

- **2.5-V Virtual Ground for 5-V/GND Analog Systems**
- **High Output-Current Capability Sink or Source . . . 20 mA Typ**
- **Micropower Operation . . . 170  $\mu$ A Typ**
- **Excellent Regulation Characteristics**
  - Output Regulation
    - 45  $\mu$ V Typ at  $I_O = 0$  to –10 mA
    - +15  $\mu$ V Typ at  $I_O = 0$  to +10 mA
  - Input Regulation = 1.5  $\mu$ V/V Typ
- **Low-Impedance Output . . . 0.0075  $\Omega$  Typ**
- **Macromodel Included**

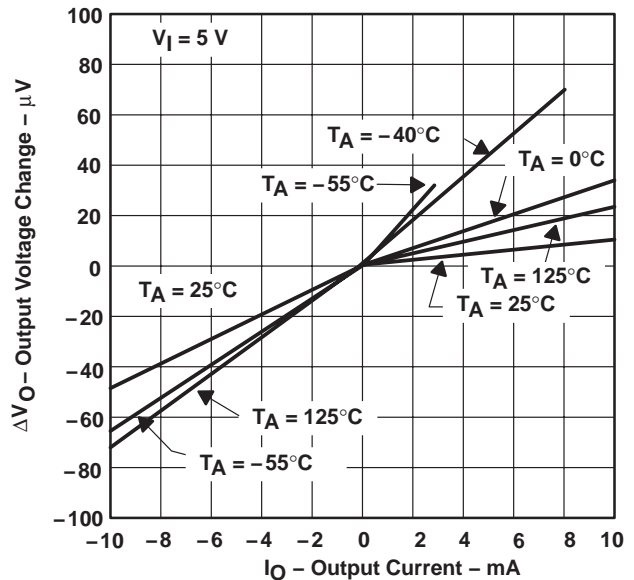
## description

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 <sub>A</sub>	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).



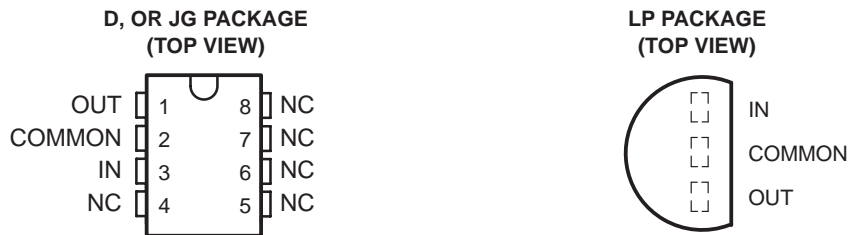
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

**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.



# TLE2425 PRECISION VIRTUAL GROUND

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NC – No internal connection

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

Continuous input voltage, $V_I$	40 V
Output current, $I_O$	$\pm 80$ 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	$T_A \leq 25^\circ\text{C}$	DERATING FACTOR	$T_A = 70^\circ\text{C}$	$T_A = 85^\circ\text{C}$	$T_A = 125^\circ\text{C}$
	POWER RATING	ABOVE $T_A = 25^\circ\text{C}$	POWER RATING	POWER RATING	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	$V_I = 4.5\text{ V to }5.5\text{ V}$	25°C	1.5	20		μV
		Full range		25		
	$V_I = 4\text{ V to }40\text{ V}$	25°C	1.5	20		μV/V
		Full range		25		
Ripple rejection	$f = 120\text{ Hz}$ , $\Delta V_I(\text{PP}) = 1\text{ V}$	25°C	80			dB
Output voltage regulation (source current)‡	$I_O = 0\text{ to }-10\text{ mA}$	25°C	-160	-45	160	μV
	Full range		-250		250	
Output voltage regulation (sink current)‡	$I_O = 0\text{ to }10\text{ mA}$	25°C	-160	15	160	μV
		Full range	-250		250	
	$I_O = 0\text{ to }20\text{ mA}$	25°C	-235	65	235	
Long-term drift of output voltage	$\Delta t = 1000\text{ h}$ , Noncumulative	25°C	15			ppm
Output impedance		25°C	7.5	22.5		mΩ
Short-circuit output current (sink current)	$V_O = 5\text{ V}$	25°C	30	55		mA
Short-circuit output current (source current)	$V_O = 0$		-30	-50		
Output noise voltage, rms	$f = 10\text{ Hz to }10\text{ kHz}$	25°C	100			μV
Output voltage response to output current step	$V_O\text{ to }0.1\%$ , $I_O = \pm 10\text{ mA}$	25°C	$C_L = 0$	110		μs
			$C_L = 100\text{ pF}$	115		
	$V_O\text{ to }0.01\%$ , $I_O = \pm 10\text{ mA}$	$C_L = 0$	180			
		$C_L = 100\text{ pF}$	180			
Output voltage response to input voltage step	$V_I = 4.5\text{ to }5.5\text{ V}$ , $V_O\text{ to }0.1\%$	25°C	12			μs
	$V_I = 4.5\text{ to }5.5\text{ V}$ , $V_O\text{ to }0.01\%$		30			
Output voltage turn-on response	$V_I = 0\text{ to }5\text{ V}$ , $V_O\text{ to }0.1\%$	25°C	125			μs
	$V_I = 0\text{ to }5\text{ V}$ , $V_O\text{ to }0.01\%$		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	250		μA
		Full range		250		
Input voltage regulation	$V_I = 4.5\text{ V to }5.5\text{ V}$	25°C	1.5	20		μV
		Full range		75		
	$V_I = 4\text{ V to }40\text{ V}$	25°C	1.5	20		μV/V
		Full range		75		
Ripple rejection	$f = 120\text{ Hz}$ , $\Delta V_I(\text{PP}) = 1\text{ V}$	25°C	80			dB
Output voltage regulation (source current)‡	$I_O = 0\text{ to }-10\text{ mA}$	25°C	-160	-45	160	μV
	Full range		-250		250	
Output voltage regulation (sink current)‡	$I_O = 0\text{ to }-20\text{ mA}$	25°C	-450	-150	450	μV
	$I_O = 0\text{ to }8\text{ mA}$	25°C	-160	15	160	
Output voltage regulation (sink current)‡	$I_O = 0\text{ to }8\text{ mA}$	25°C	-160	15	160	μV
	Full range		-250		250	
Output voltage regulation (sink current)‡	$I_O = 0\text{ to }20\text{ mA}$	25°C	-235	65	235	μV
	Full range		-235		235	
Long-term drift of output voltage	$\Delta t = 1000\text{ h}$ , Noncumulative	25°C	15			ppm
Output impedance		25°C	7.5	22.5		mΩ
Short-circuit output current (sink current)	$V_O = 5\text{ V}$	25°C	30	55		mA
Short-circuit output current (source current)	$V_O = 0$		-30	-50		
Output noise voltage, rms	$f = 10\text{ Hz to }10\text{ kHz}$	25°C	100			μV
Output voltage response to output current step	$V_O\text{ to }0.1\%$ , $I_O = \pm 10\text{ mA}$	$C_L = 0$	110			μs
		$C_L = 100\text{ pF}$	115			
	$V_O\text{ to }0.01\%$ , $I_O = \pm 10\text{ mA}$	$C_L = 0$	180			
		$C_L = 100\text{ pF}$	180			
Output voltage response to input voltage step	$V_I = 4.5\text{ to }5.5\text{ V}$ , $V_O\text{ to }0.1\%$	25°C	12			μs
	$V_I = 4.5\text{ to }5.5\text{ V}$ , $V_O\text{ to }0.01\%$		30			
Output voltage turn-on response	$V_I = 0\text{ to }5\text{ V}$ , $V_O\text{ to }0.1\%$	25°C	125			μs
	$V_I = 0\text{ to }5\text{ V}$ , $V_O\text{ to }0.01\%$		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	250	μA
		Full range			250	
Input voltage regulation	$V_I = 4.5\text{ V to }5.5\text{ V}$	25°C		1.5	20	μV
		Full range			100	
	$V_I = 4.5\text{ V to }40\text{ V}$	25°C		1.5	20	μV/V
		Full range			100	
Ripple rejection	$f = 120\text{ Hz}$ , $\Delta V_I(\text{PP}) = 1\text{ V}$	25°C		80		dB
Output voltage regulation (source current)‡	$I_O = 0\text{ to }-10\text{ mA}$	25°C	-160	-45	160	μV
	Full range		-250		250	
Output voltage regulation (sink current)‡	$I_O = 0\text{ to }-20\text{ mA}$	25°C	-450	-150	450	μV
	$I_O = 0\text{ to }3\text{ mA}$	25°C	-160	15	160	
Output voltage regulation (sink current)‡	$I_O = 0\text{ to }20\text{ mA}$	25°C	-235	65	235	μV
	Full range		-250		250	
Long-term drift of output voltage	$\Delta t = 1000\text{ h}$ , Noncumulative	25°C		15		ppm
Output impedance		25°C		7.5	22.5	mΩ
Short-circuit output current (sink current)	$V_O = 5\text{ V}$	25°C	30	55		mA
Short-circuit output current (source current)	$V_O = 0$		-30	-50		
Output noise voltage, rms	$f = 10\text{ Hz to }10\text{ kHz}$	25°C		100		μV
Output voltage response to output current step	$V_O\text{ to }0.1\%$ , $I_O = \pm 10\text{ mA}$	25°C	$C_L = 0$		110	μs
			$C_L = 100\text{ pF}$		115	
	$V_O\text{ to }0.01\%$ , $I_O = \pm 10\text{ mA}$	$C_L = 0$		180		
		$C_L = 100\text{ pF}$		180		
Output voltage response to input voltage step	$V_I = 4.5\text{ to }5.5\text{ V}$ , $V_O\text{ to }0.1\%$	25°C		12	μs	
	$V_I = 4.5\text{ to }5.5\text{ V}$ , $V_O\text{ to }0.01\%$			30		
Output voltage turn-on response	$V_I = 0\text{ to }5\text{ V}$ , $V_O\text{ to }0.1\%$	25°C		125	μs	
	$V_I = 0\text{ to }5\text{ V}$ , $V_O\text{ to }0.01\%$			210		

† Full range is -55°C to 125°C.

‡ The listed values are not production tested.

# TLE2425 PRECISION VIRTUAL GROUND

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## TYPICAL CHARACTERISTICS

Table Of Graphs

		FIGURE
Output voltage	Distribution	1
	vs Free-air temperature	2
Output voltage hysteresis	vs Free-air temperature	3
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†

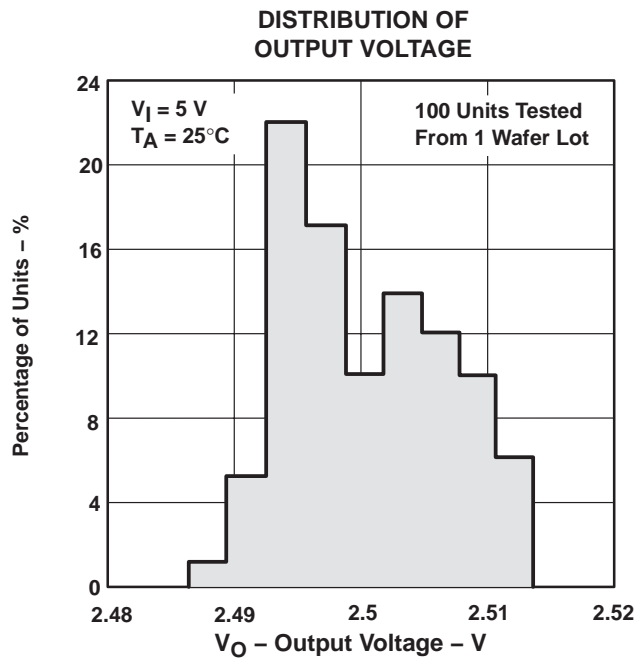


Figure 1

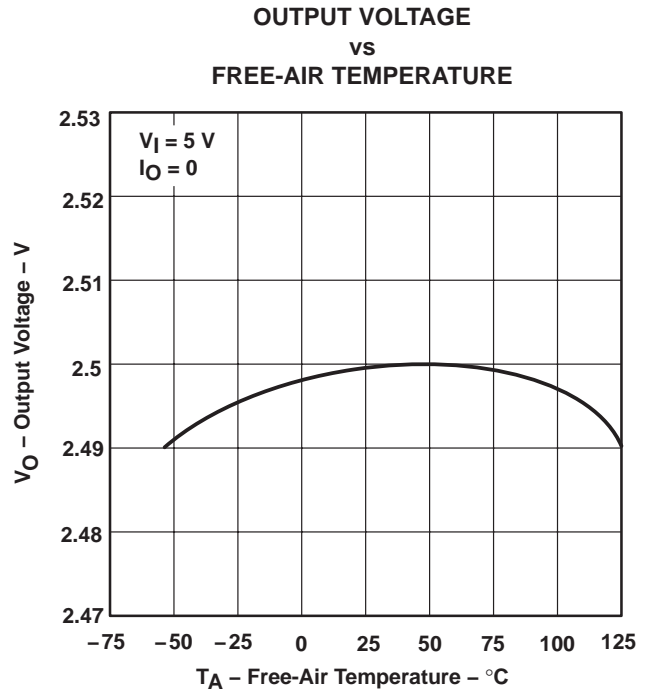


Figure 2

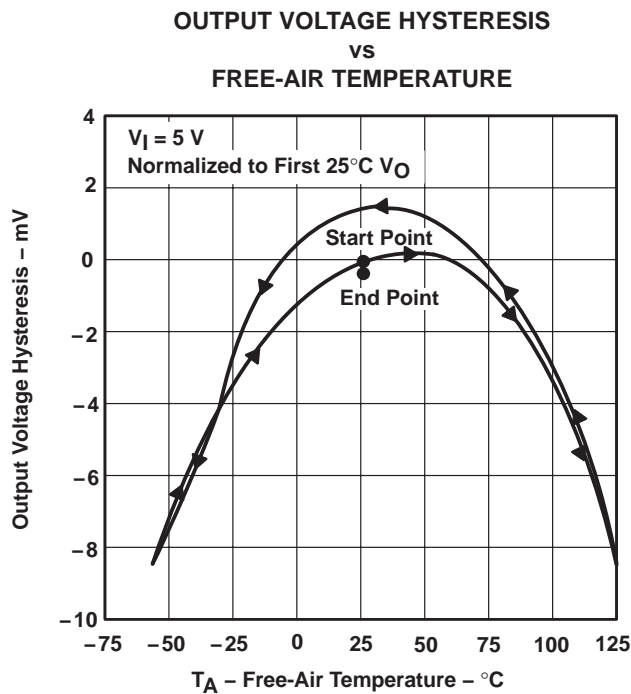


Figure 3

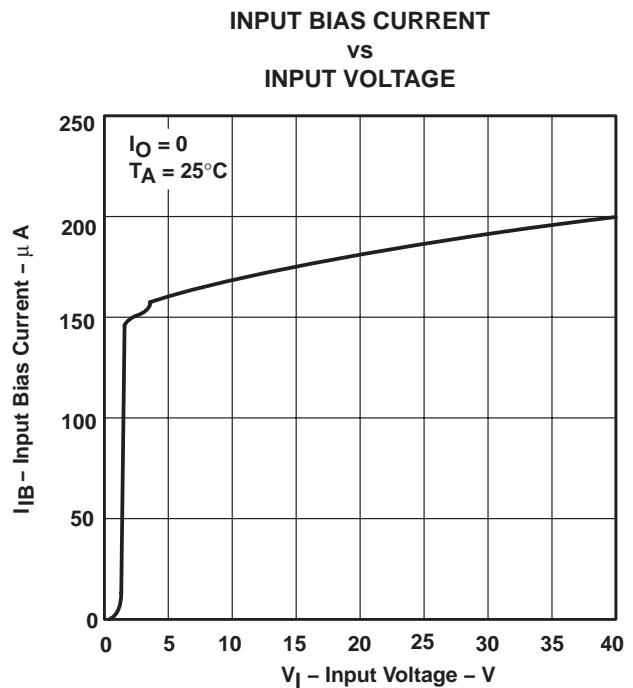


Figure 4

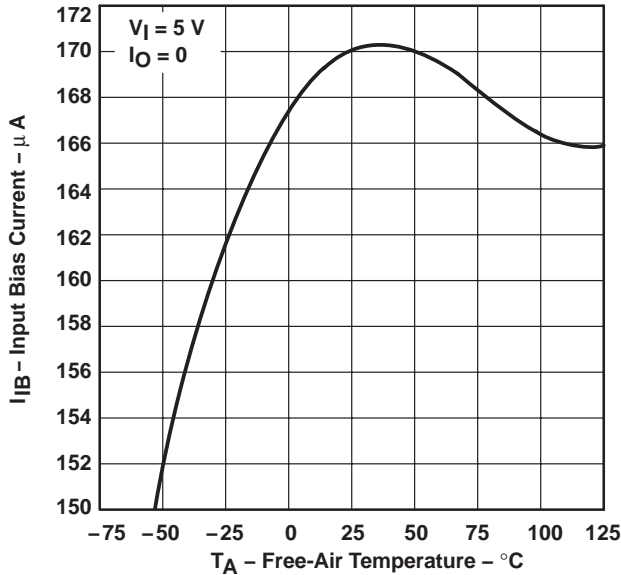
† Data at high and low temperatures are applicable within rated operating free-air temperature ranges of the various devices.

# TLE2425 PRECISION VIRTUAL GROUND

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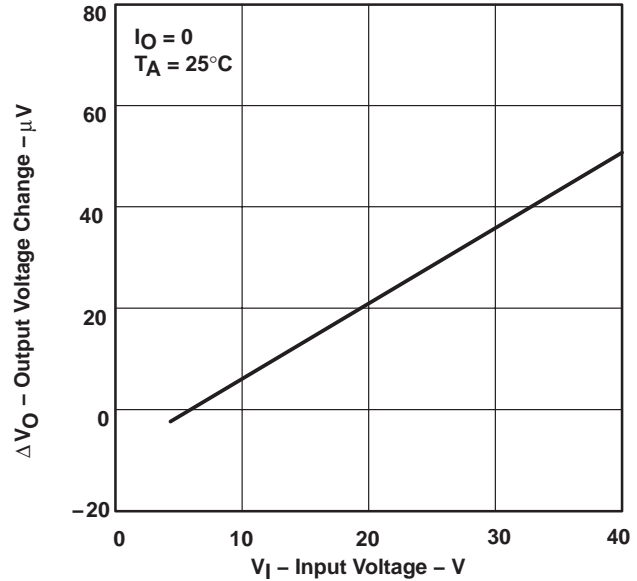
## TYPICAL CHARACTERISTICS†

**INPUT BIAS CURRENT  
vs  
FREE-AIR TEMPERATURE**



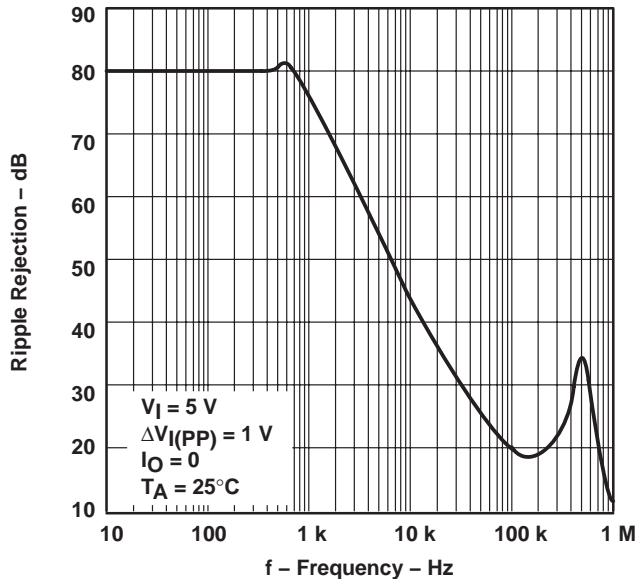
**Figure 5**

**INPUT VOLTAGE REGULATION**



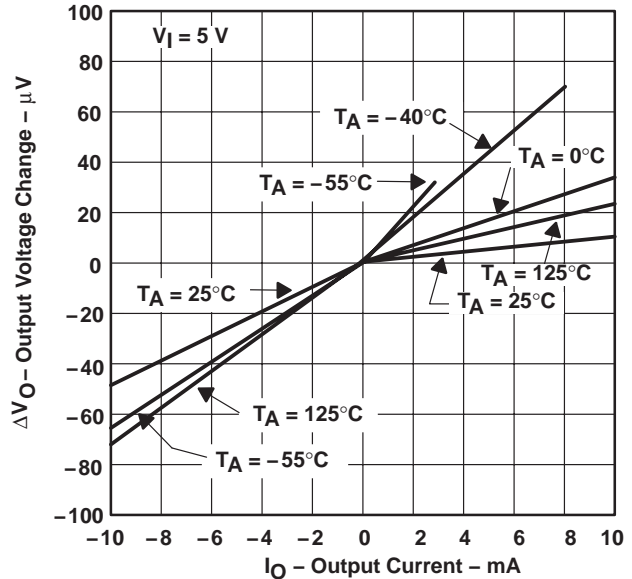
**Figure 6**

**RIPPLE REJECTION  
vs  
FREQUENCY**



**Figure 7**

**OUTPUT VOLTAGE REGULATION**



**Figure 8**

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



TYPICAL CHARACTERISTICS

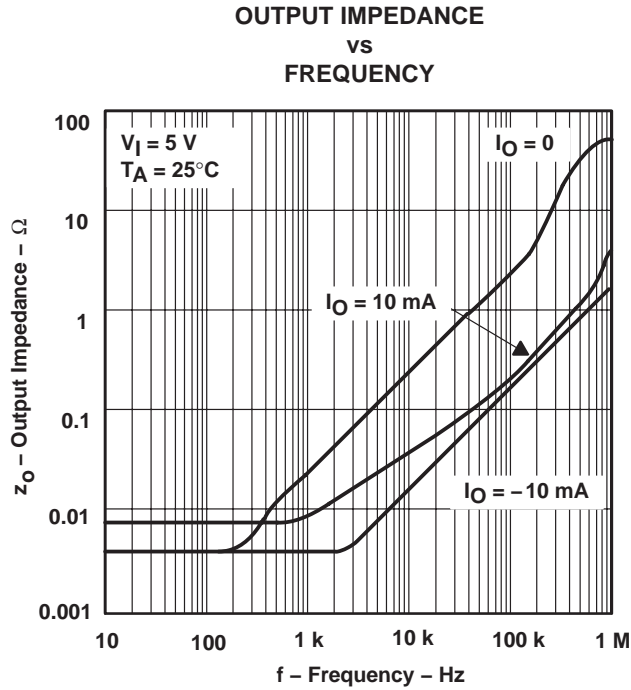


Figure 9

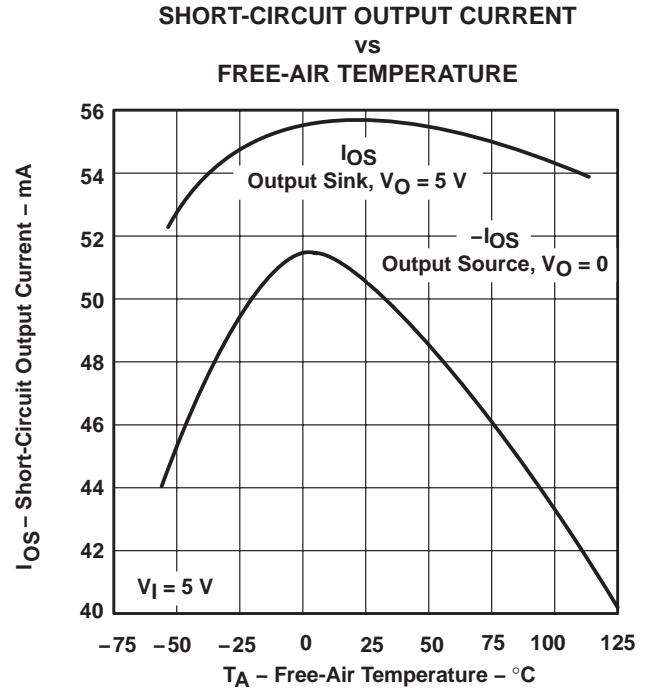


Figure 10

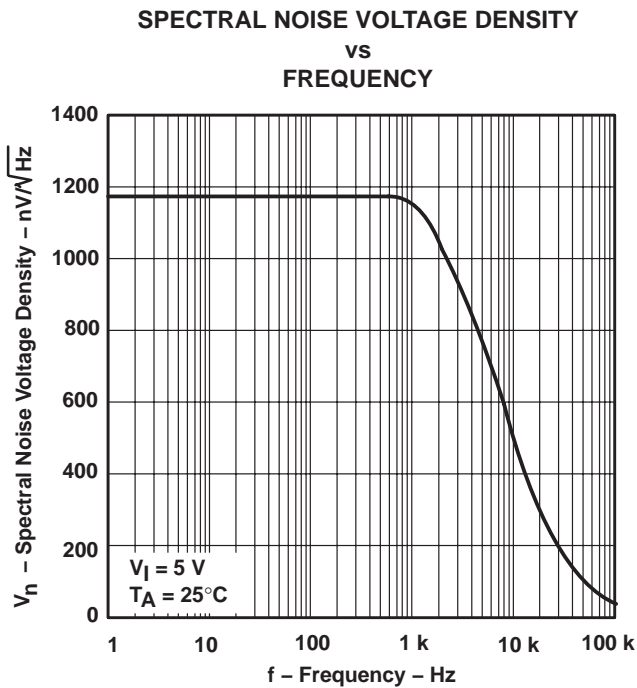


Figure 11

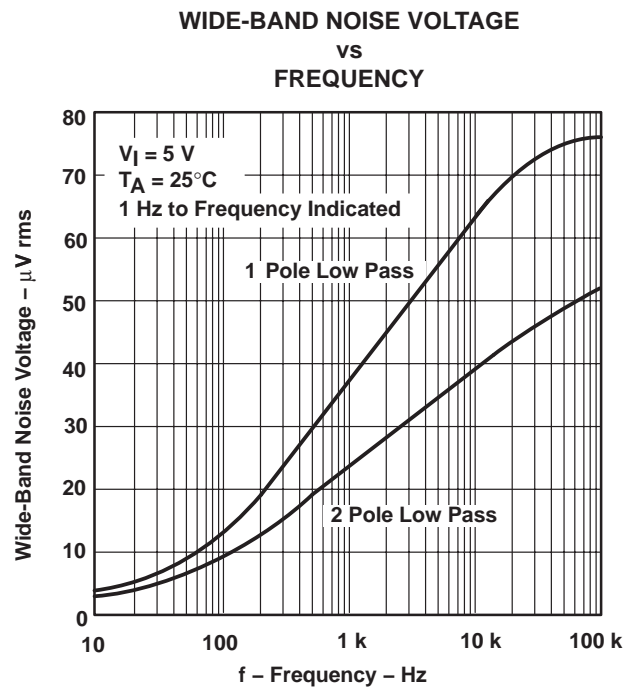
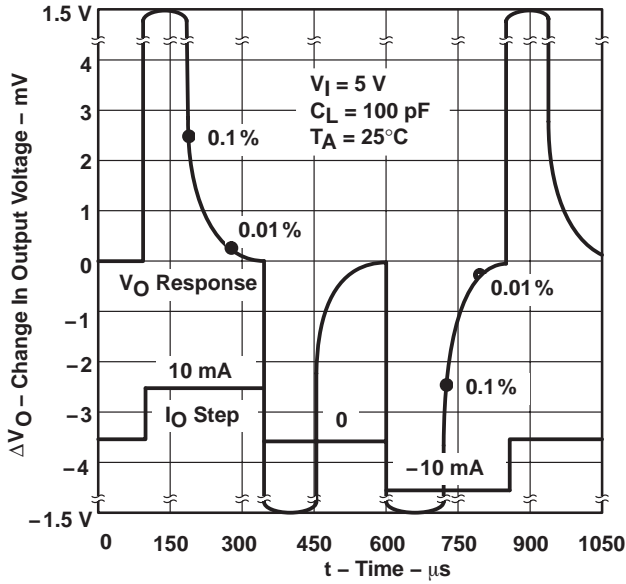


Figure 12

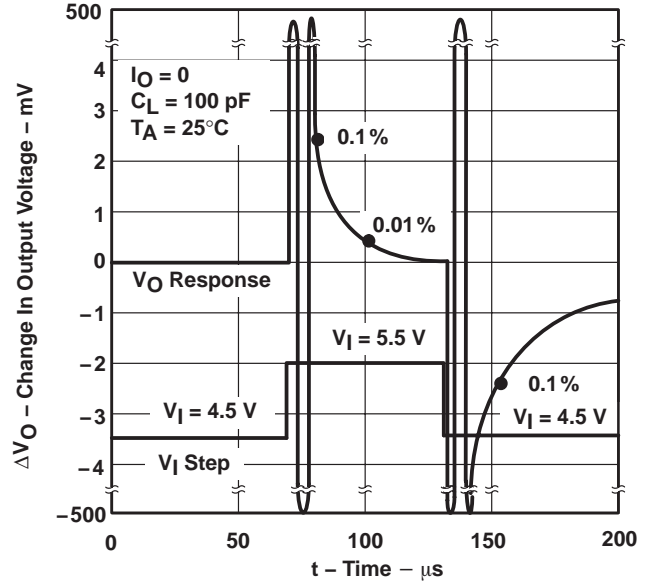
**TYPICAL CHARACTERISTICS**

**OUTPUT VOLTAGE RESPONSE TO OUTPUT CURRENT STEP VS TIME**



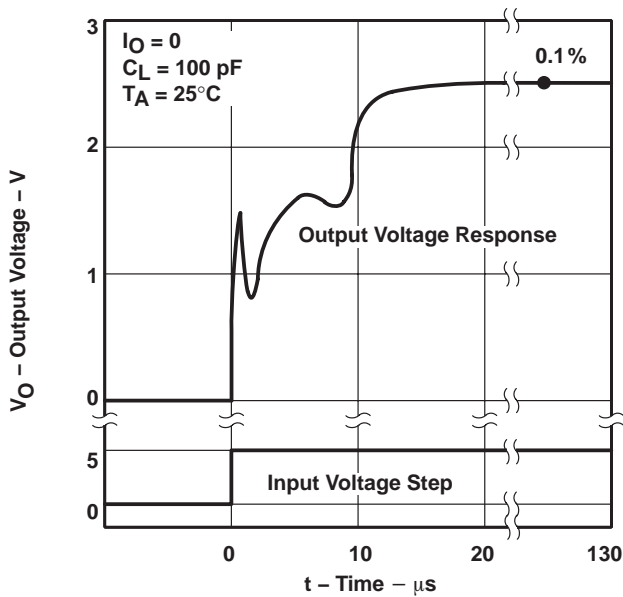
**Figure 13**

**OUTPUT VOLTAGE RESPONSE TO INPUT VOLTAGE STEP VS TIME**



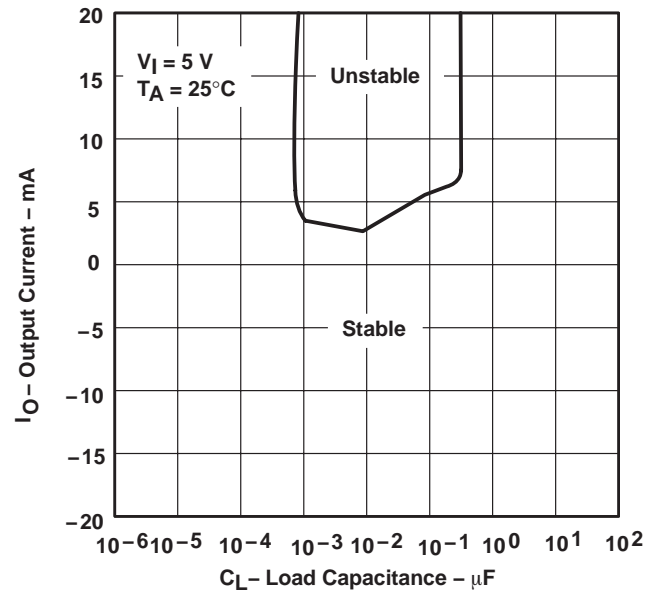
**Figure 14**

**OUTPUT VOLTAGE POWER-UP RESPONSE VS TIME**



**Figure 15**

**STABILITY RANGE OUTPUT CURRENT VS LOAD CAPACITANCE**



**Figure 16**

macromodel information

```

* 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
*
*
* OPAMP SECTION
C1 11 12 21.66E-12
C2 6 7 30.00E-12
C3 87 0 10.64E-9
CPSR 85 86 15.9E-9
DCM+ 81 82 DX
DCM- 83 81 DX
DC 5 53 DX
DE 54 5 DX
DLN 92 90 DX
DLP 90 91 DX
DP 4 3 DX
ECMR 84 99 (2,99) 1
EGND 99 0 POLY(2) (3,0) (4,0) 0 .5 .5
EPSR 85 0 POLY(1) (3,4) -16.22E-6 3.24E-6
ENSE 89 2 POLY(1) (88,0) 120E-6 1
FB 7 99 POLY(6) VB VC VE VLP VLN VPSR 0 74.8E6 -10E6 10E6 10E6
+ -10E6 74E6
GA 6 0 11 12 320.4E-6
GCM 0 6 10 99 1.013E-9
GPSR 85 86 (85,86) 100E-6
GRC1 4 11 (4,11) 3.204E-4
GRC2 4 12 (4,12) 3.204E-4
GRE1 13 10 (13,10) 1.038E-3
GRE2 14 10 (14,10) 1.038E-3
HLIM 90 0 VLIM 1K
HCMR 80 1 POLY(2) VCM+ VCM- 0 1E2 1E2
IRP 3 4 146E-6
IEE 3 10 DC 24.05E-6
IIO 2 0 .2E-9
I1 88 0 1E-21
Q1 11 89 13 QX
Q2 12 80 14 QX
R2 6 9 100.0E3
RCM 84 81 1K
REE 10 99 8.316E6
RN1 87 0 2.55E8
RN2 87 88 11.67E3

```

# TLE2425 PRECISION VIRTUAL GROUND

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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)	Op Temp (°C)	Top-Side Markings (4)	Samples
5962-9555601Q2A	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI	-55 to 125		
5962-9555601QPA	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI	-55 to 125		
TLE2425CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		2425C	<a href="#">Samples</a>
TLE2425CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		2425C	<a href="#">Samples</a>
TLE2425CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		2425C	<a href="#">Samples</a>
TLE2425CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		2425C	<a href="#">Samples</a>
TLE2425CLP	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type		2425C	<a href="#">Samples</a>
TLE2425CLPE3	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type		2425C	<a href="#">Samples</a>
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		Q2425	<a href="#">Samples</a>
TLE2425CPSG4	ACTIVE	SO	PS	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		Q2425	<a href="#">Samples</a>
TLE2425CPSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		Q2425	<a href="#">Samples</a>
TLE2425CPSRG4	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		Q2425	<a href="#">Samples</a>
TLE2425ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		2425I	<a href="#">Samples</a>
TLE2425IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		2425I	<a href="#">Samples</a>
TLE2425IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		2425I	<a href="#">Samples</a>
TLE2425IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		2425I	<a href="#">Samples</a>
TLE2425ILP	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type		2425I	<a href="#">Samples</a>

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
TLE2425ILPE3	ACTIVE	TO-92	LP	3	1000	Pb-Free (RoHS)	CU SN	N / A for Pkg Type		2425I	<a href="#">Samples</a>
TLE2425MD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	2425M	<a href="#">Samples</a>
TLE2425MDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	2425M	<a href="#">Samples</a>
TLE2425MDR	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	-55 to 125	2425M	
TLE2425MDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	2425M	<a href="#">Samples</a>
TLE2425MFKB	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI	-55 to 125		
TLE2425MJG	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI	-55 to 125		
TLE2425MJGB	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI	-55 to 125		
TLE2425MLP	OBSOLETE	TO-92	LP	3		TBD	Call TI	Call TI	-55 to 125		

(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.

(4) Only one of markings shown within the brackets will appear on the physical device.

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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



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

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



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

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



4040047-3/M 06/11

## MECHANICAL DATA

PS (R-PDSO-G8)

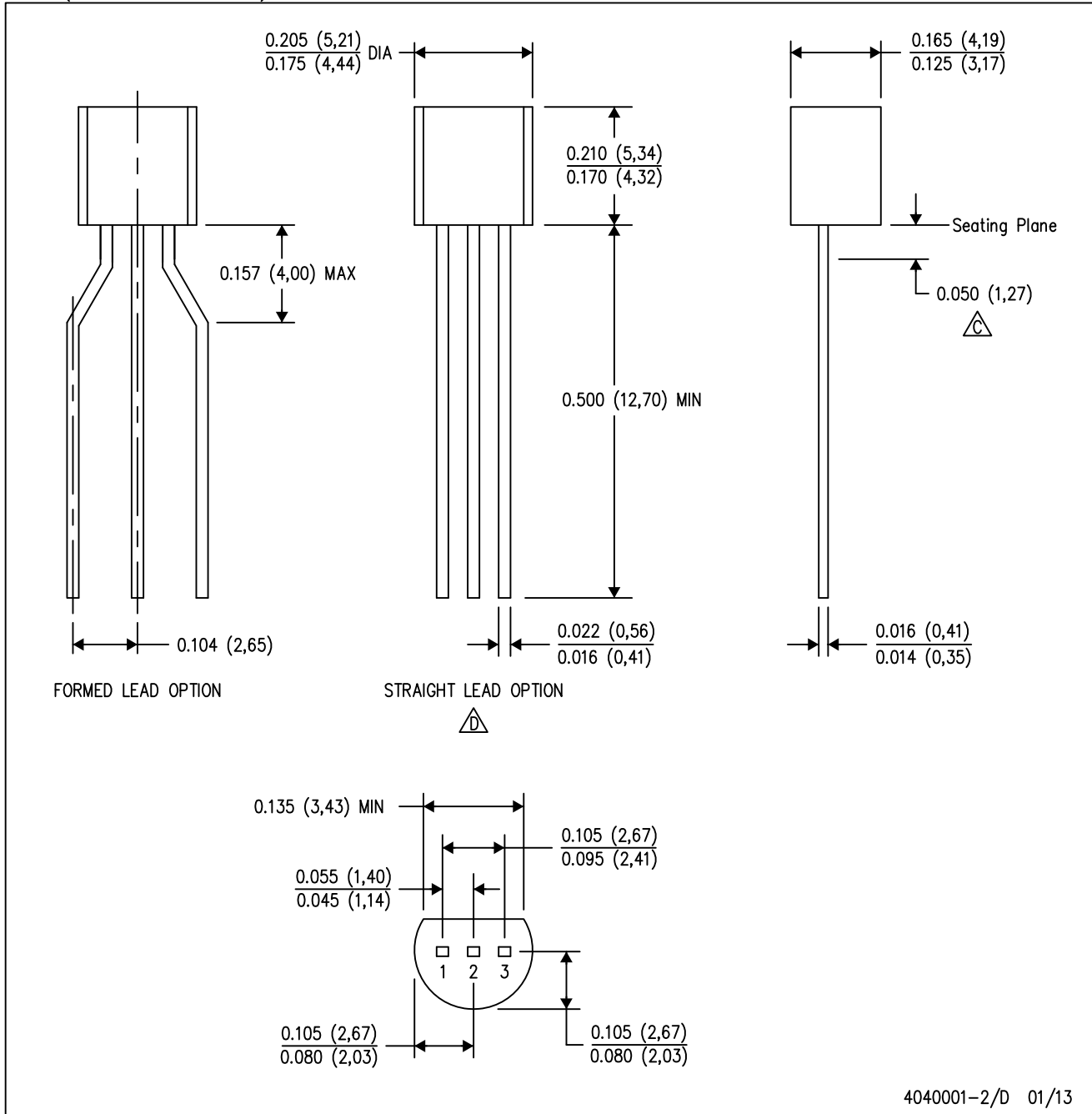
PLASTIC SMALL-OUTLINE PACKAGE



- 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



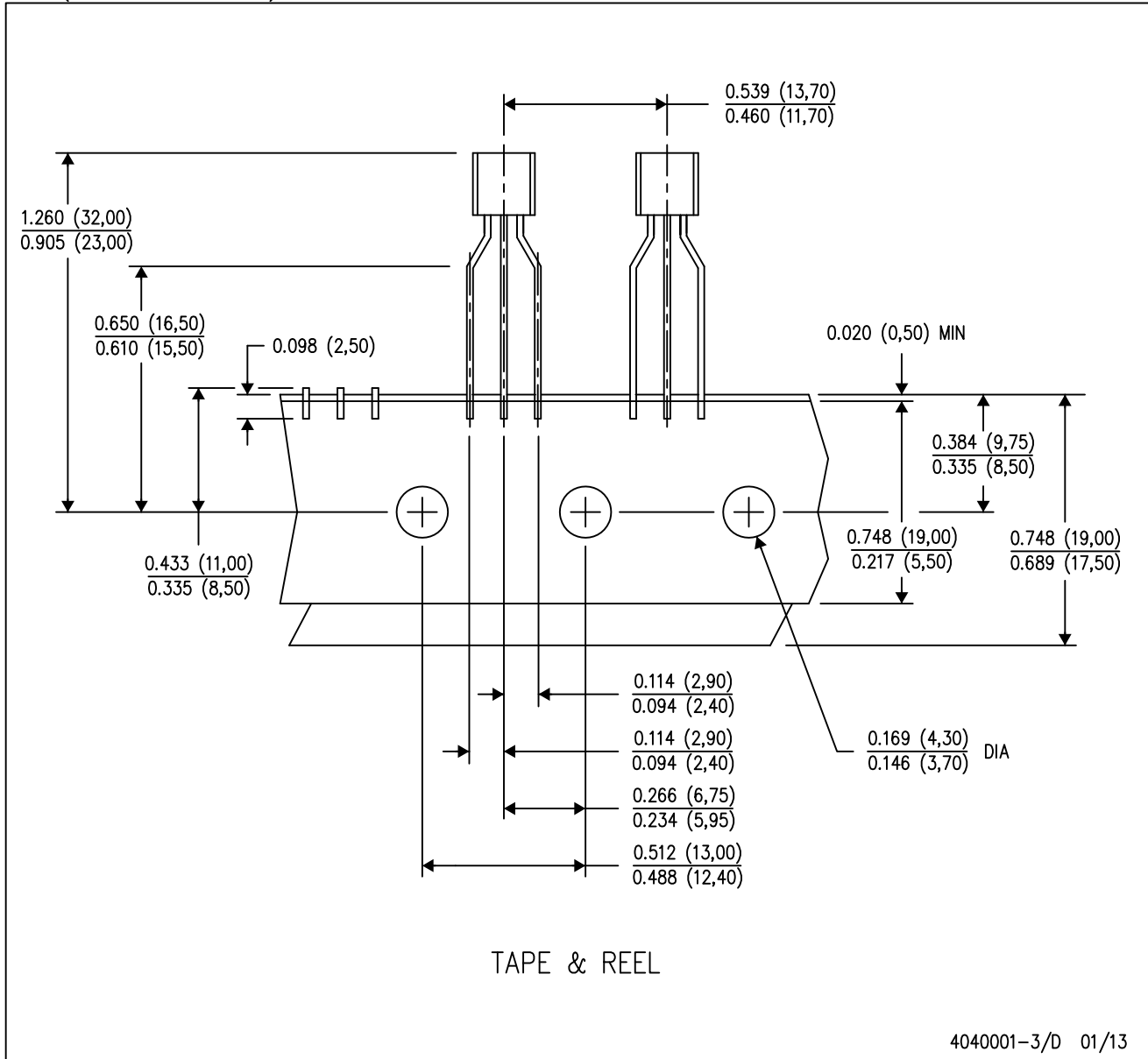
4040001-2/D 01/13

- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Lead dimensions are not controlled within this area.
  - Falls within JEDEC TO-226 Variation AA (TO-226 replaces TO-92).
  - Shipping Method:
    - Straight lead option available in either bulk pack or tape & reel.
    - Formed lead option available in tape & reel or ammo pack.
    - Specific products can be offered in limited combinations of shipping mediums and lead options.
    - Consult product folder for more information on available options.

# MECHANICAL DATA

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 Formed Lead Option package.

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