

	FIGURE
Shunt regulator	17
Single-supply comparator with temperature-compensated threshold	18
Precision high-current series regulator	19
Output control of a three-terminal fixed regulator	20
High-current shunt regulator	21
Crowbar circuit	22
Precision 5-V 1.5-A regulator	23
Efficient 5-V precision regulator	24
PWM converter with reference	25
Voltage monitor	26
Delay timer	27
Precision current limiter	28
Precision constant-current sink	29

TYPICAL CHARACTERISTICS†



† Data is for devices having the indicated value of  $V_{ref}$  at  $I_{KA} = 10$  mA,  $T_A = 25^\circ\text{C}$ .

Figure 5

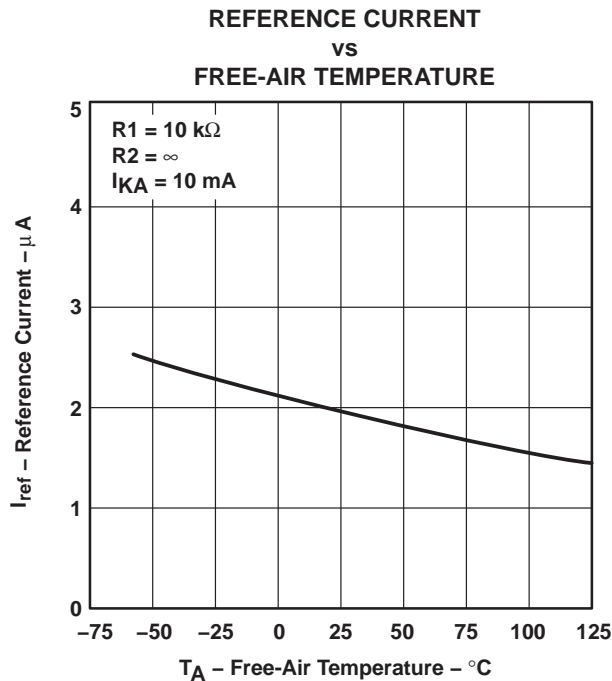


Figure 6

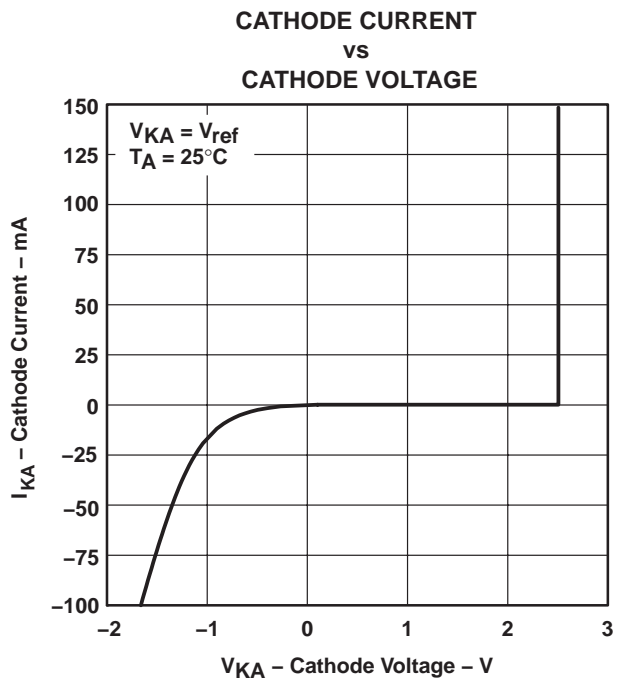


Figure 7

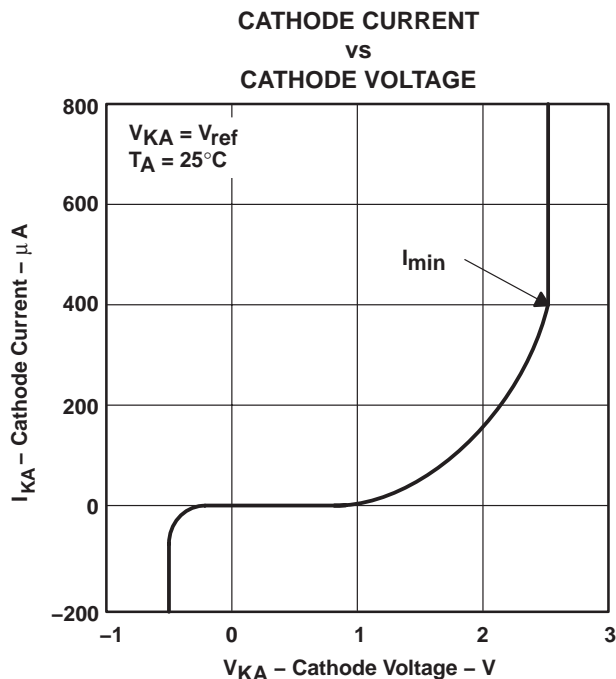


Figure 8

† Data at high and low temperatures is applicable only within the recommended operating free-air temperature ranges of the various devices.

# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

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## TYPICAL CHARACTERISTICS†

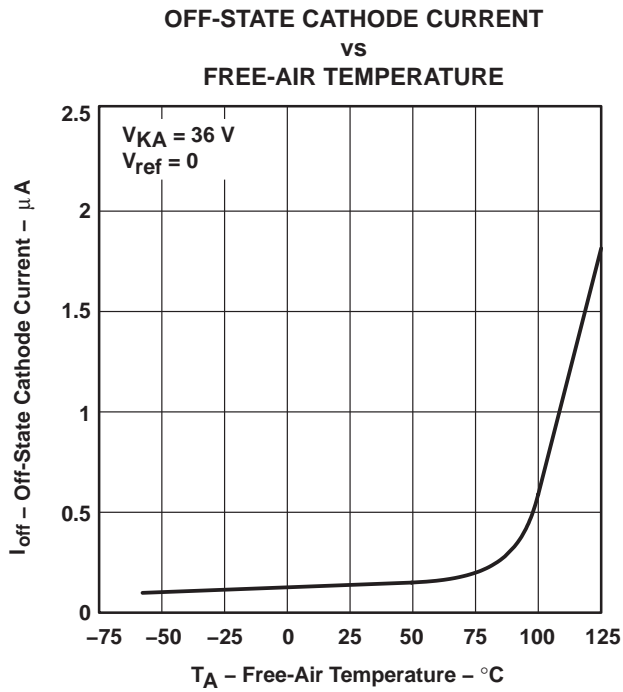


Figure 9

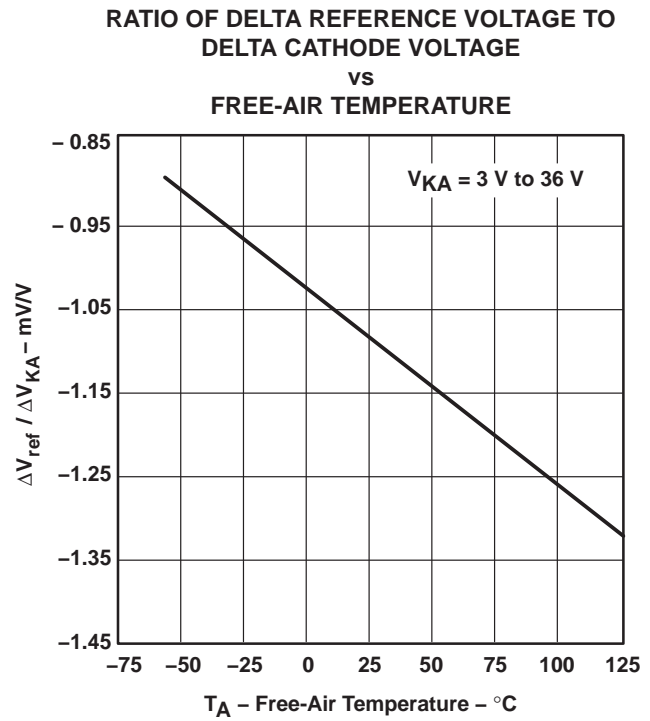


Figure 10

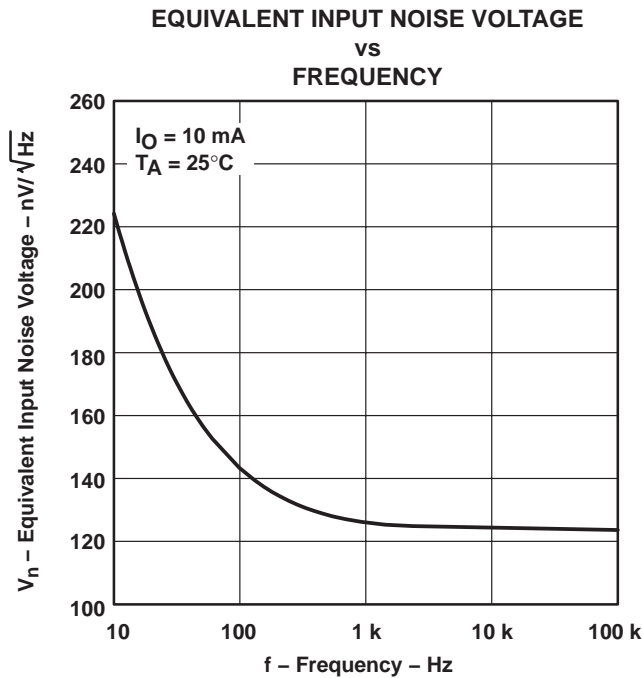


Figure 11

† Data at high and low temperatures is applicable only within the recommended operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE  
 OVER A 10-SECOND PERIOD

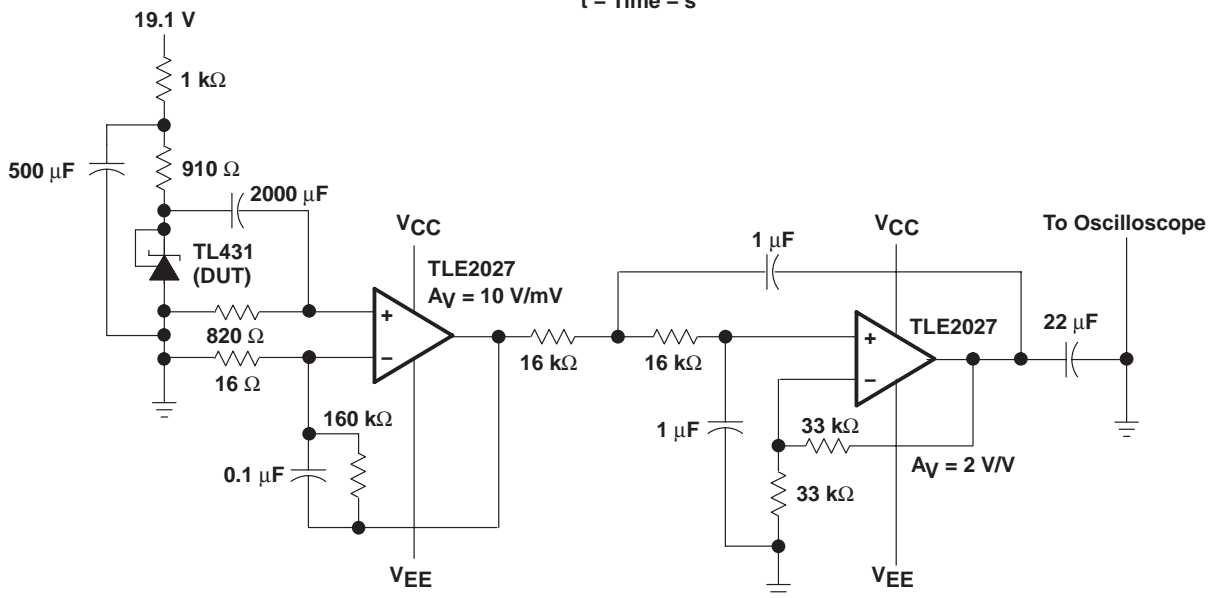
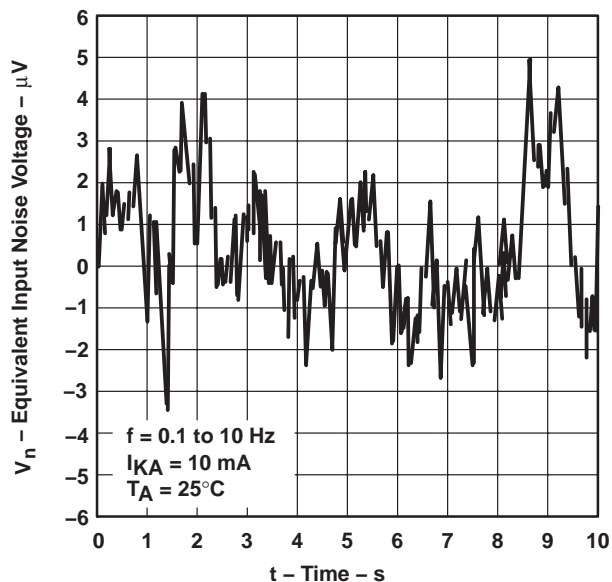


Figure 12. Test Circuit for Equivalent Input Noise Voltage

# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

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## TYPICAL CHARACTERISTICS

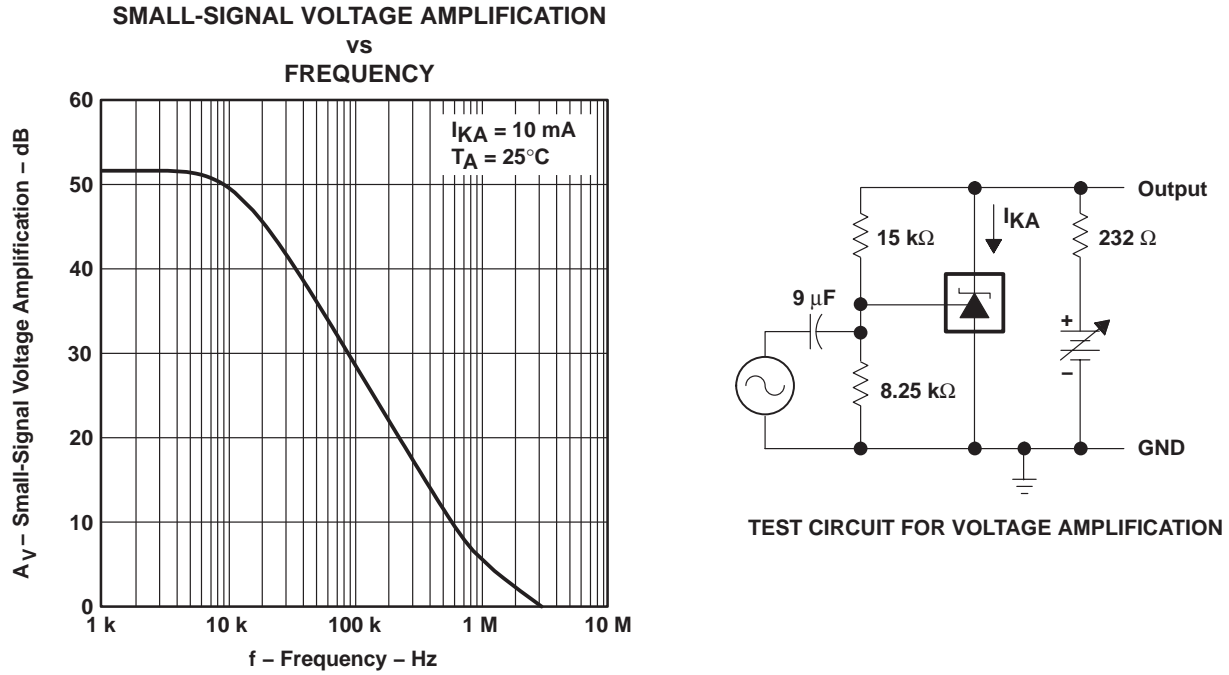


Figure 13

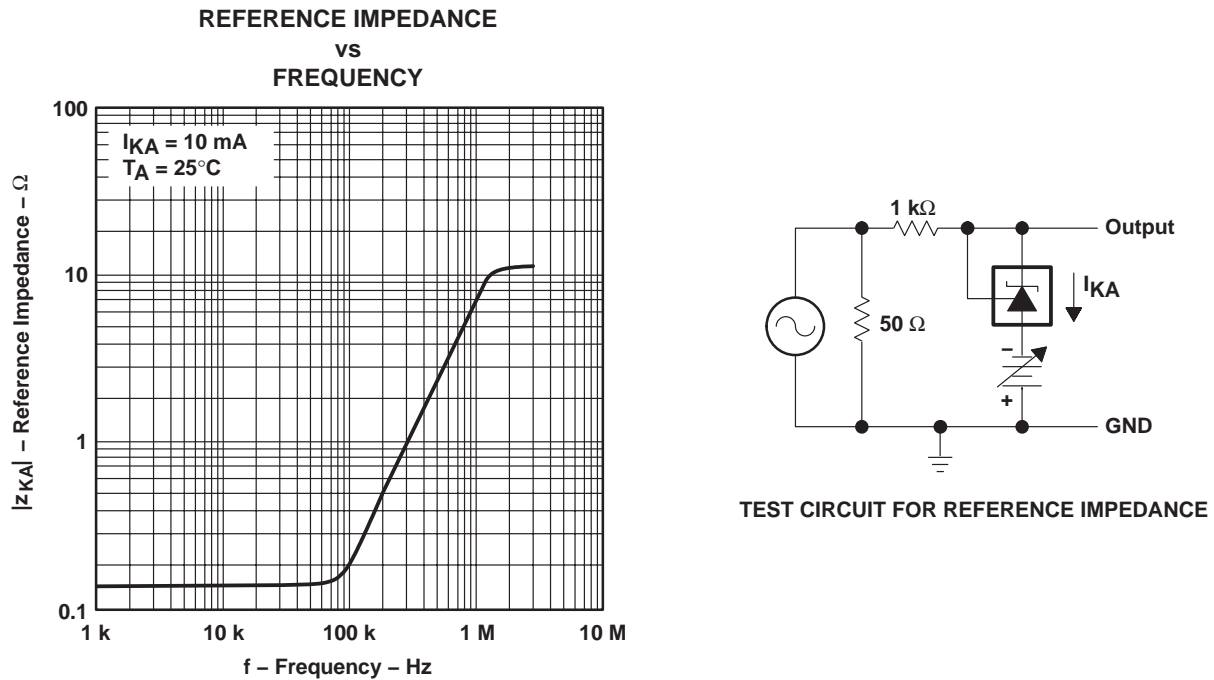


Figure 14

TYPICAL CHARACTERISTICS

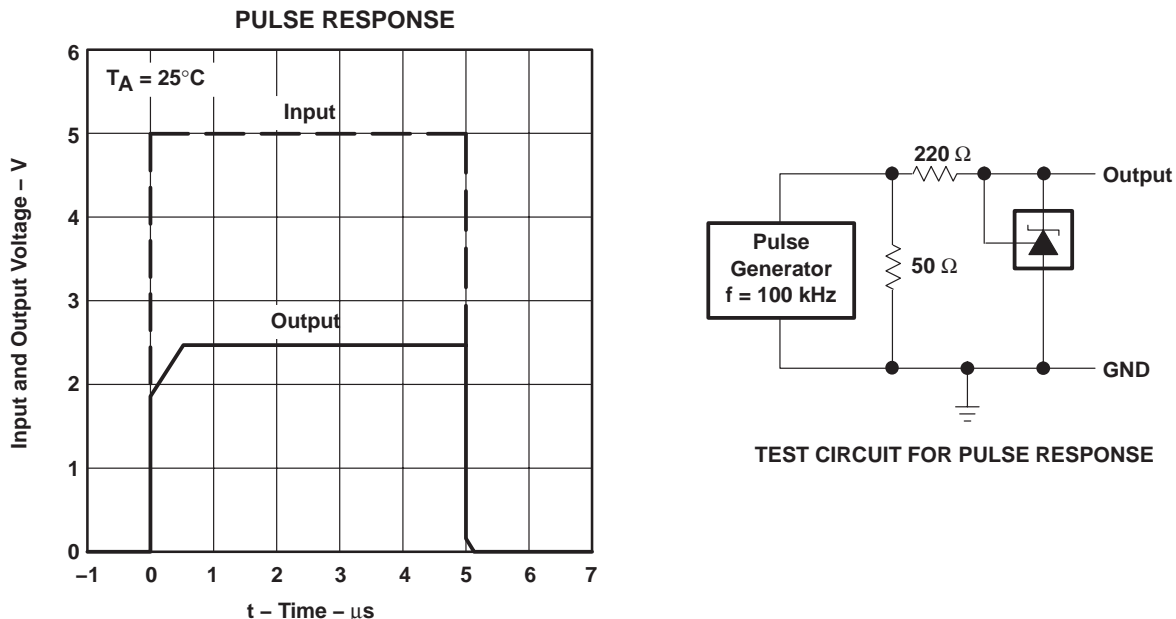


Figure 15

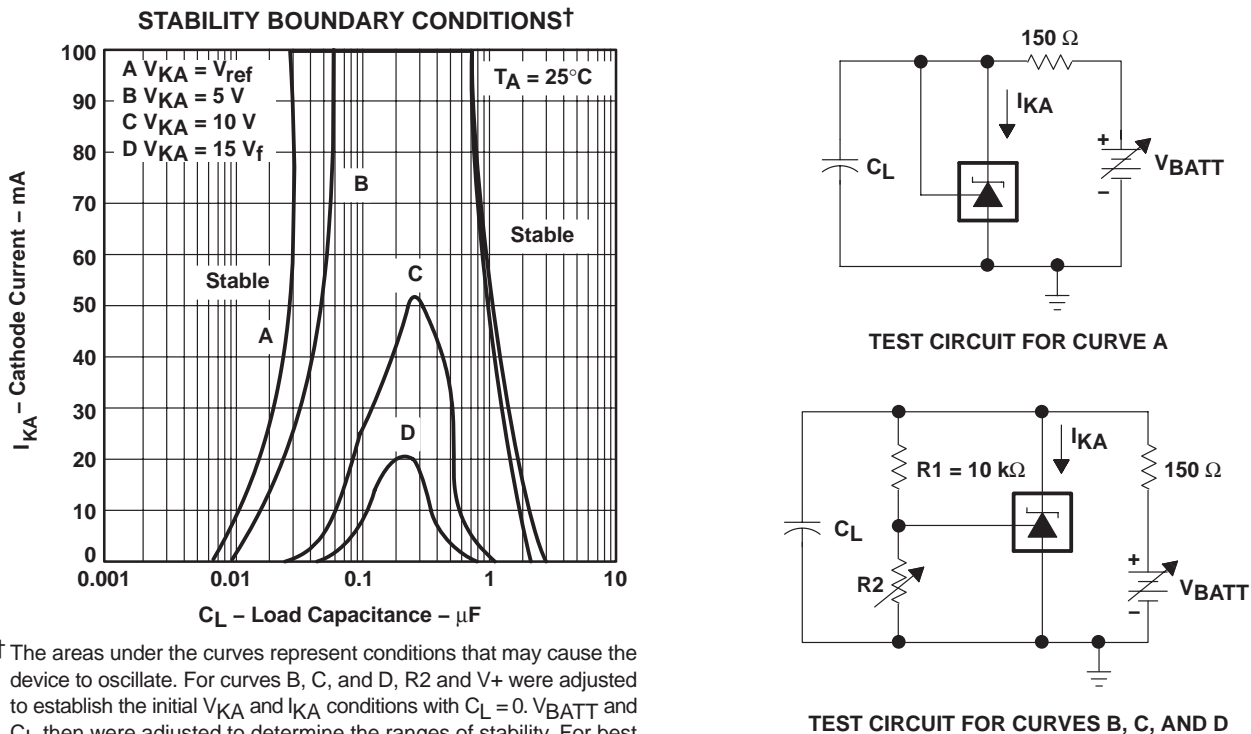
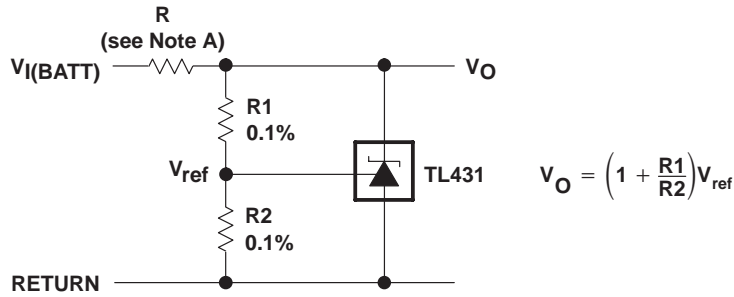


Figure 16

# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS005V – JULY 1978 – REVISED NOVEMBER 2003

## APPLICATION INFORMATION



NOTE A: R should provide cathode current  $\geq 1$  mA to the TL431 at minimum  $V_{I(BATT)}$ .

Figure 17. Shunt Regulator

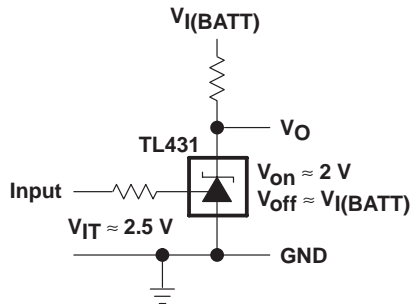
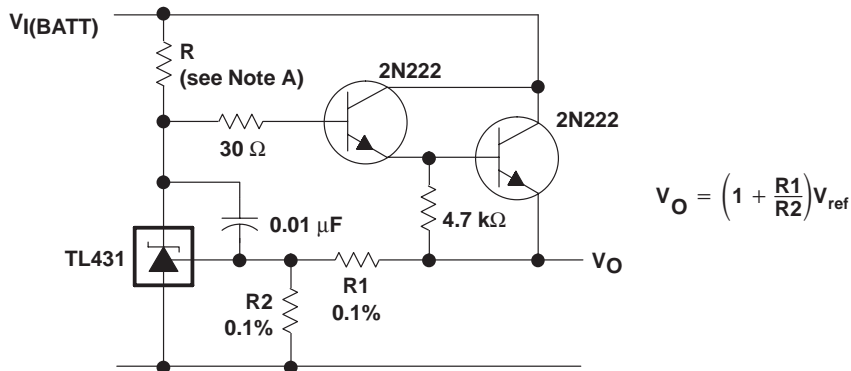


Figure 18. Single-Supply Comparator With Temperature-Compensated Threshold



NOTE A: R should provide cathode current  $\geq 1$  mA to the TL431 at minimum  $V_{I(BATT)}$ .

Figure 19. Precision High-Current Series Regulator



APPLICATION INFORMATION

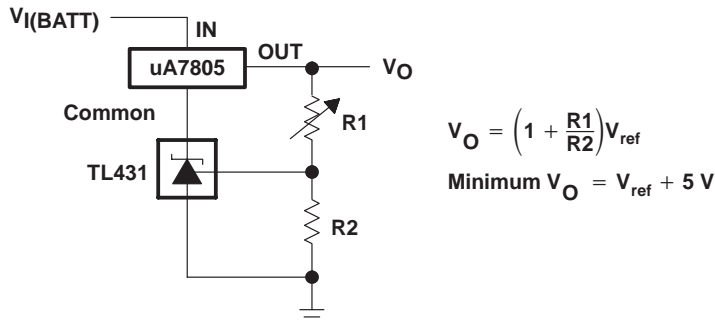


Figure 20. Output Control of a Three-Terminal Fixed Regulator

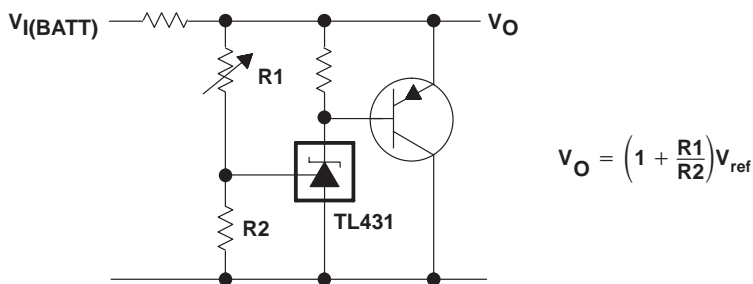
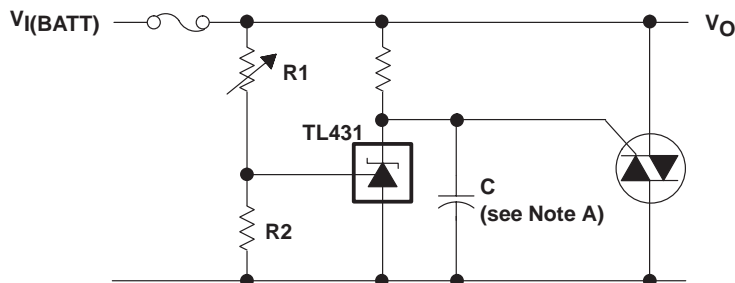


Figure 21. High-Current Shunt Regulator



NOTE A: Refer to the stability boundary conditions in Figure 16 to determine allowable values for C.

Figure 22. Crowbar Circuit

# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS005V – JULY 1978 – REVISED NOVEMBER 2003

## APPLICATION INFORMATION

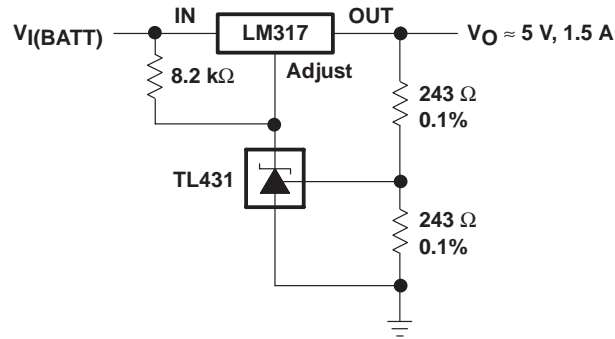
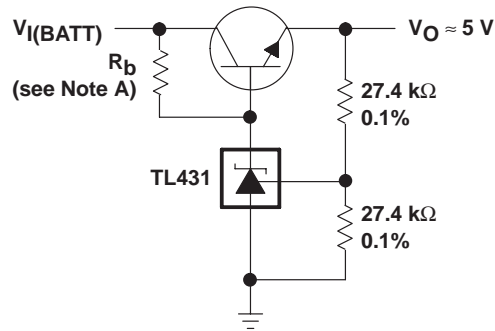


Figure 23. Precision 5-V 1.5-A Regulator



NOTE A:  $R_b$  should provide cathode current  $\geq 1$  mA to the TL431.

Figure 24. Efficient 5-V Precision Regulator

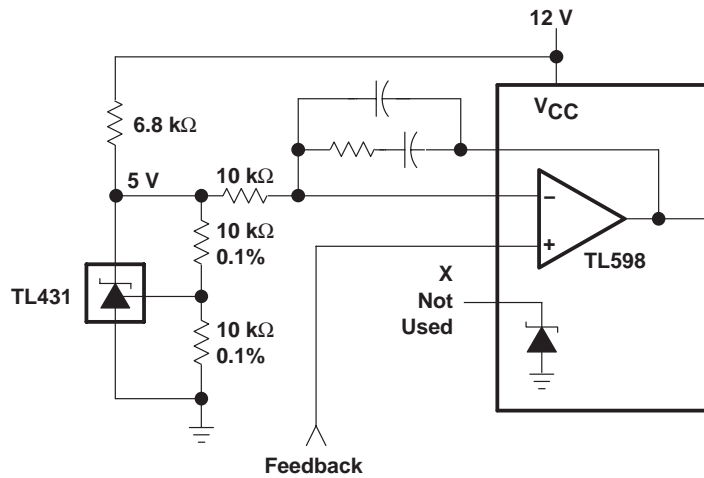
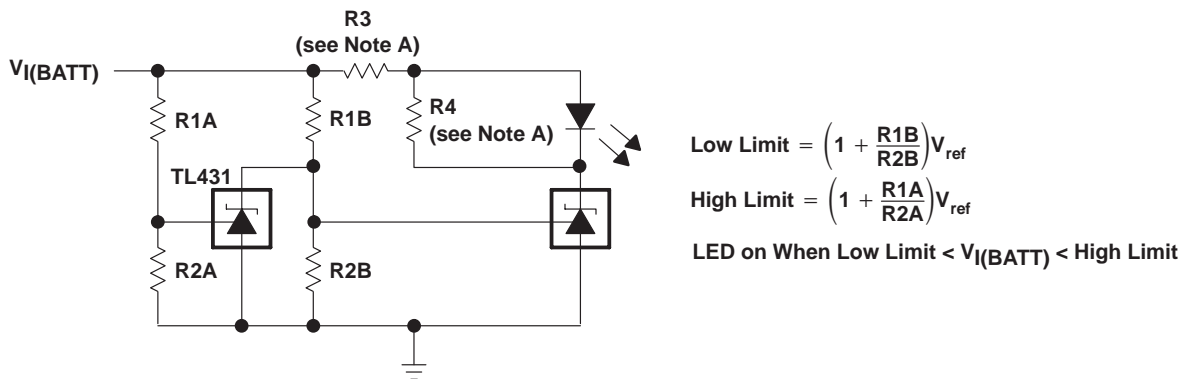


Figure 25. PWM Converter With Reference

APPLICATION INFORMATION



NOTE A: R3 and R4 are selected to provide the desired LED intensity and cathode current  $\geq 1$  mA to the TL431 at the available  $V_{I(BATT)}$ .

Figure 26. Voltage Monitor

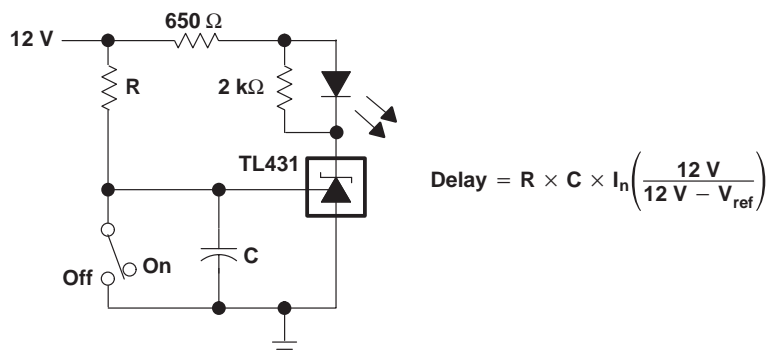


Figure 27. Delay Timer

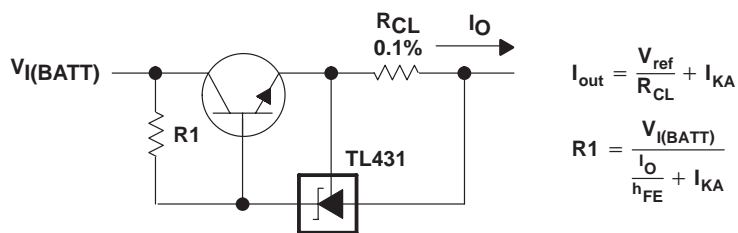


Figure 28. Precision Current Limiter

# TL431, TL431A, TL432, TL432A ADJUSTABLE PRECISION SHUNT REGULATORS

SLVS005V – JULY 1978 – REVISED NOVEMBER 2003

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## APPLICATION INFORMATION

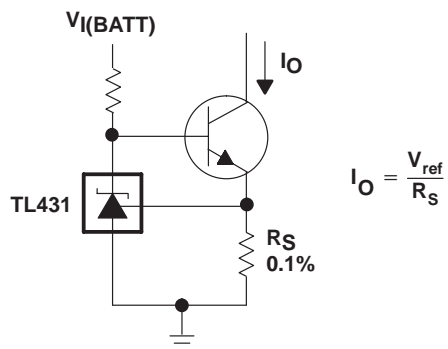


Figure 29. Precision Constant-Current Sink

JG (R-GDIP-T8)

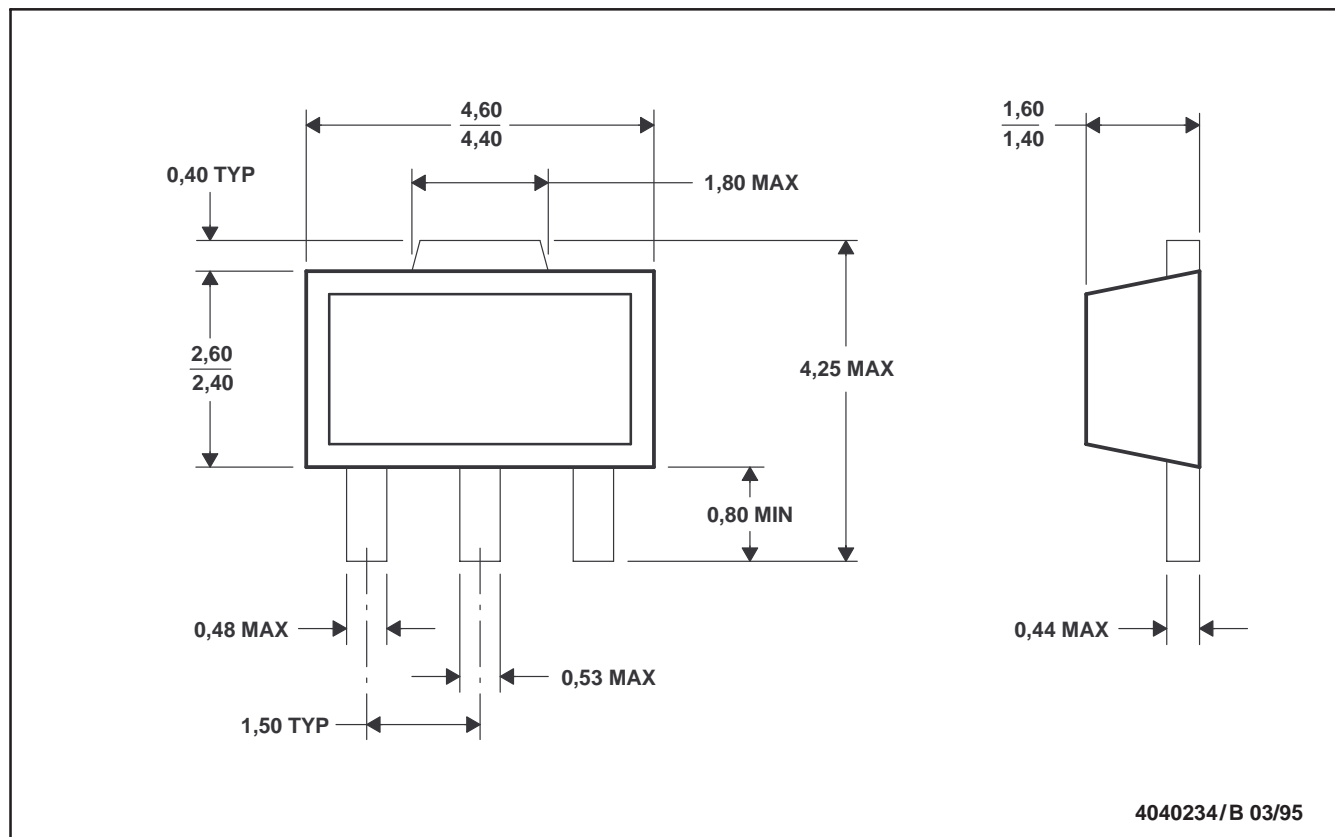
CERAMIC DUAL-IN-LINE



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification.  
 E. Falls within MIL STD 1835 GDIP1-T8

PK (R-PSSO-F3)

PLASTIC SINGLE-IN-LINE PACKAGE



- NOTES: A. All linear dimensions are in millimeters.  
B. This drawing is subject to change without notice.  
C. The center lead is in electrical contact with the tab.

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

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package can be hermetically sealed with a metal lid.
  - D. The terminals are gold plated.
  - E. Falls within JEDEC MS-004

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE



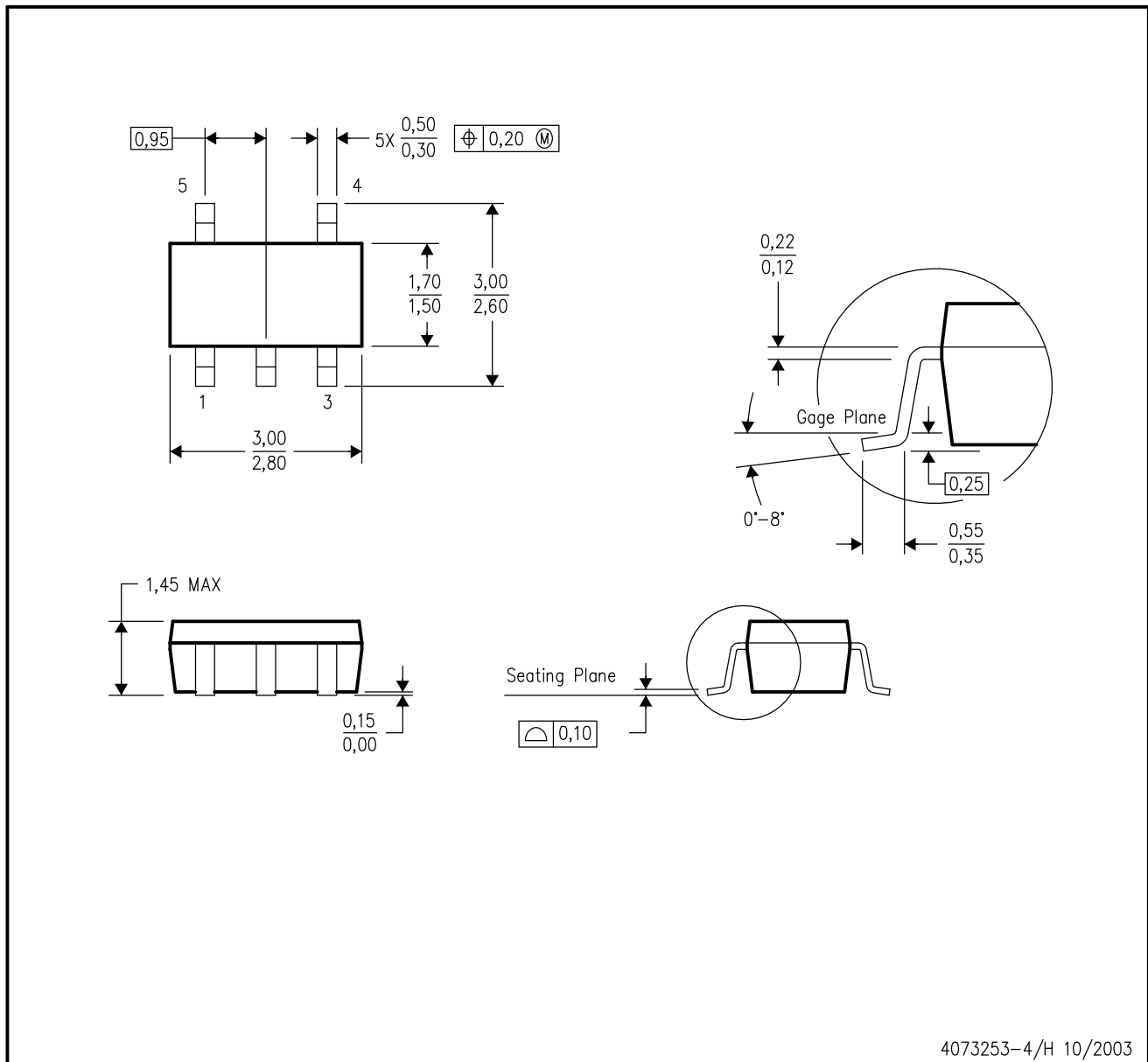
- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001

For the latest package information, go to [http://www.ti.com/sc/docs/package/pkg\\_info.htm](http://www.ti.com/sc/docs/package/pkg_info.htm)



DBV (R-PDSO-G5)

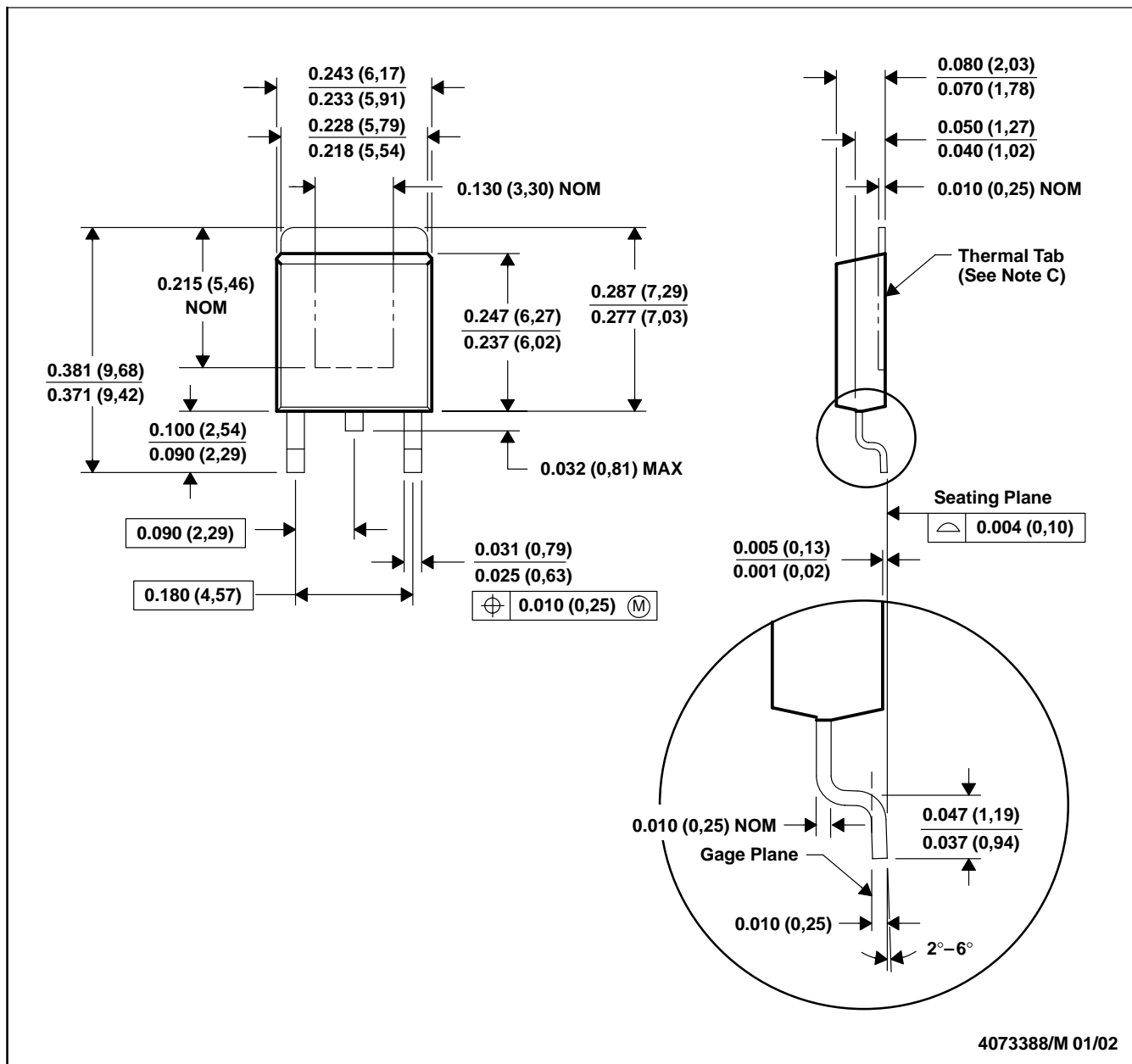
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Falls within JEDEC MO-178 Variation AA.

KTP (R-PSFM-G2)

PowerFLEX™ PLASTIC FLANGE-MOUNT PACKAGE



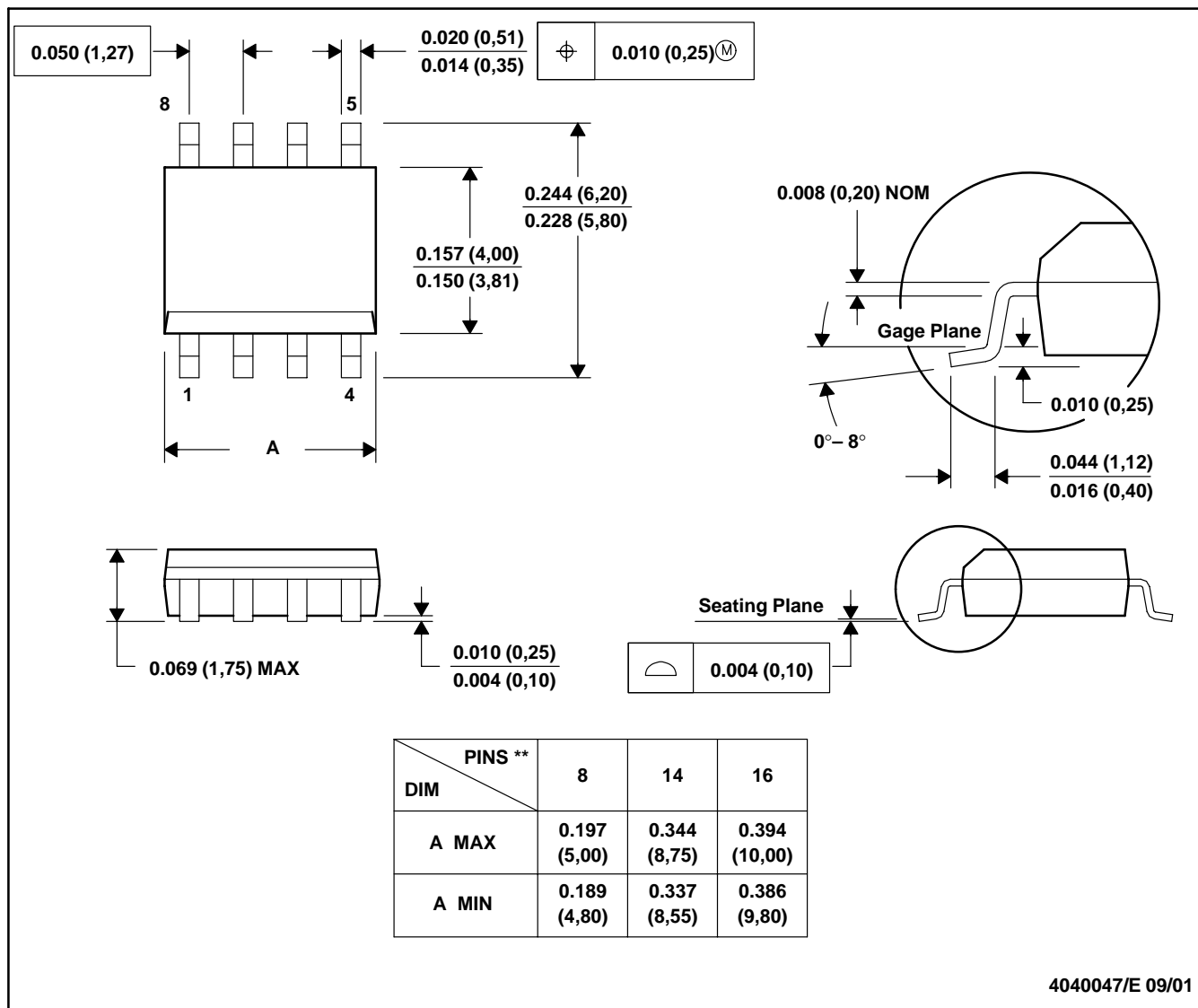
- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. The center lead is in electrical contact with the thermal tab.  
 D. Dimensions do not include mold protrusions, not to exceed 0.006 (0,15).  
 E. Falls within JEDEC TO-252 variation AC.

PowerFLEX is a trademark of Texas Instruments.

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

PLASTIC SMALL-OUTLINE PACKAGE

8 PINS SHOWN



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

# MECHANICAL DATA

PS (R-PDSO-G8)

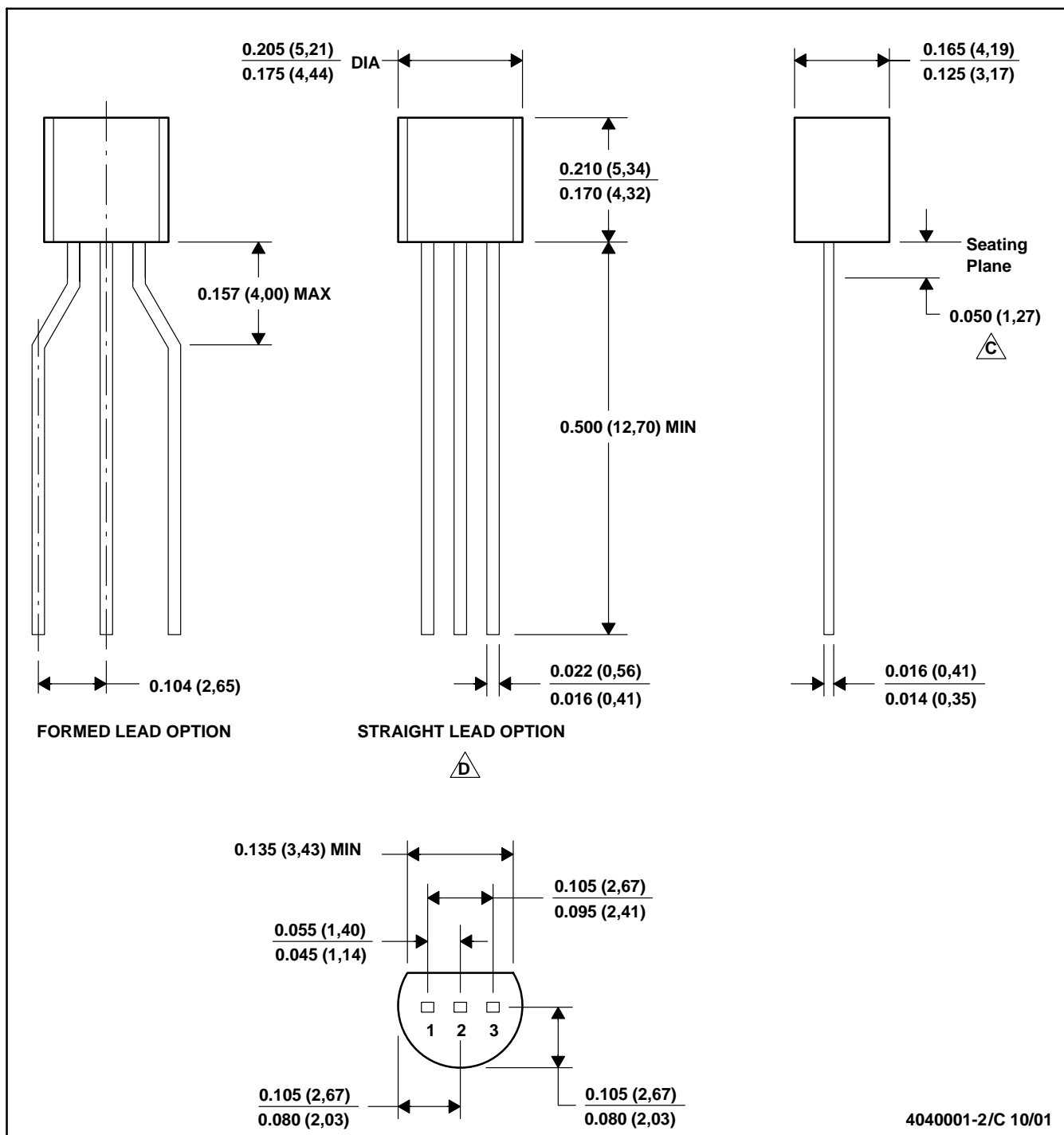
PLASTIC SMALL-OUTLINE PACKAGE



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

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



4040001-2/C 10/01

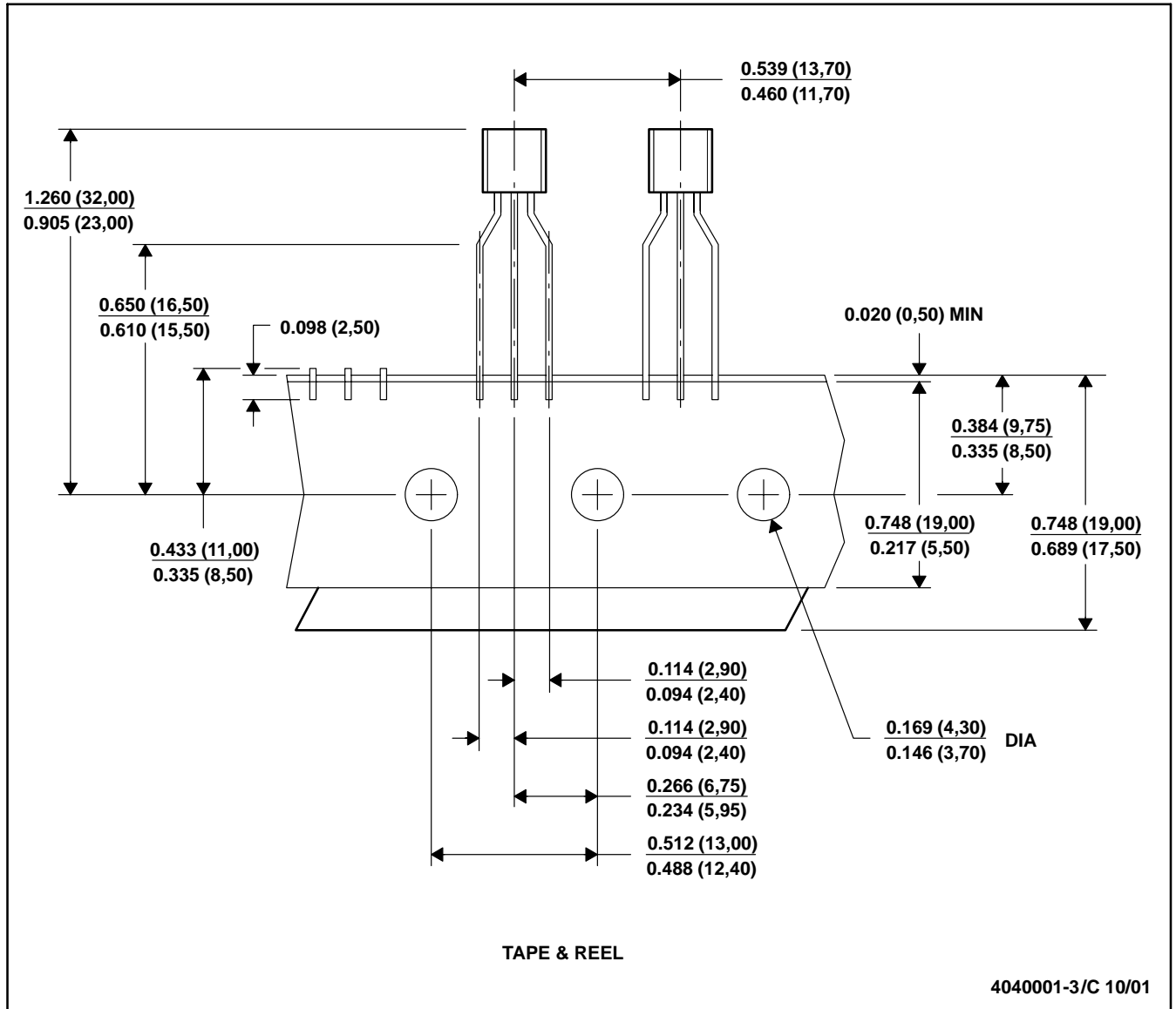


# MECHANICAL DATA

MSOT002A – OCTOBER 1994 – REVISED NOVEMBER 2001

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Tape and Reel information for the Format Lead Option package.

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

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

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

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Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
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Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
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		Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
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