

- 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

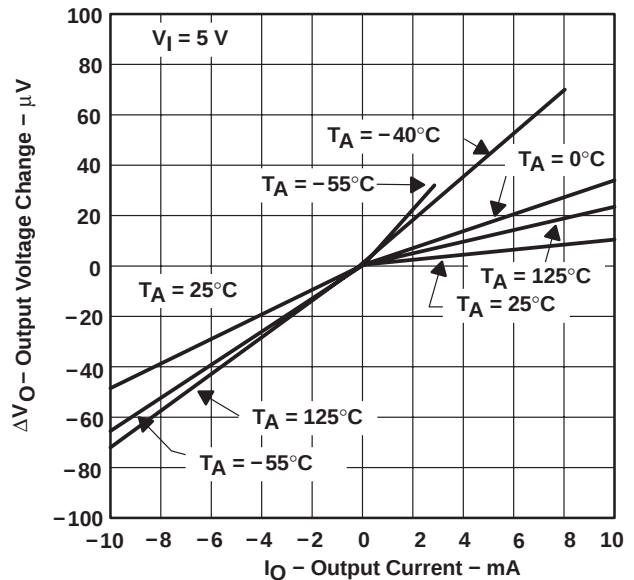
description

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**

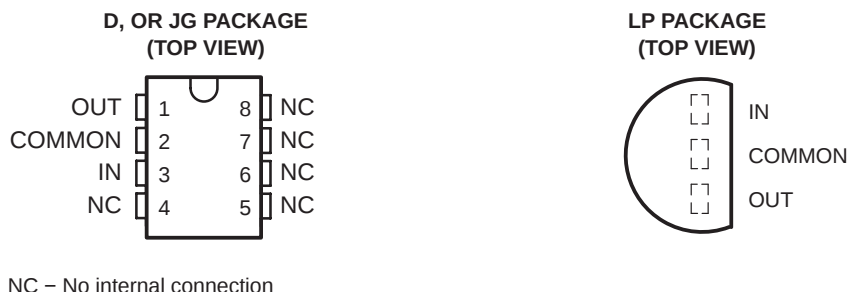
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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)[†]

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			μA
			Full range	250			
Input voltage regulation	V _I = 4.5 V to 5.5 V		25°C	1.5			μV
			Full range	25			
	V _I = 4 V to 40 V		25°C	1.5			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			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†

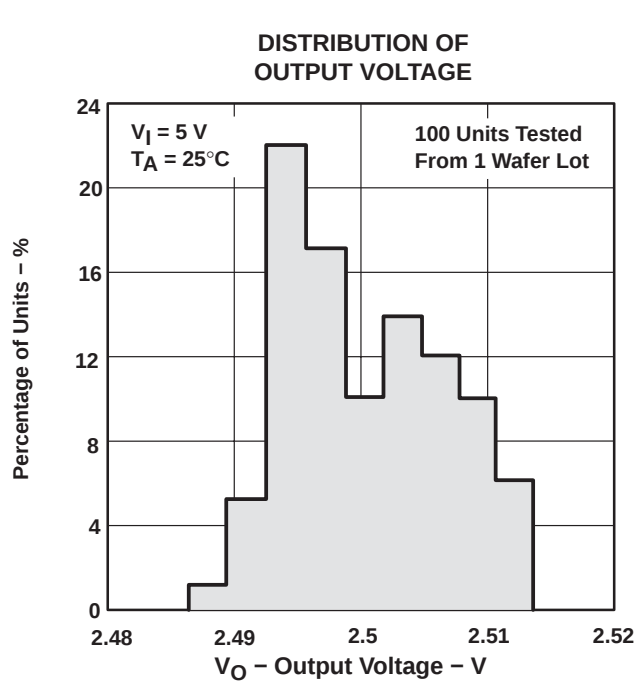


Figure 1

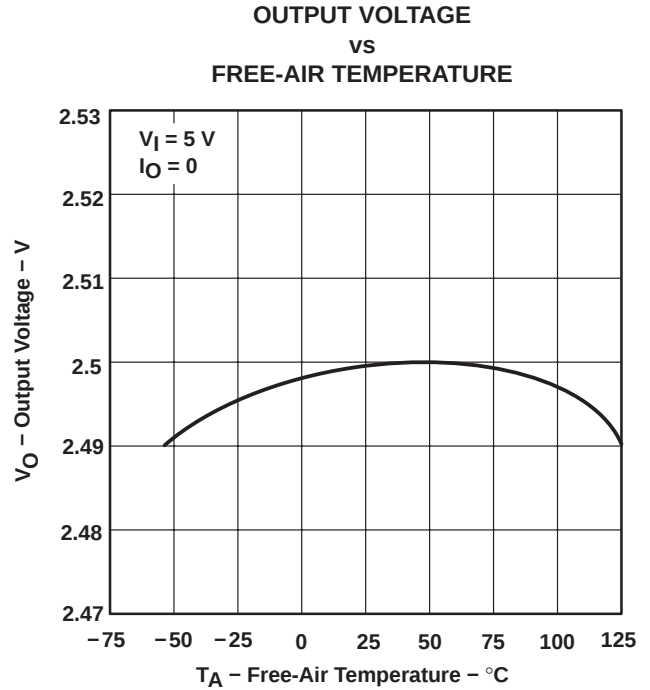


Figure 2

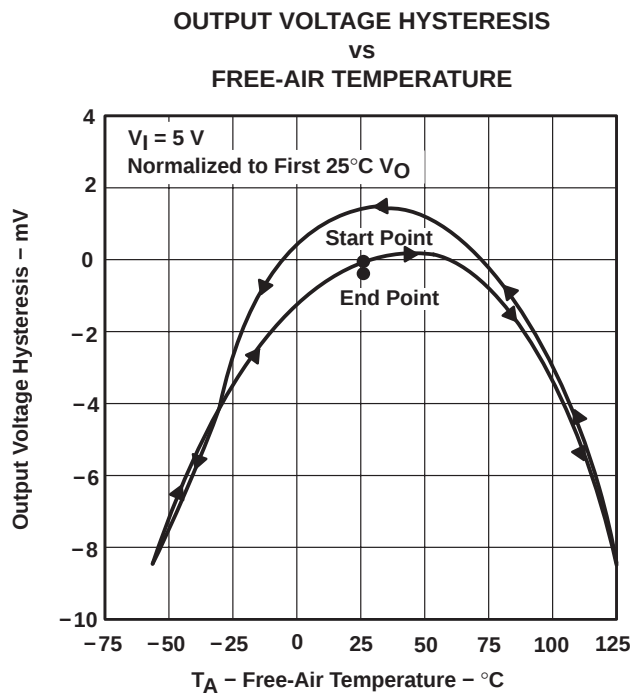


Figure 3

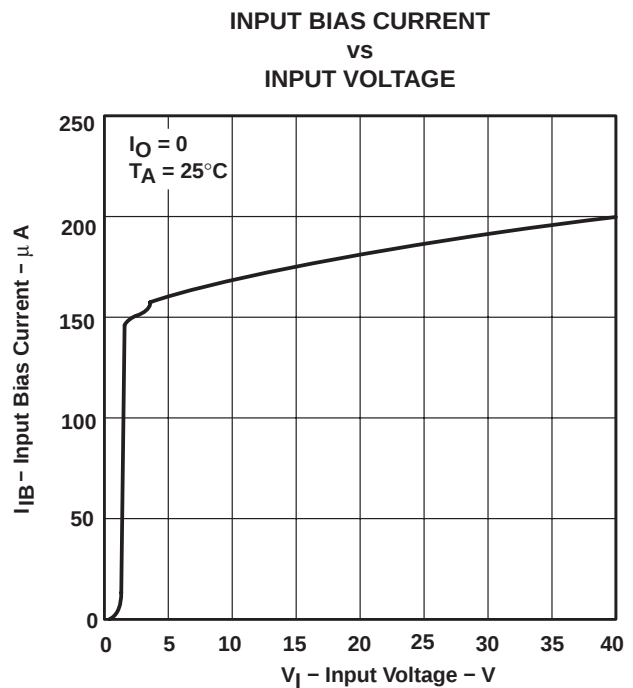


Figure 4

† 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†

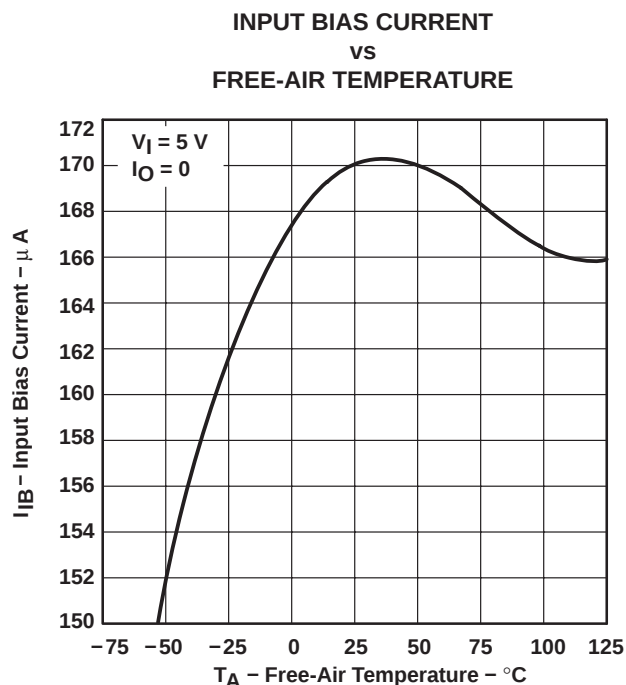


Figure 5

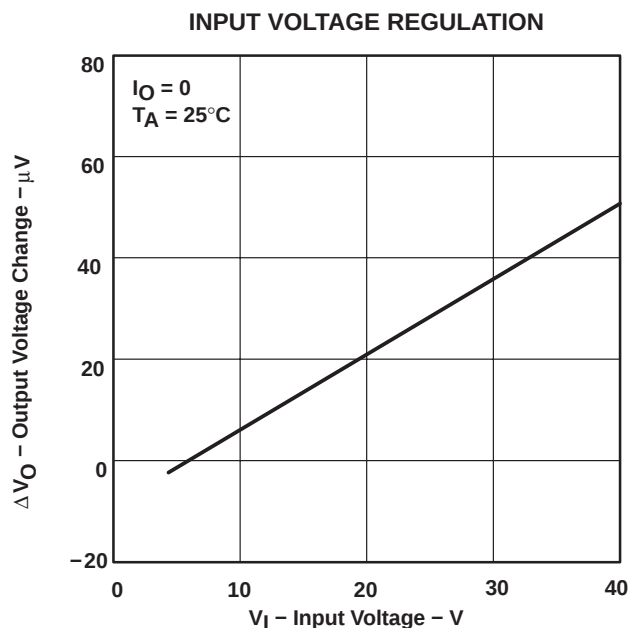


Figure 6

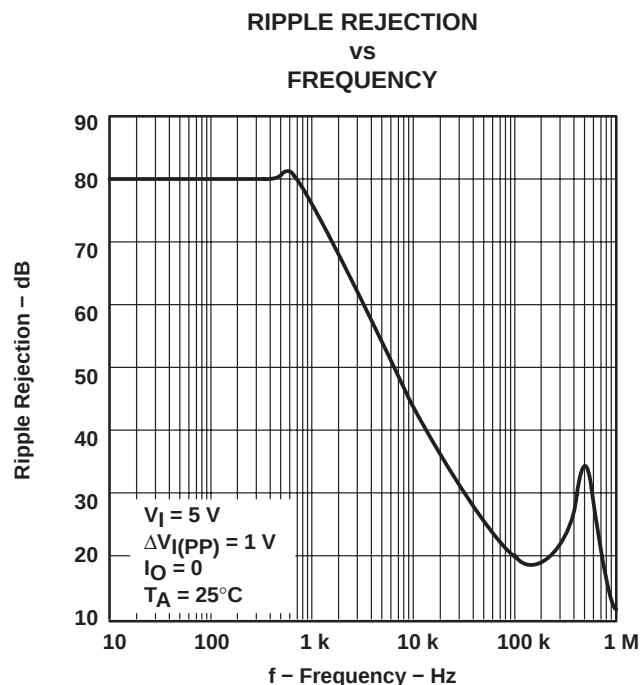


Figure 7

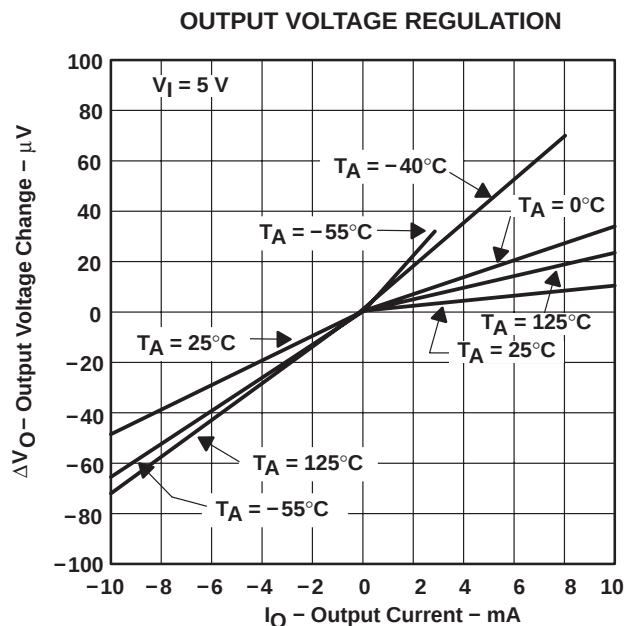


Figure 8

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

TYPICAL CHARACTERISTICS

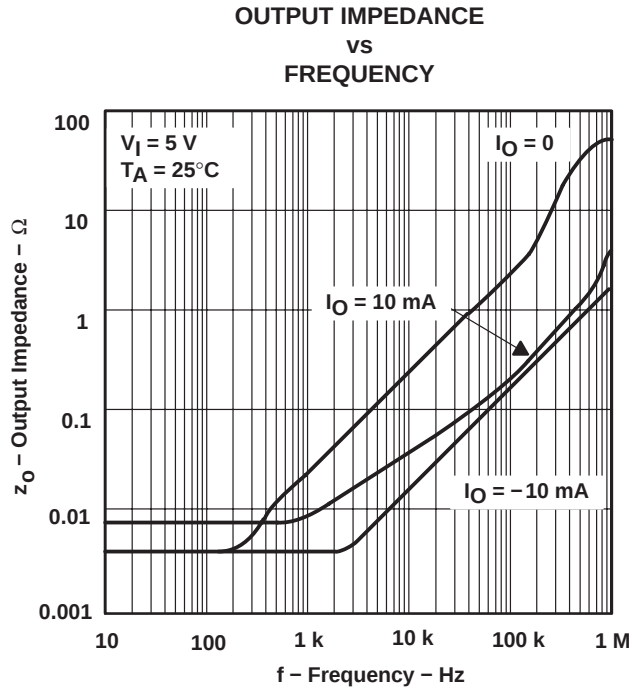


Figure 9

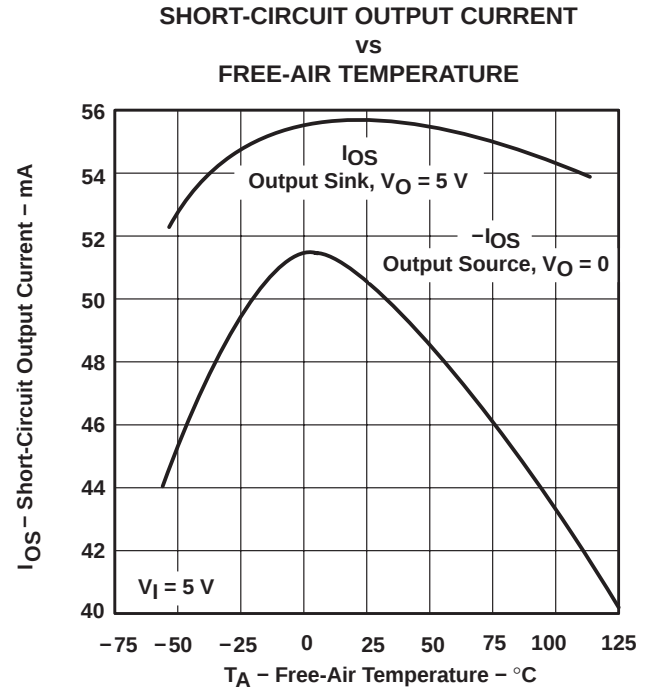


Figure 10

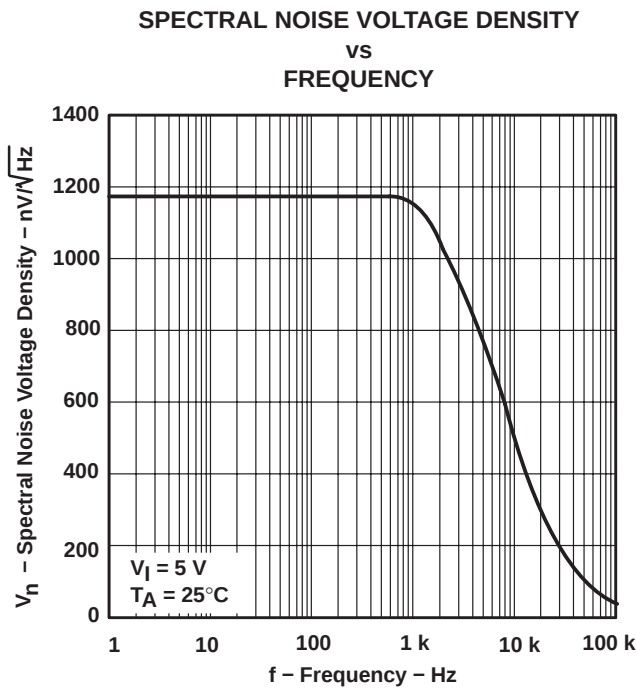


Figure 11

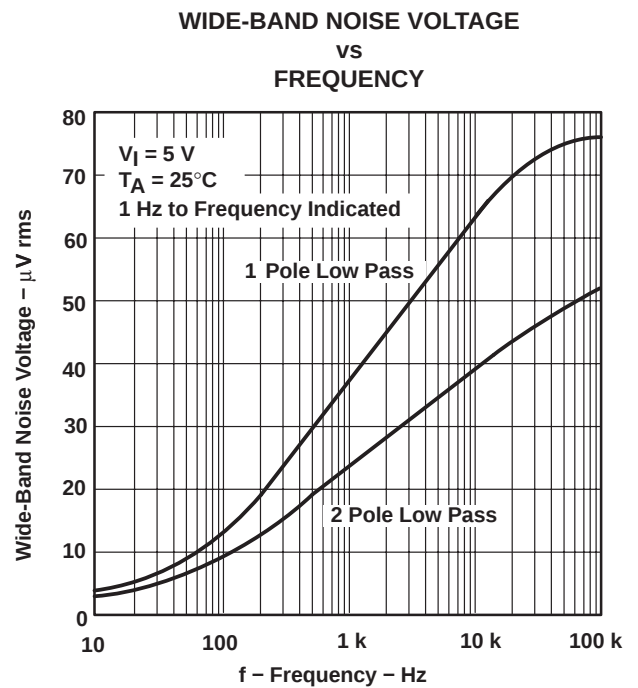


Figure 12

TYPICAL CHARACTERISTICS

**OUTPUT VOLTAGE RESPONSE
TO OUTPUT CURRENT STEP**

VS
TIME

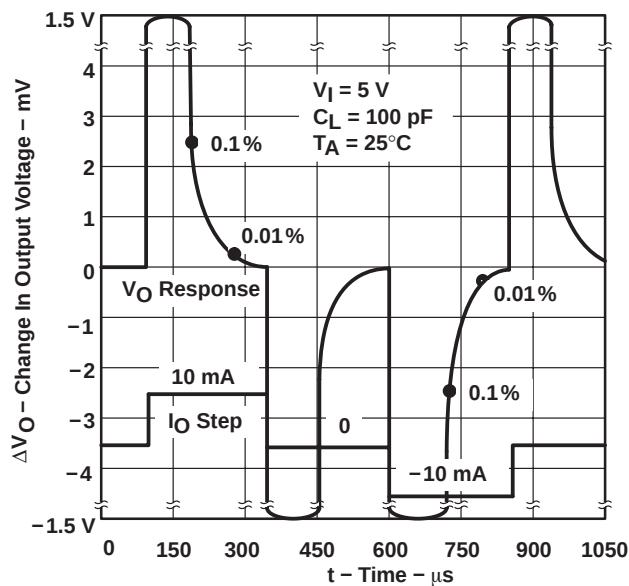


Figure 13

**OUTPUT VOLTAGE RESPONSE
TO INPUT VOLTAGE STEP**

VS
TIME

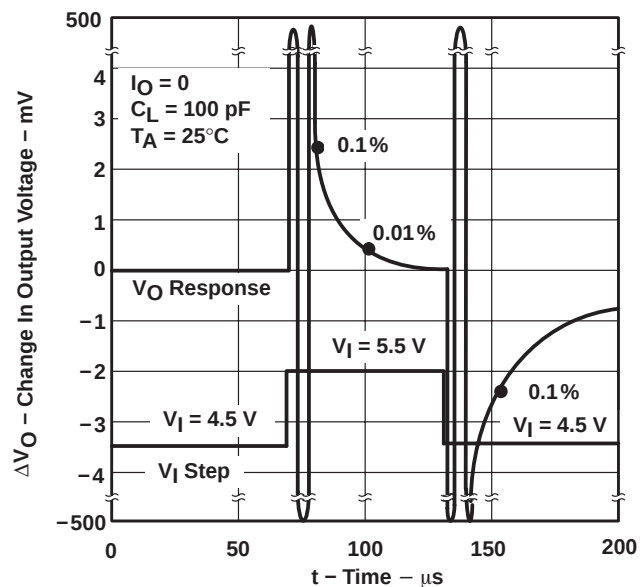


Figure 14

OUTPUT VOLTAGE POWER-UP RESPONSE

VS
TIME

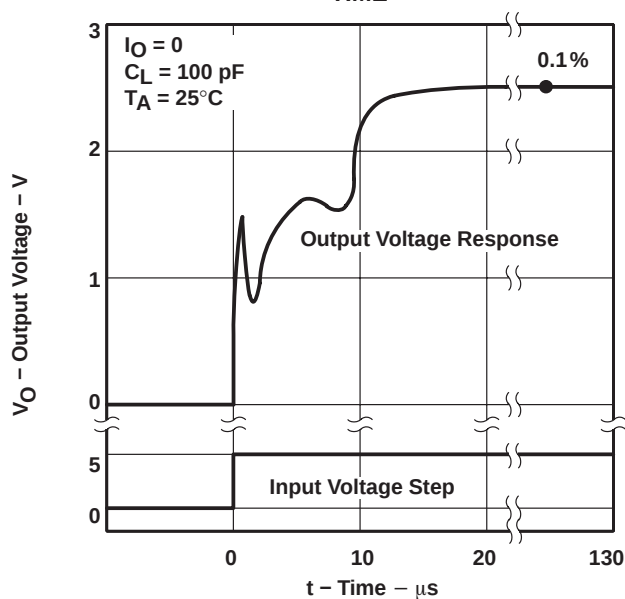


Figure 15

**STABILITY RANGE
OUTPUT CURRENT**

VS
LOAD CAPACITANCE

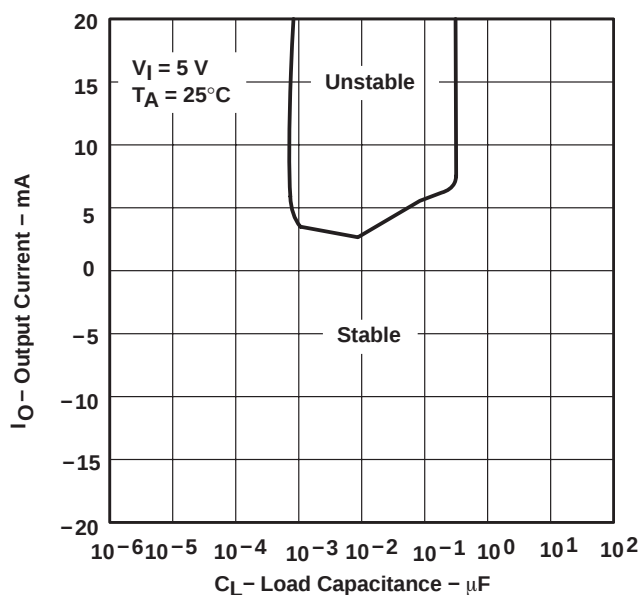


Figure 16

```

*      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 finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLE2425CD	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		2425C	Samples
TLE2425CDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		2425C	Samples
TLE2425CLP	ACTIVE	TO-92	LP	3	1000	RoHS & Green	SN	N / A for Pkg Type		2425C	Samples
TLE2425CPS	ACTIVE	SO	PS	8	80	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		Q2425	Samples
TLE2425CPSR	ACTIVE	SO	PS	8	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		Q2425	Samples
TLE2425ID	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		2425I	Samples
TLE2425IDG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		2425I	Samples
TLE2425IDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		2425I	Samples
TLE2425IDRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM		2425I	Samples
TLE2425ILP	ACTIVE	TO-92	LP	3	1000	RoHS & Green	SN	N / A for Pkg Type		2425I	Samples
TLE2425MD	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2425M	Samples
TLE2425MDG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2425M	Samples
TLE2425MDRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 125	2425M	Samples

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

- (3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.
- (4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.
- (5) 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.
- (6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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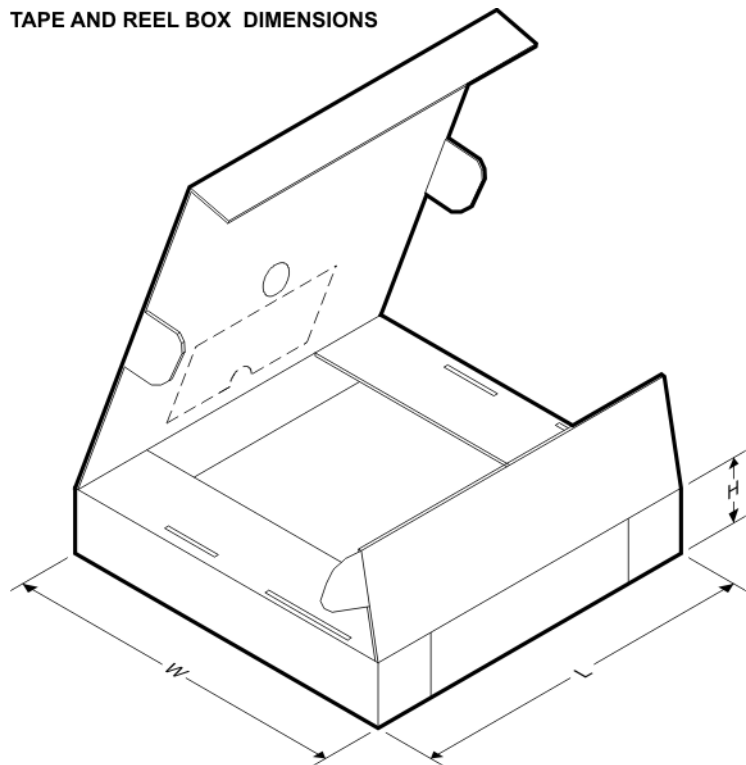
TAPE AND REEL INFORMATION



*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
TLE2425CPSR	SO	PS	8	2000	330.0	16.4	8.35	6.6	2.4	12.0	16.0	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	350.0	350.0	43.0
TLE2425CPSR	SO	PS	8	2000	853.0	449.0	35.0
TLE2425IDR	SOIC	D	8	2500	350.0	350.0	43.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
TLE2425CD	D	SOIC	8	75	505.46	6.76	3810	4
TLE2425CPS	PS	SOP	8	80	530	10.5	4000	4.1
TLE2425ID	D	SOIC	8	75	505.46	6.76	3810	4
TLE2425IDG4	D	SOIC	8	75	505.46	6.76	3810	4
TLE2425MD	D	SOIC	8	75	505.46	6.76	3810	4
TLE2425MDG4	D	SOIC	8	75	505.46	6.76	3810	4



PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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.



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

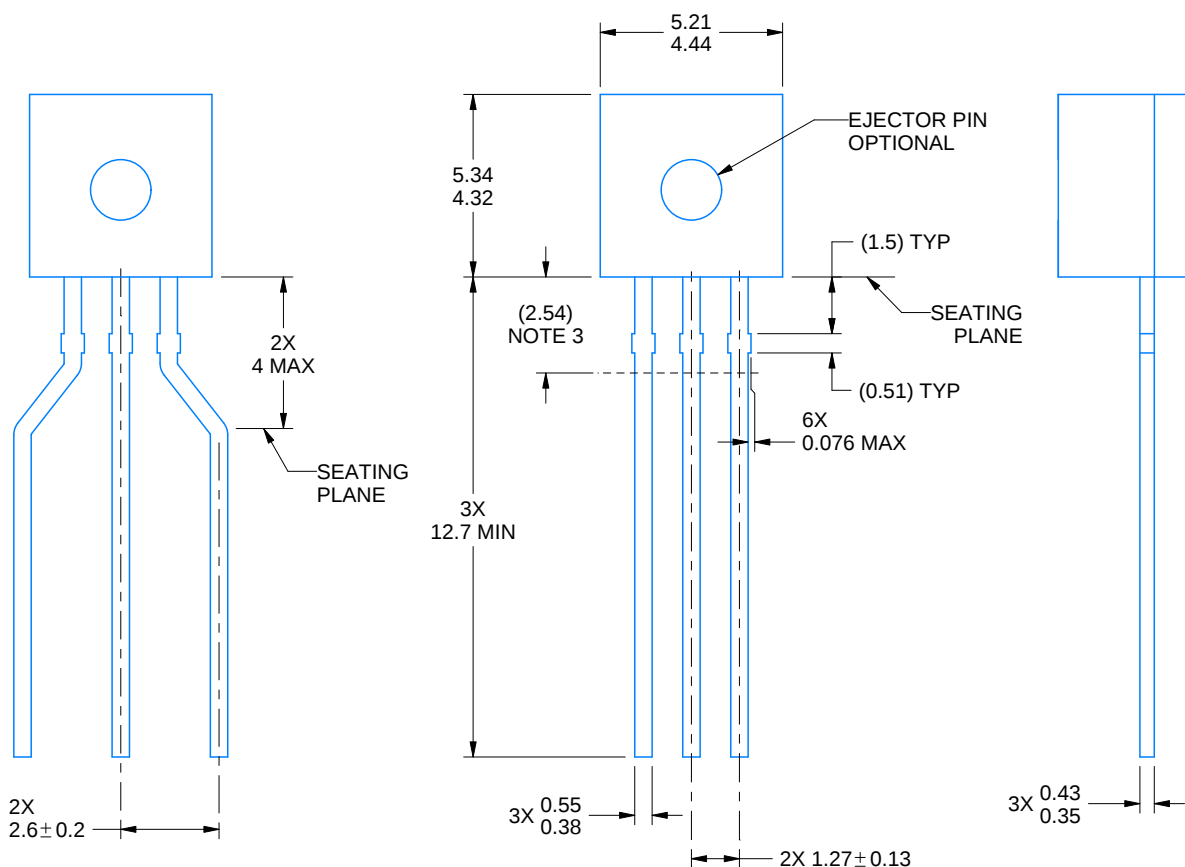
LP0003A



PACKAGE OUTLINE

TO-92 - 5.34 mm max height

TO-92



4215214/B 04/2017

NOTES:

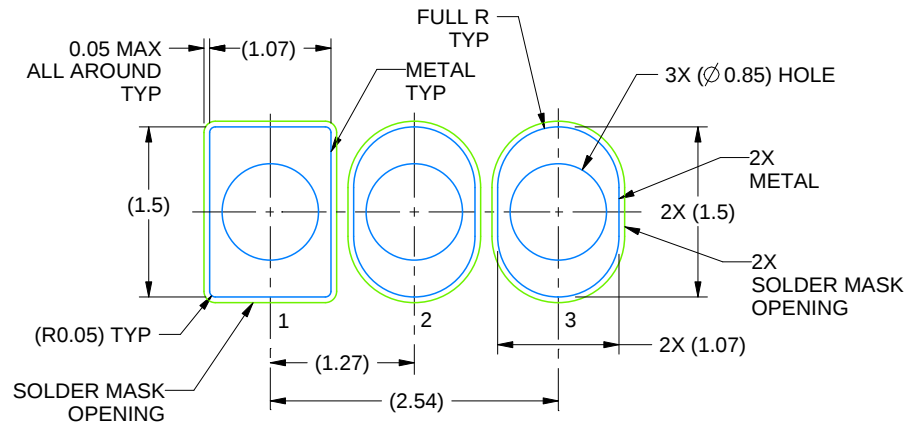
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Lead dimensions are not controlled within this area.
4. Reference JEDEC TO-226, variation AA.
5. Shipping method:
 - a. Straight lead option available in bulk pack only.
 - b. Formed lead option available in tape and reel or ammo pack.
 - c. Specific products can be offered in limited combinations of shipping medium and lead options.
 - d. Consult product folder for more information on available options.

EXAMPLE BOARD LAYOUT

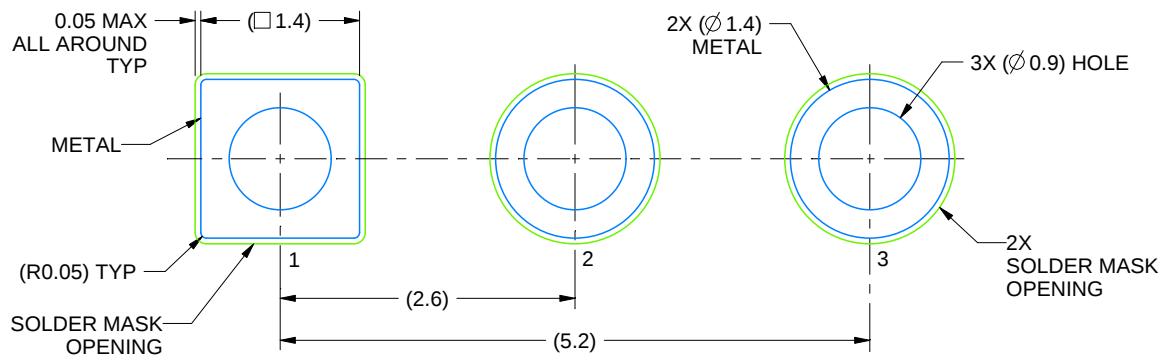
LP0003A

TO-92 - 5.34 mm max height

TO-92



LAND PATTERN EXAMPLE
STRAIGHT LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X



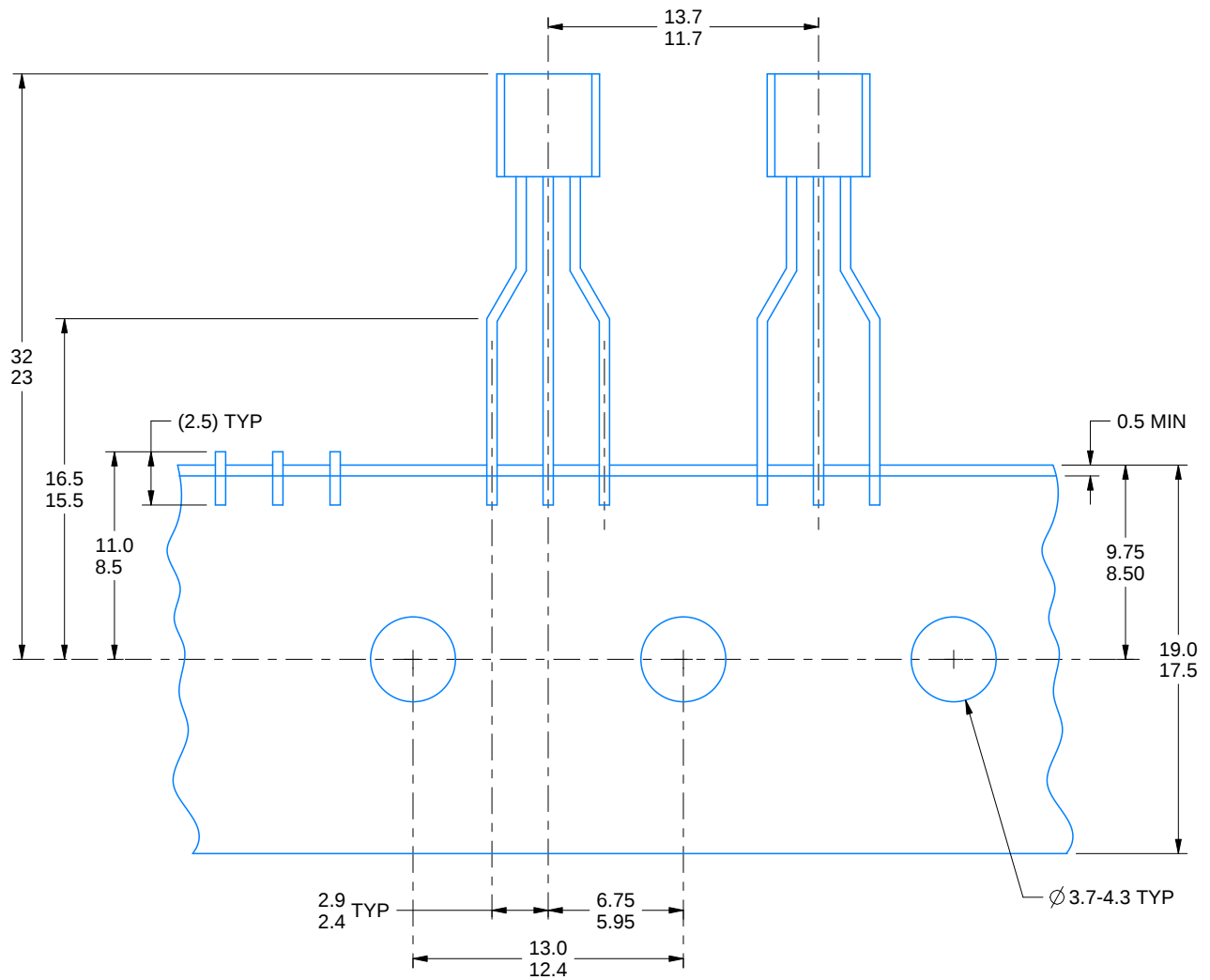
LAND PATTERN EXAMPLE
FORMED LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X

4215214/B 04/2017

LP0003A

TO-92 - 5.34 mm max height

TO-92



FOR FORMED LEAD OPTION PACKAGE

4215214/B 04/2017

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