

- 2.5-V Virtual Ground for 5-V/GND Analog Systems
- High Output-Current Capability Sink or Source . . . 20 mA Typ
- Micropower Operation . . . 170 μ A Typ

- Excellent Regulation Characteristics
 - Output Regulation
 - 45 μ V Typ at $I_O = 0$ to –10 mA
 - +15 μ V Typ at $I_O = 0$ to +10 mA
 - Input Regulation = 1.5 μ V/V Typ
- Low-Impedance Output . . . 0.0075 Ω Typ
- Macromodel Included

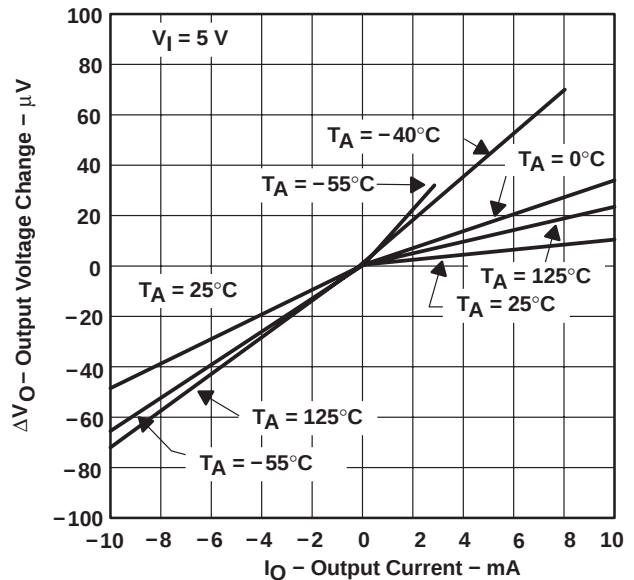
description

In signal-conditioning applications using a single power source, a reference voltage is required for termination of all signal grounds. To accomplish this, engineers have typically used solutions consisting of resistors, capacitors, operational amplifiers, and voltage references. Texas Instruments has eliminated all of those components with one easy-to-use 3-terminal device. That device is the TLE2425 precision virtual ground.

Use of the TLE2425 over other typical circuit solutions gives the designer increased dynamic signal range, improved signal-to-noise ratio, lower distortion, improved signal accuracy, and easier interfacing to ADCs and DACs. These benefits are the result of combining a precision micropower voltage reference and a high-performance precision operational amplifier in a single silicon chip. It is the precision and performance of these two circuit functions together that yield such dramatic system-level performance.

The TLE2425 improves input regulation as well as output regulation and, in addition, reduces output impedance and power dissipation in a majority of virtual-ground-generation circuits. Both input regulation and load regulation exceed 12 bits of accuracy on a single 5-V system. Signal-conditioning front ends of data acquisition systems that push 12 bits and beyond can use the TLE2425 to eliminate a major source of system error.

OUTPUT REGULATION



AVAILABLE OPTIONS

T_A	SMALL OUTLINE (D)	PLASTIC TO-226AA (LP)
0°C to 70°C	TLE2425CD	TLE2425CD
–40°C to 85°C	TLE2425ID	TLE2425ID
–55°C to 125°C	TLE2425MD	—

† The D package is available taped and reeled. Add R suffix to the device type (e.g., TLE2425CDR).



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**

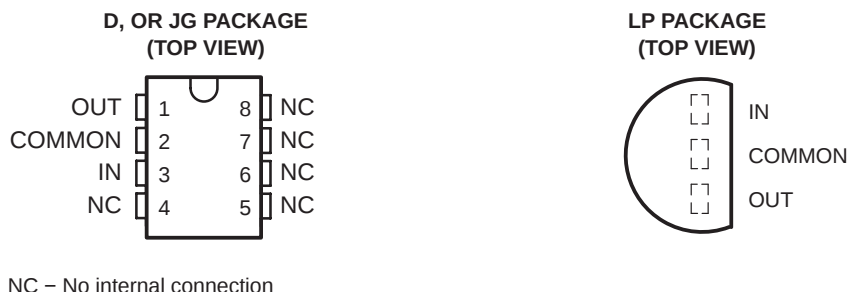
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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)[†]

Continuous input voltage, V_I	40 V
Output current, I_O	±80 mA
Duration of short-circuit current at (or below) 25°C (see Note 1)	unlimited
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A :	
C-suffix	0°C to 70°C
I-suffix	–40°C to 85°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: D package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG or LP package	300°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: The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
LP	775 mW	6.2 mW/°C	496 mW	403 mW	155 mW

recommended operating conditions

	C-SUFFIX		I-SUFFIX		M-SUFFIX		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Input voltage, V_I	4	40	4	40	4	40	V
Operating free-air temperature, T_A	0	70	–40	85	–55	125	°C

electrical characteristics at specified free-air temperature, $V_I = 5\text{ V}$, $I_O = 0$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS		T _A [†]	TLE2425C			UNIT	
				MIN	TYP	MAX		
Output voltage			25°C	2.48	2.5	2.52	V	
			Full range	2.47		2.53		
Temperature coefficient of output voltage			25°C	20			ppm/°C	
Bias current	I _O = 0	25°C	170			250	μA	
		Full range	250					
Input voltage regulation	V _I = 4.5 V to 5.5 V	25°C	1.5			20	μV	
		Full range	25					
	V _I = 4 V to 40 V	25°C	1.5			20	μV/V	
		Full range	25					
Ripple rejection	f = 120 Hz,	ΔV _{I(PP)} = 1 V	25°C	80			dB	
Output voltage regulation (source current) [‡]	I _O = 0 to −10 mA		25°C	−160	−45	160	μV	
			Full range	−250		250		
	I _O = 0 to −20 mA		25°C	−450	−150	450		
Output voltage regulation (sink current) [‡]	I _O = 0 to 10 mA		25°C	−160	15	160	μV	
			Full range	−250		250		
	I _O = 0 to 20 mA		25°C	−235	65	235		
Long-term drift of output voltage	Δt = 1000 h,	Noncumulative	25°C	15			ppm	
Output impedance			25°C	7.5			22.5	mΩ
Short-circuit output current (sink current)	V _O = 5 V		25°C	30	55		mA	
Short-circuit output current (source current)	V _O = 0			−30	−50			
Output noise voltage, rms	f = 10 Hz to 10 kHz		25°C	100			μV	
Output voltage response to output current step	V _O to 0.1%, I _O = ±10 mA	C _L = 0	25°C	110			μs	
		C _L = 100 pF		115				
	V _O to 0.01%, I _O = ±10 mA	C _L = 0		180				
		C _L = 100 pF		180				
Output voltage response to input voltage step	V _I = 4.5 to 5.5 V, V _O to 0.1%		25°C	12			μs	
	V _I = 4.5 to 5.5 V, V _O to 0.01%			30				
Output voltage turn-on response	V _I = 0 to 5 V, V _O to 0.1%		25°C	125			μs	
	V _I = 0 to 5 V, V _O to 0.01%			210				

[†] Full range is 0°C to 70°C.

[‡] The listed values are not production tested.

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electrical characteristics at specified free-air temperature, $V_I = 5\text{ V}$, $I_O = 0$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS		T _A [†]	TLE2425I			UNIT	
				MIN	TYP	MAX		
Output voltage			25°C	2.48	2.5	2.52	V	
			Full range	2.47		2.53		
Temperature coefficient of output voltage			25°C	20			ppm/°C	
Bias current	I _O = 0		25°C	170			μA	
			Full range	250				
Input voltage regulation	V _I = 4.5 V to 5.5 V		25°C	1.5			μV	
			Full range	75				
	V _I = 4 V to 40 V		25°C	1.5			μV/V	
			Full range	75				
Ripple rejection	f = 120 Hz, ΔV _{I(PP)} = 1 V		25°C	80			dB	
Output voltage regulation (source current) [‡]	I _O = 0 to −10 mA		25°C	−160	−45	160	μV	
			Full range	−250		250		
	I _O = 0 to −20 mA		25°C	−450	−150	450		
Output voltage regulation (sink current) [‡]	I _O = 0 to 8 mA		25°C	−160	15	160	μV	
			Full range	−250		250		
	I _O = 0 to 20 mA		25°C	−235	65	235		
Long-term drift of output voltage	Δt = 1000 h, Noncumulative		25°C	15			ppm	
Output impedance			25°C	7.5			22.5	mΩ
Short-circuit output current (sink current)	V _O = 5 V		25°C	30	55		mA	
Short-circuit output current (source current)	V _O = 0			−30	−50			
Output noise voltage, rms	f = 10 Hz to 10 kHz		25°C	100			μV	
Output voltage response to output current step	V _O to 0.1%, I _O = ±10 mA	C _L = 0	25°C	110			μs	
		C _L = 100 pF		115				
	V _O to 0.01%, I _O = ±10 mA	C _L = 0		180				
		C _L = 100 pF		180				
Output voltage response to input voltage step	V _I = 4.5 to 5.5 V, V _O to 0.1%		25°C	12			μs	
	V _I = 4.5 to 5.5 V, V _O to 0.01%			30				
Output voltage turn-on response	V _I = 0 to 5 V, V _O to 0.1%		25°C	125			μs	
	V _I = 0 to 5 V, V _O to 0.01%			210				

† Full range is -40°C to 85°C.

‡ The listed values are not production tested.



electrical characteristics at specified free-air temperature, $V_I = 5\text{ V}$, $I_O = 0$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS		T _A [†]	TLE2425M			UNIT	
				MIN	TYP	MAX		
Output voltage			25°C	2.48	2.5	2.52	V	
			Full range	2.47		2.53		
Temperature coefficient of output voltage			25°C	20			ppm/°C	
Bias current	I _O = 0		25°C	170			μA	
			Full range	250				
Input voltage regulation	V _I = 4.5 V to 5.5 V		25°C	1.5			μV	
			Full range	100				
	V _I = 4.5 V to 40 V		25°C	1.5			μV/V	
			Full range	100				
Ripple rejection	f = 120 Hz,	ΔV _{I(PP)} = 1 V	25°C	80			dB	
Output voltage regulation (source current) [‡]	I _O = 0 to −10 mA		25°C	−160	−45	160	μV	
			Full range	−250		250		
	I _O = 0 to −20 mA		25°C	−450	−150	450		
Output voltage regulation (sink current) [‡]	I _O = 0 to 3 mA		25°C	−160	15	160	μV	
			Full range	−250		250		
	I _O = 0 to 20 mA		25°C	−235	65	235		
Long-term drift of output voltage	Δt = 1000 h,	Noncumulative	25°C	15			ppm	
Output impedance			25°C	7.5			22.5	mΩ
Short-circuit output current (sink current)	V _O = 5 V		25°C	30	55		mA	
Short-circuit output current (source current)	V _O = 0			−30	−50			
Output noise voltage, rms	f = 10 Hz to 10 kHz		25°C	100			μV	
Output voltage response to output current step	V _O to 0.1%, I _O = ±10 mA	C _L = 0	25°C	110			μs	
		C _L = 100 pF		115				
	V _O to 0.01%, I _O = ±10 mA	C _L = 0		180				
		C _L = 100 pF		180				
Output voltage response to input voltage step	V _I = 4.5 to 5.5 V, V _O to 0.1%		25°C	12			μs	
	V _I = 4.5 to 5.5 V, V _O to 0.01%			30				
Output voltage turn-on response	V _I = 0 to 5 V, V _O to 0.1%		25°C	125			μs	
	V _I = 0 to 5 V, V _O to 0.01%			210				

[†] Full range is -55°C to 125°C.

[‡] The listed values are not production tested.

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TYPICAL CHARACTERISTICS

Table Of Graphs

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Input bias current	vs Input voltage	4
	vs Free-air temperature	5
Input voltage regulation		6
Ripple rejection	vs Frequency	7
Output voltage regulation		8
Output impedance	vs Frequency	9
Short-circuit output current	vs Free-air temperature	10
Spectral noise voltage density	vs Frequency	11
Wide-band noise voltage	vs Frequency	12
Output voltage change with current step	vs Time	13
Output voltage change with voltage step	vs Time	14
Output voltage power-up response	vs Time	15
Output current	vs Load capacitance	16



TYPICAL CHARACTERISTICS†

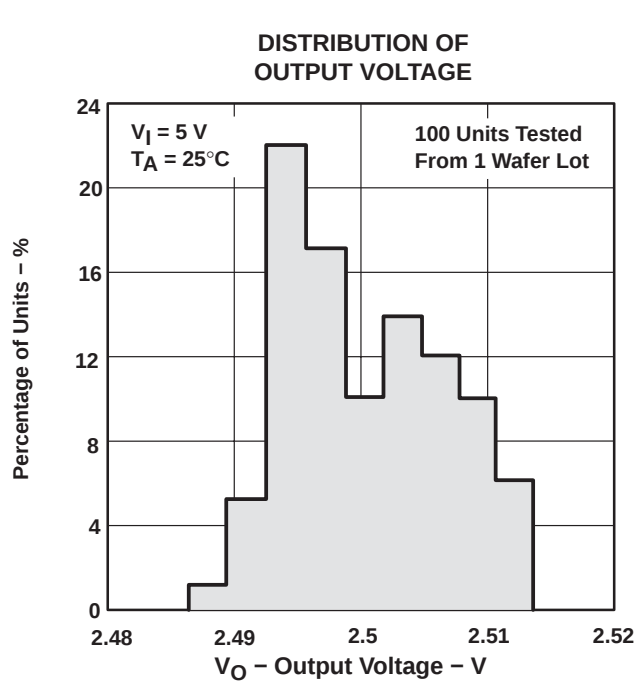


Figure 1

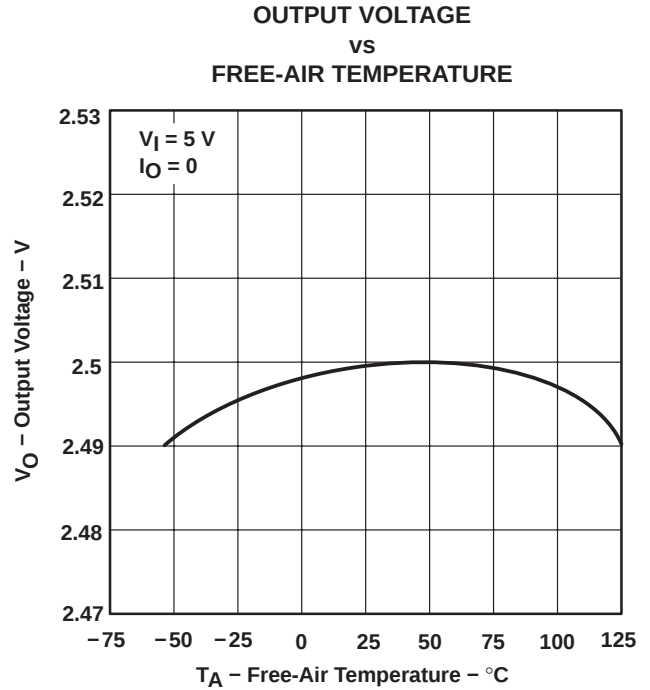


Figure 2

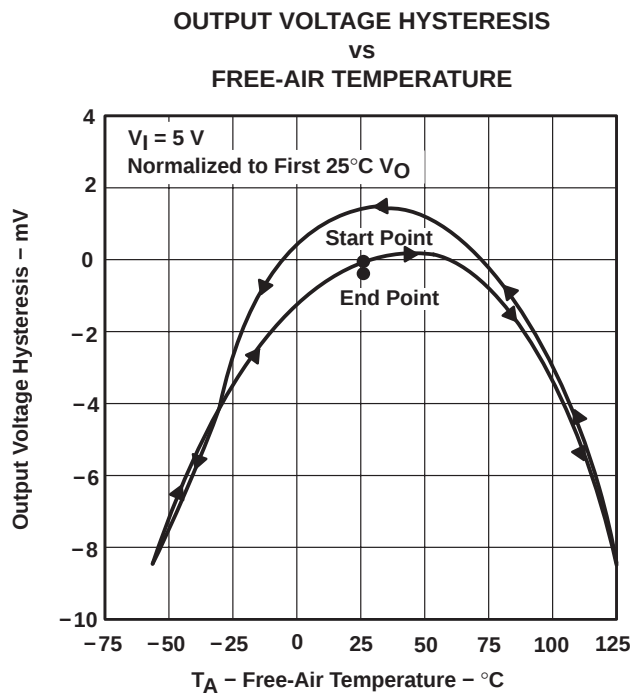


Figure 3

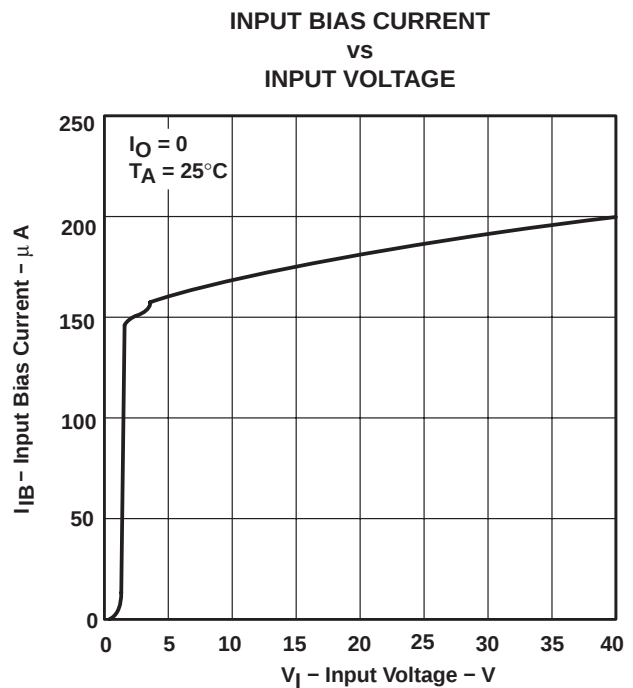


Figure 4

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

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TYPICAL CHARACTERISTICS†

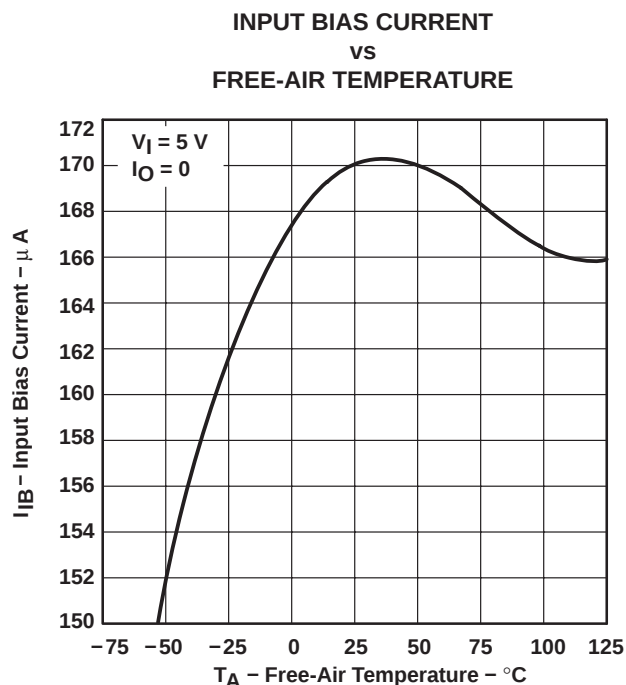


Figure 5

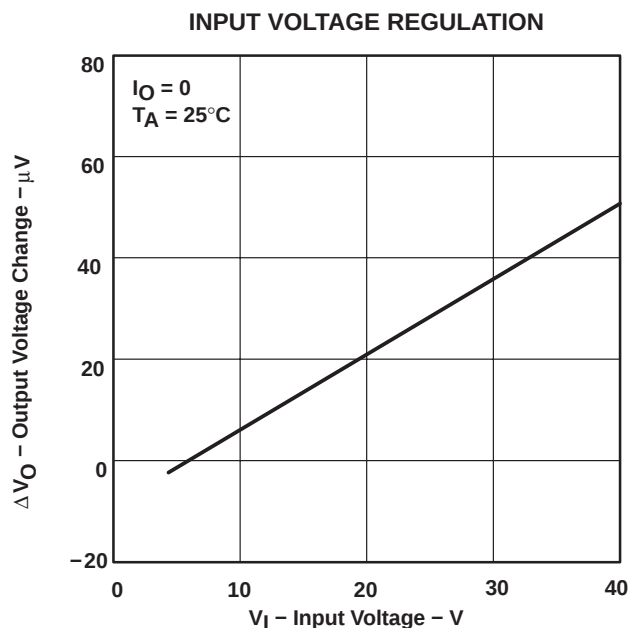


Figure 6

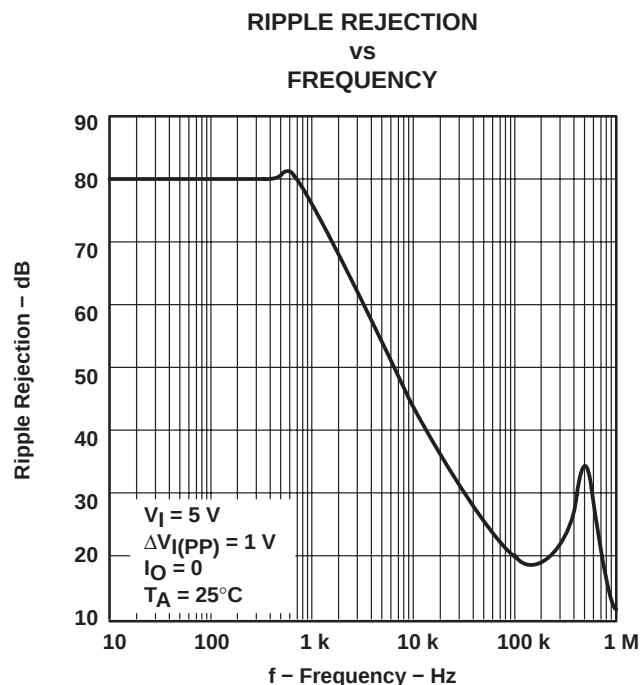


Figure 7

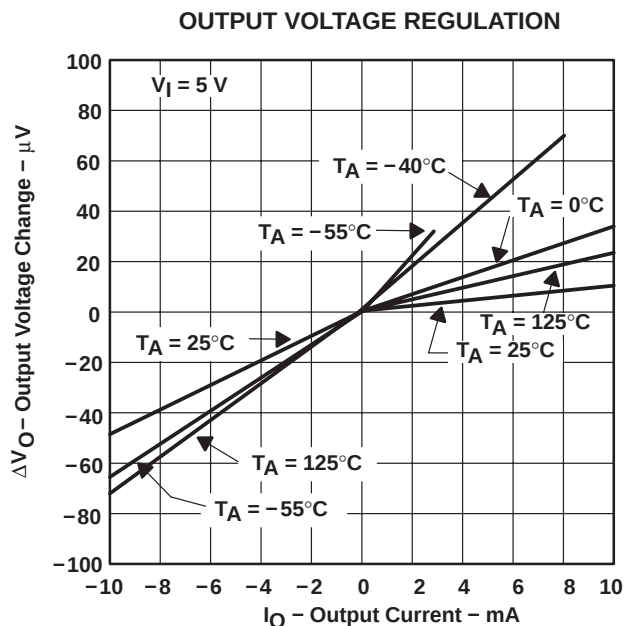


Figure 8

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

TYPICAL CHARACTERISTICS

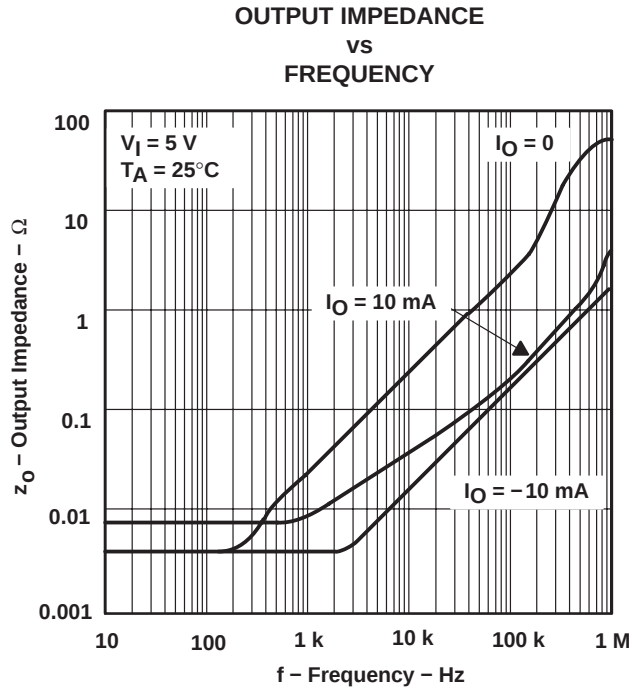


Figure 9

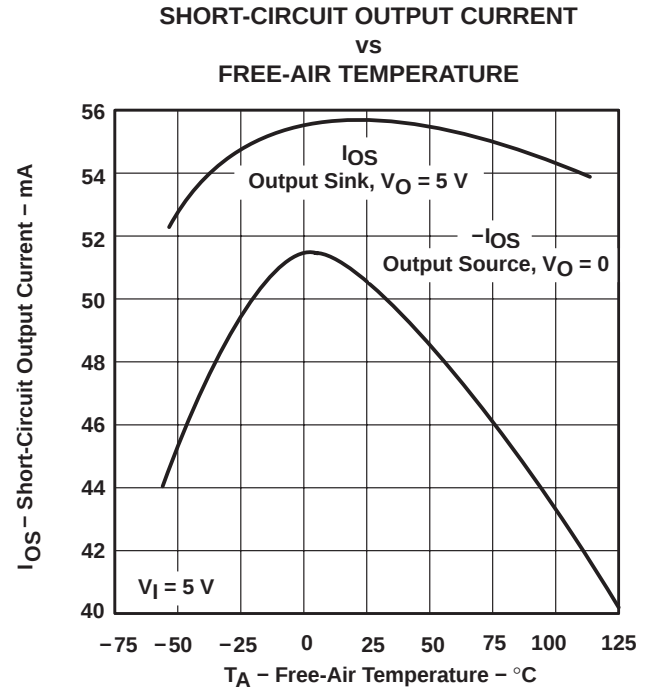


Figure 10

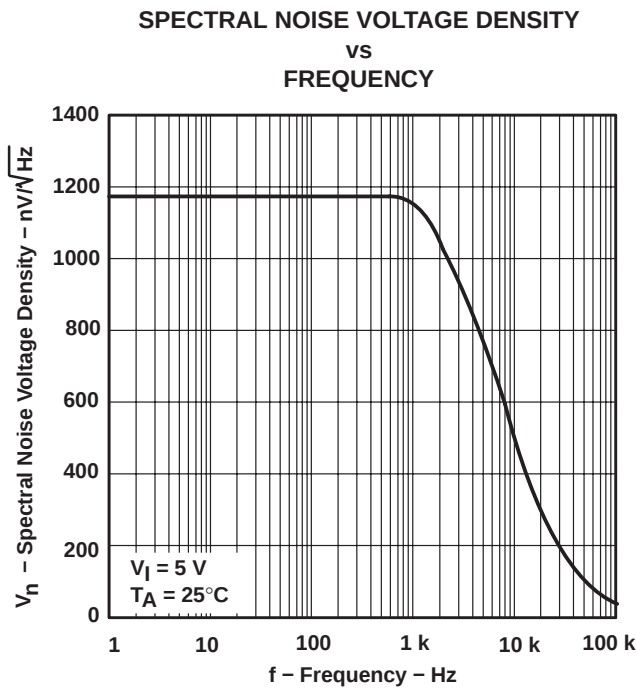


Figure 11

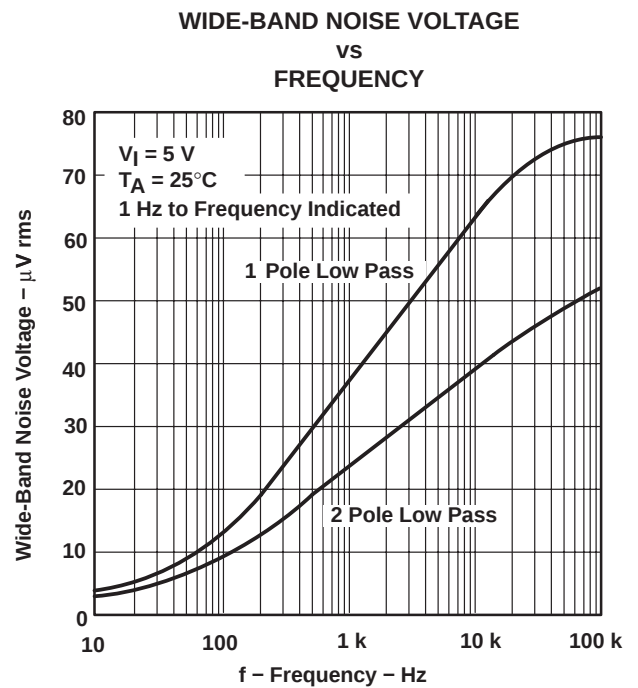


Figure 12

TYPICAL CHARACTERISTICS

**OUTPUT VOLTAGE RESPONSE
TO OUTPUT CURRENT STEP**

VS
TIME

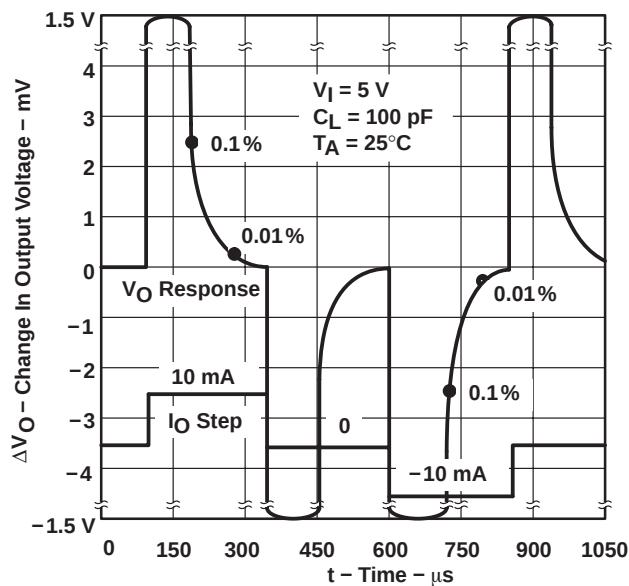


Figure 13

**OUTPUT VOLTAGE RESPONSE
TO INPUT VOLTAGE STEP**

VS
TIME

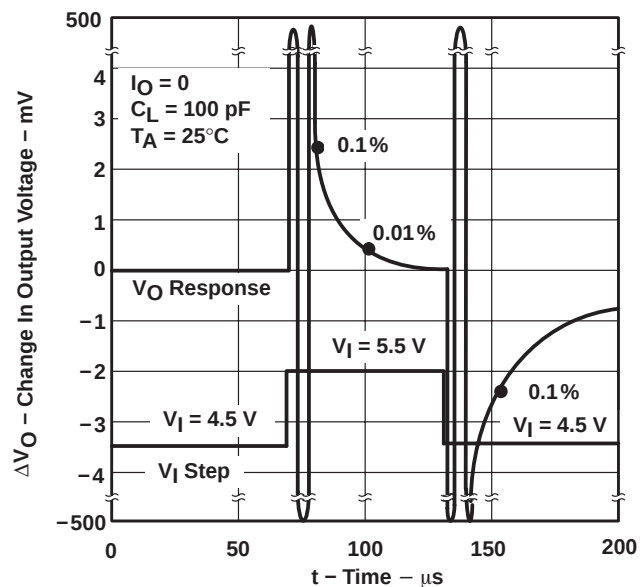


Figure 14

OUTPUT VOLTAGE POWER-UP RESPONSE

VS
TIME

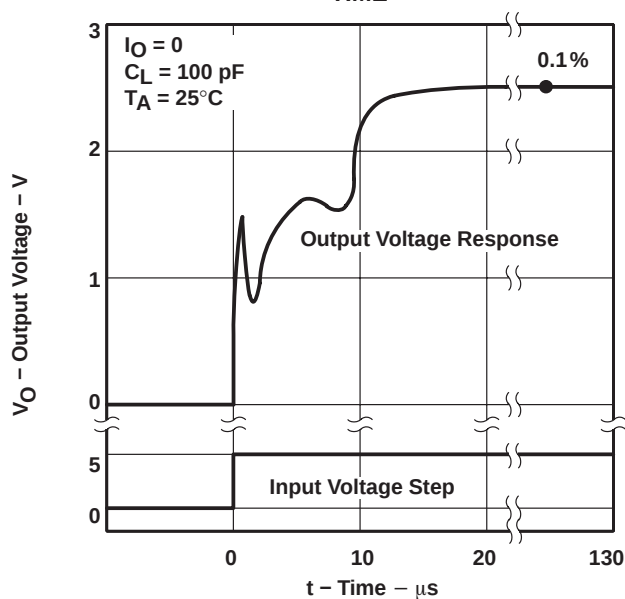


Figure 15

**STABILITY RANGE
OUTPUT CURRENT**

VS
LOAD CAPACITANCE

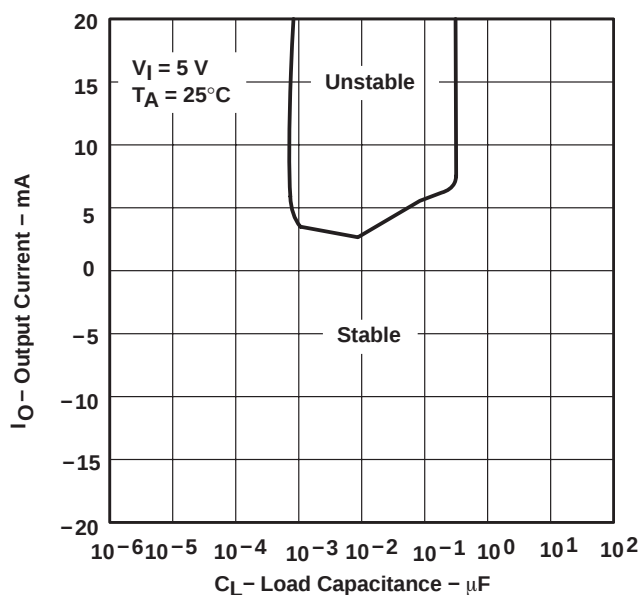


Figure 16

```

*      TLE2425 OPERATIONAL AMPLIFIER "MACROMODEL" SUBCIRCUIT
*      CREATED USING PARTS RELEASE 4.03 ON 08/21/90 AT 13:51
*      REV (N/A)      SUPPLY VOLTAGE: 5 V
*      CONNECTIONS:  INPUT
*                   |      COMMON
*                   |      |      OUTPUT
*                   |      |      |
*.SUBCKT TLE2425  3      4      5
*

```



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macromodel information (continued)

```
RO1      8  5  63
RO2      7 99  62
VCM+    82 99  1.0
VCM-    83 99 -2.3
VB       9  0  DC  0
VC       3 53  DC  1.400
VE      54  4  DC  1.400
VLIM     7  8  DC  0
VLP     91  0  DC  30
VLN      0 92  DC  30
VPSR     0 86  DC  0
RFB      5  2  1K
RIN     30  1  1K
RCOM    34  4  .1
*REGULATOR SECTION
RG1     30  0  20MEG
RG2     30 31  .2
RG3     31 35  400K
RG4     35 34  411K
RG5     31 36  25MEG
HREG    31 32  POLY(2)   VPSET VNSET  0  1E2 1E2
VREG    32 33  DC  0V
EREG    33 34  POLY(1)   (36,34)  1.23 1
VADJ    36 34  1.27V
HPSET   37  0  VREG  1.030E3
VPSET   38  0  DC  20V
HNSET   39  0  VREG  6.11E5
VNSET   40  0  DC -20V
DSUB     4 34  DX
DPOS    37 38  DX
DNNEG   40 39  DX
.MODEL DX  D(IS=800.0E-18)
.MODEL QX  PNP(IS=800.0E-18 BF=480)
.ENDS
```

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
5962-9555601Q2A	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI
5962-9555601QPA	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI
TLE2425CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425CLP	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TLE2425CLPE3	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TLE2425CLPR	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI
TLE2425CPS	ACTIVE	SO	PS	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425CPSG4	ACTIVE	SO	PS	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425CPSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425CPSRG4	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425ILP	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TLE2425ILPE3	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TLE2425MD	ACTIVE	SOIC	D	8	75	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLE2425MDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425MDR	ACTIVE	SOIC	D	8	2500	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLE2425MDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLE2425MFKB	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI
TLE2425MJG	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI
TLE2425MJGB	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI
TLE2425MLP	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI

⁽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.

OBSELETE: 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.

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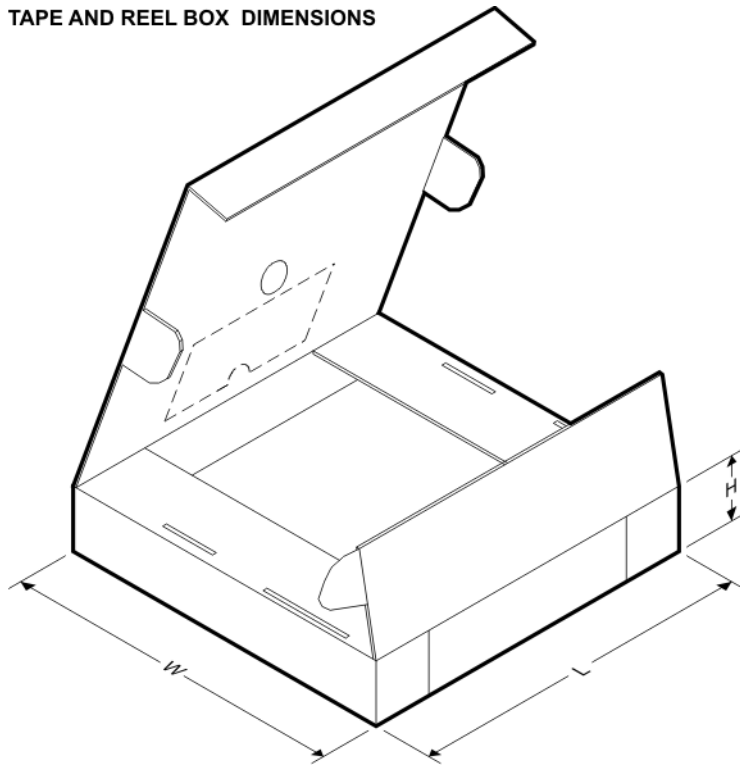
TAPE AND REEL INFORMATION



*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
TLE2425CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLE2425IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



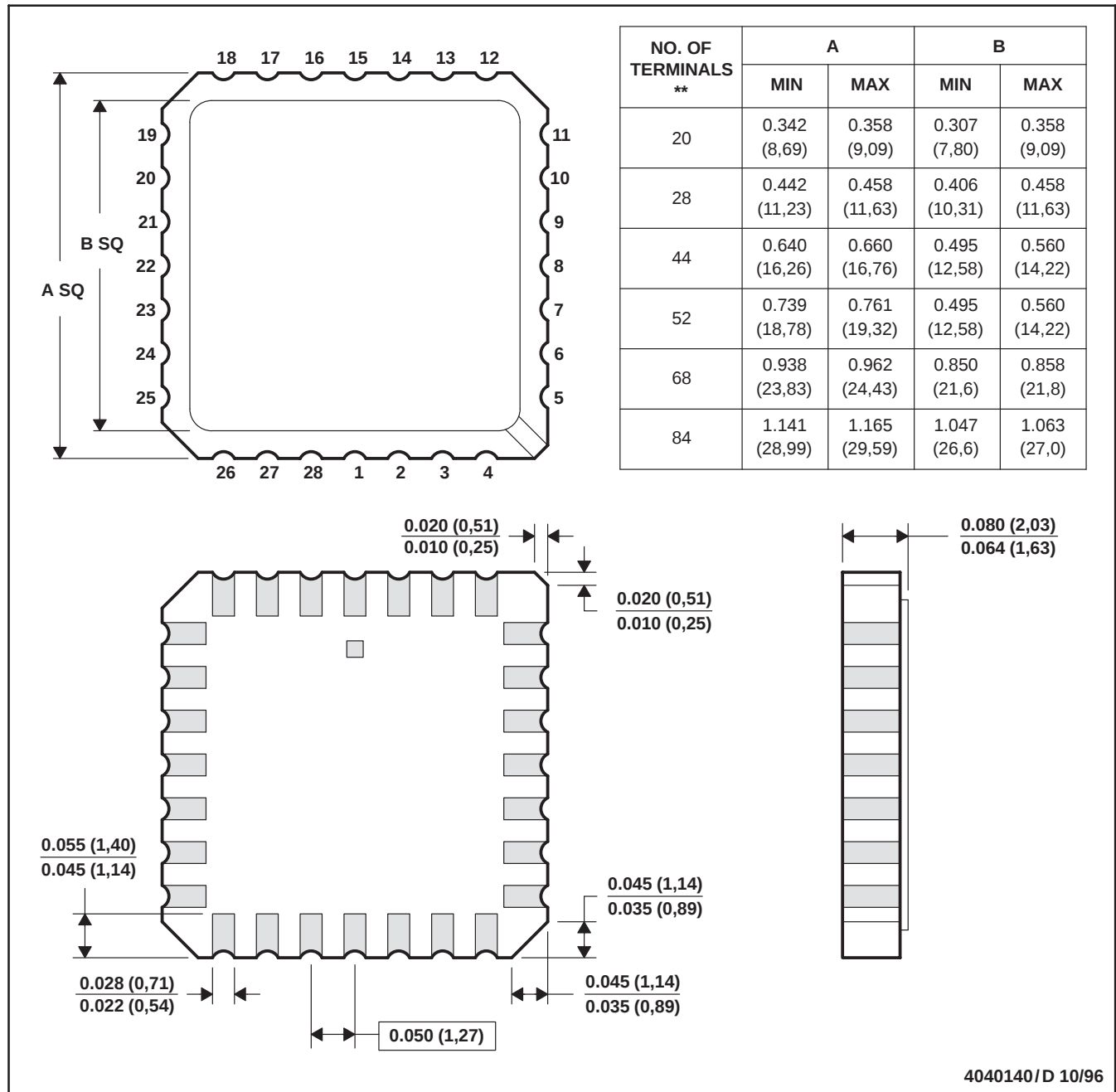
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLE2425CDR	SOIC	D	8	2500	346.0	346.0	29.0
TLE2425IDR	SOIC	D	8	2500	346.0	346.0	29.0

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

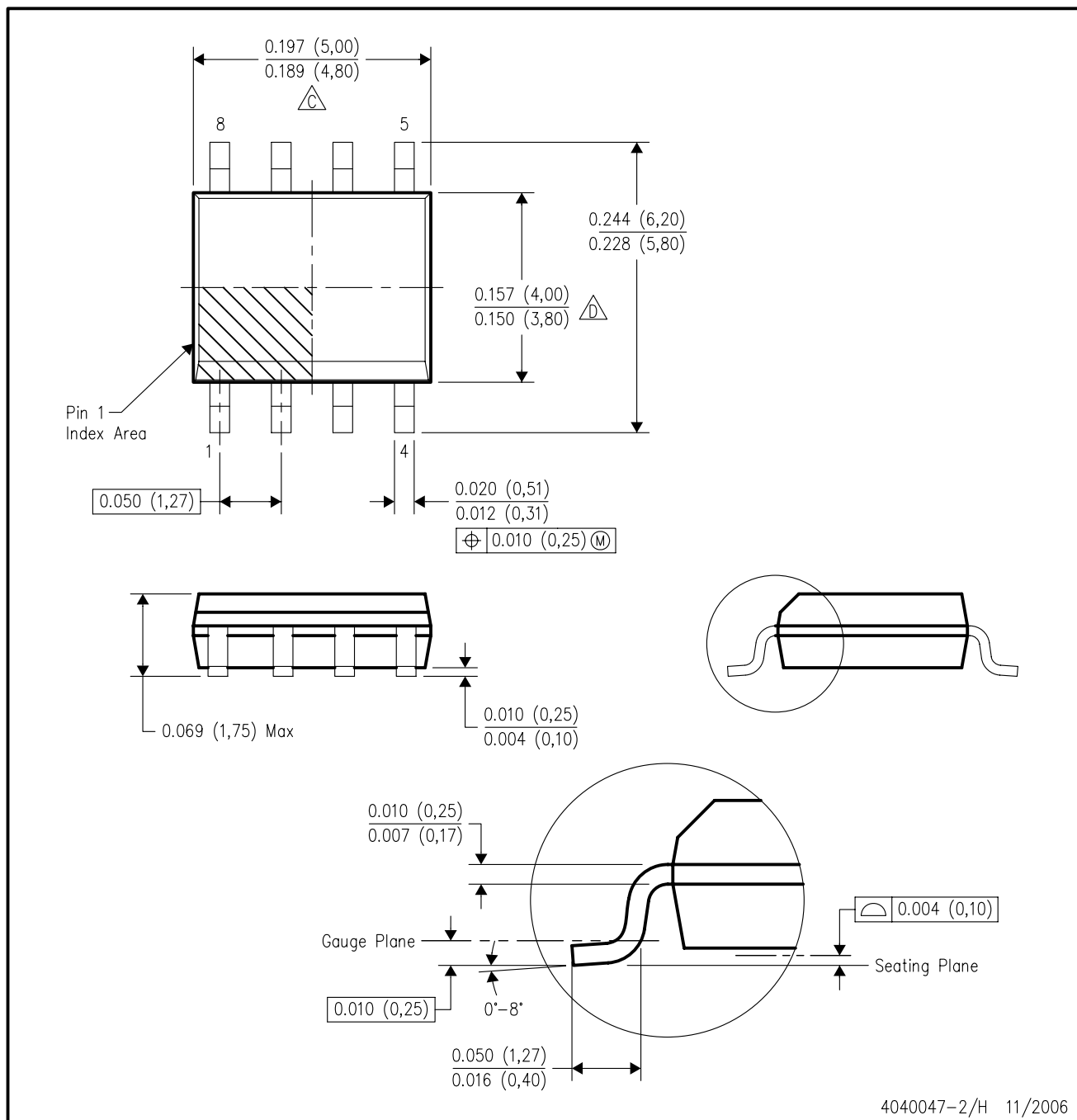
28 TERMINAL SHOWN



- 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.
 - The terminals are gold plated.
 - Falls within JEDEC MS-004

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



4040047-2/H 11/2006

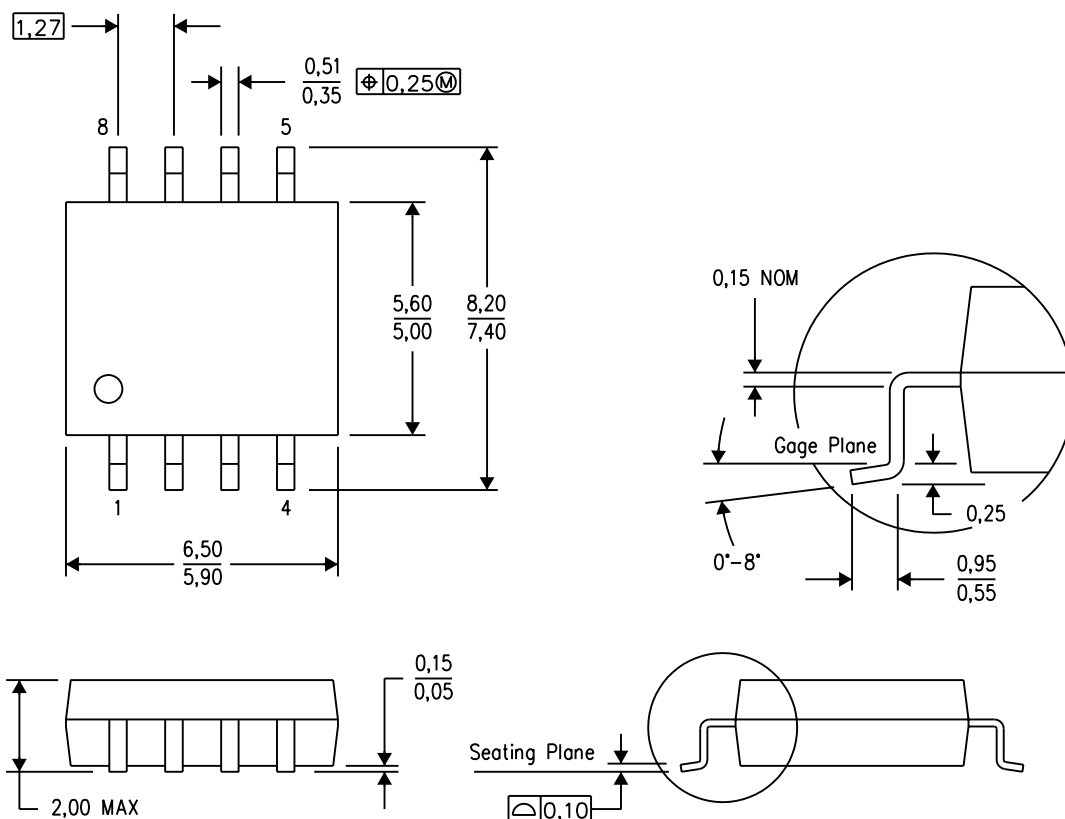
NOTES:

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

MECHANICAL DATA

PS (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

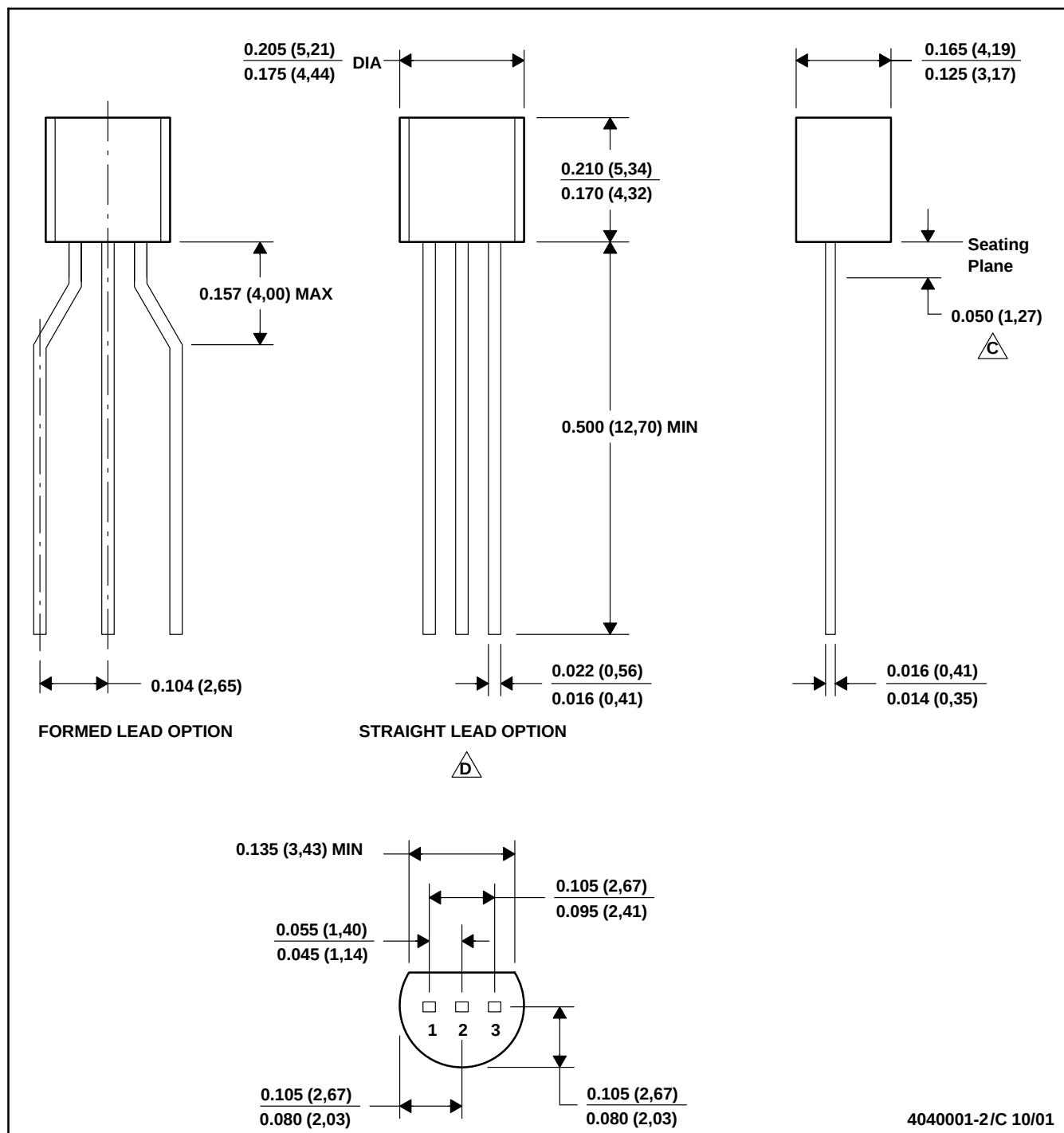


4040063/C 03/03

- 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



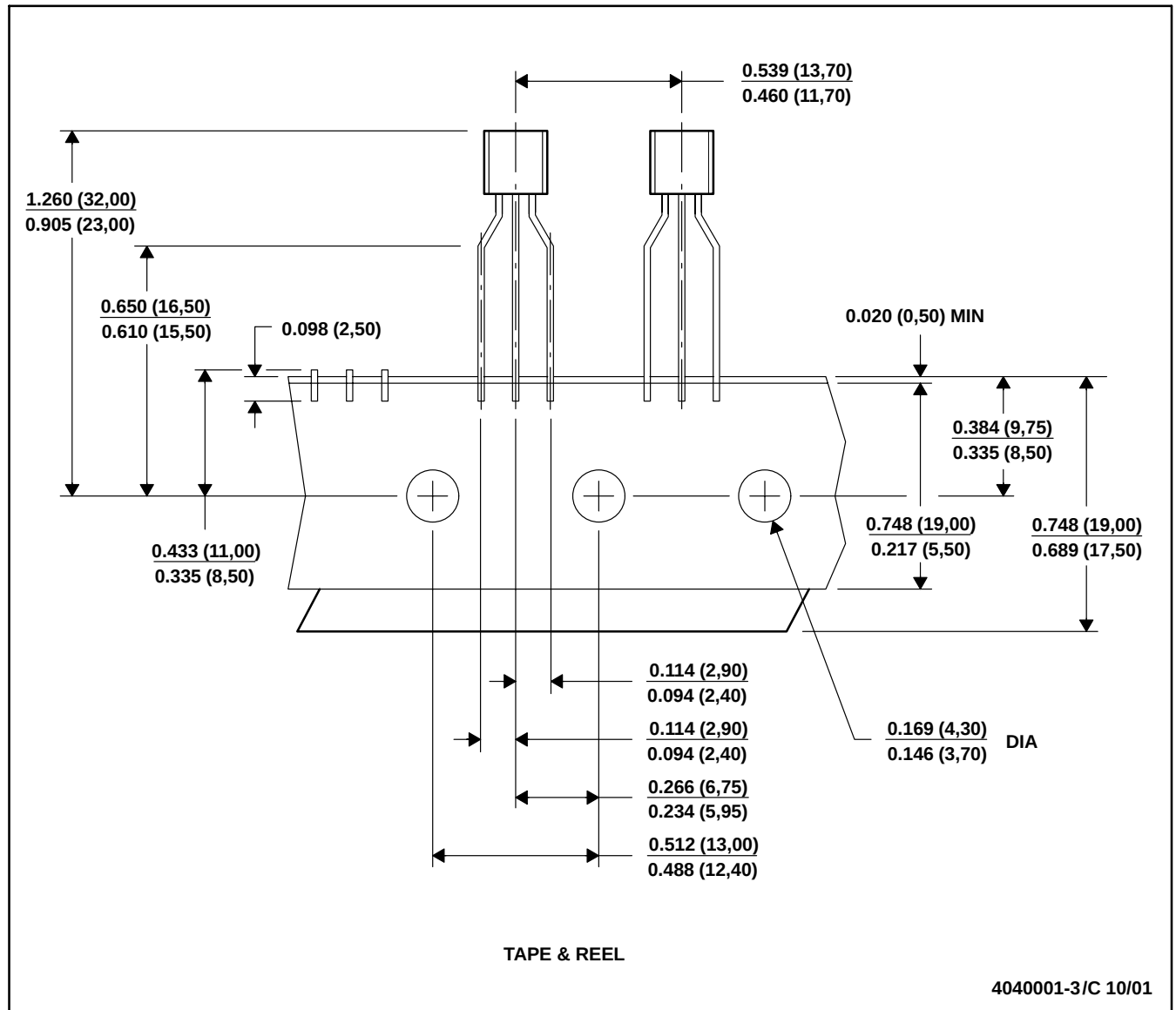
- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Lead dimensions are not controlled within this area.
 D. Falls within JEDEC TO -226 Variation AA (TO-226 replaces TO-92).
 E. Shipping Method:
 Straight lead option available in bulk pack only.
 Formed lead option available in tape & reel or ammo pack.

MECHANICAL DATA

MSOT002A – OCTOBER 1994 – REVISED NOVEMBER 2001

LP (O-PBCY-W3)

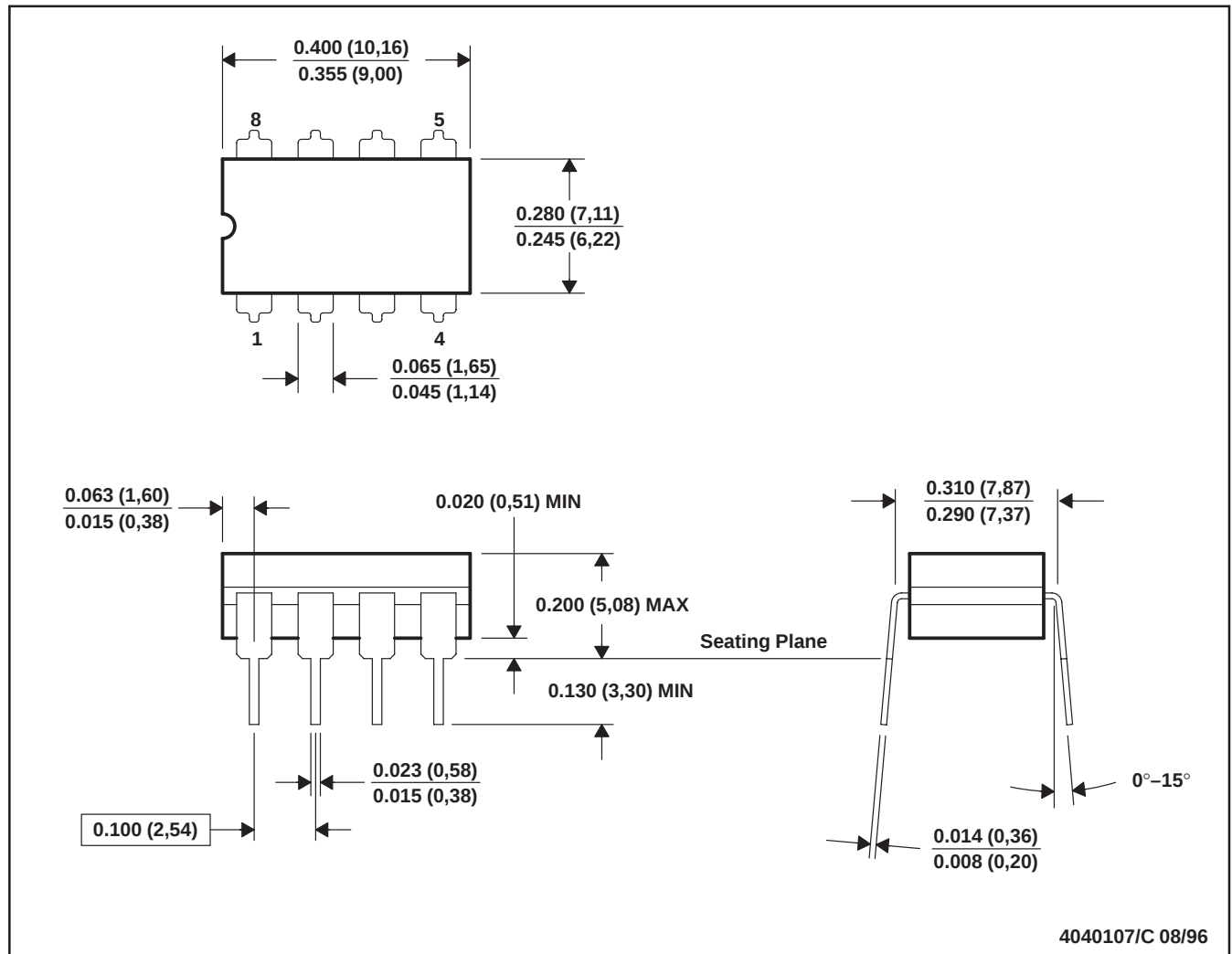
PLASTIC CYLINDRICAL PACKAGE



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

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

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