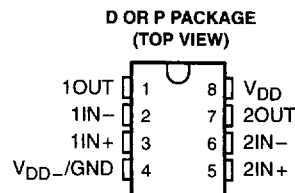


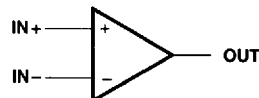
# TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y LinCMOS™ DUAL OPERATIONAL AMPLIFIERS

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- **A-Suffix Versions Offer 5-mV  $V_{IO}$**
- **B-Suffix Versions Offer 2-mV  $V_{IO}$**
- **Wide Range of Supply Voltages**  
1.4 V to 16 V
- **True Single-Supply Operation**
- **Common-Mode Input Voltage Includes the Negative Rail**
- **Low Noise . . . 30 nV/ $\sqrt{\text{Hz}}$  Typ at  $f = 1$  kHz (High-Bias Versions)**



symbol (each amplifier)



## description

The TLC252, TLC25L2, and TLC25M2 are low-cost, low-power dual operational amplifiers designed to operate with single or dual supplies. These devices utilize the Texas Instruments silicon gate LinCMOS™ process, giving them stable input offset voltages that are available in selected grades of 2, 5, or 10 mV maximum, very high input impedances, and extremely low input offset and bias currents. Because the input common-mode range extends to the negative rail and the power consumption is extremely low, this series is ideally suited for battery-powered or energy-conserving applications. The series offers operation down to a 1.4-V supply, is stable at unity gain, and has excellent noise characteristics.

These devices have internal electrostatic-discharge (ESD) protection circuits that prevent catastrophic failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015.1. However, care should be exercised in handling these devices as exposure to ESD may result in a degradation of the device parametric performance.

## AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	PACKAGED DEVICES		CHIP FORM (Y)
		SMALL OUTLINE (D)	PLASTIC DIP (P)	
0°C to 70°C	10 mV	TLC252CD	TLC252CP	TLC252Y
	5 mV	TLC252ACD	TLC252ACP	—
	2 mV	TLC252BCD	TLC252BCP	—
	10 mV	TLC25L2CD	TLC25L2CP	TLC25L2Y
	5 mV	TLC25L2ACD	TLC25L2ACP	—
	2 mV	TLC25L2BCD	TLC25L2BCP	—
	10 mV	TLC25M2CD	TLC25M2CP	TLC25M2Y
	5 mV	TLC25M2ACD	TLC25M2ACP	—
	2 mV	TLC25M2BCD	TLC25M2BCP	—

The D package is available taped and reeled. Add the suffix R to the device type (e.g., TLC252CDR). Chips are tested at 25°C.

LinCMOS is a trademark of Texas Instruments Incorporated.

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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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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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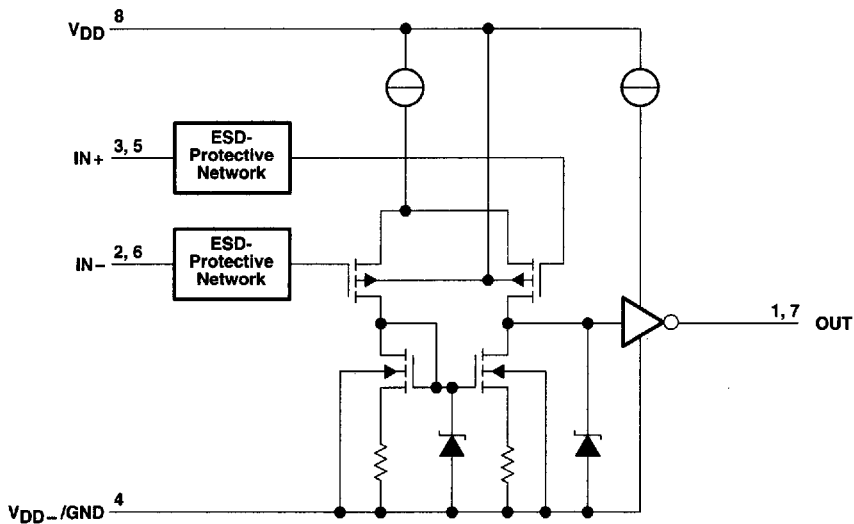
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**description (continued)**

Because of the extremely high input impedance and low input bias and offset currents, applications for the TLC252/25\_2 series include many areas that have previously been limited to BIFET and NFET product types. Any circuit using high-impedance elements and requiring small offset errors is a good candidate for cost-effective use of these devices. Many features associated with bipolar technology are available with LinCMOS™ operational amplifiers without the power penalties of traditional bipolar devices. General applications such as transducer interfacing, analog calculations, amplifier blocks, active filters, and signal buffering are all easily designed with the TLC252/25\_2 series devices. Remote and inaccessible equipment applications are possible using their low-voltage and low-power capabilities. The TLC252/25\_2 series is well suited to solve the difficult problems associated with single-battery and solar-cell-powered applications. This series includes devices that are characterized for the commercial temperature range and are available in 8-pin plastic dip and the small-outline package. The device is also available in chip form.

The TLC252/25\_2 series is characterized for operation from 0°C to 70°C.

**equivalent schematic (each amplifier)**



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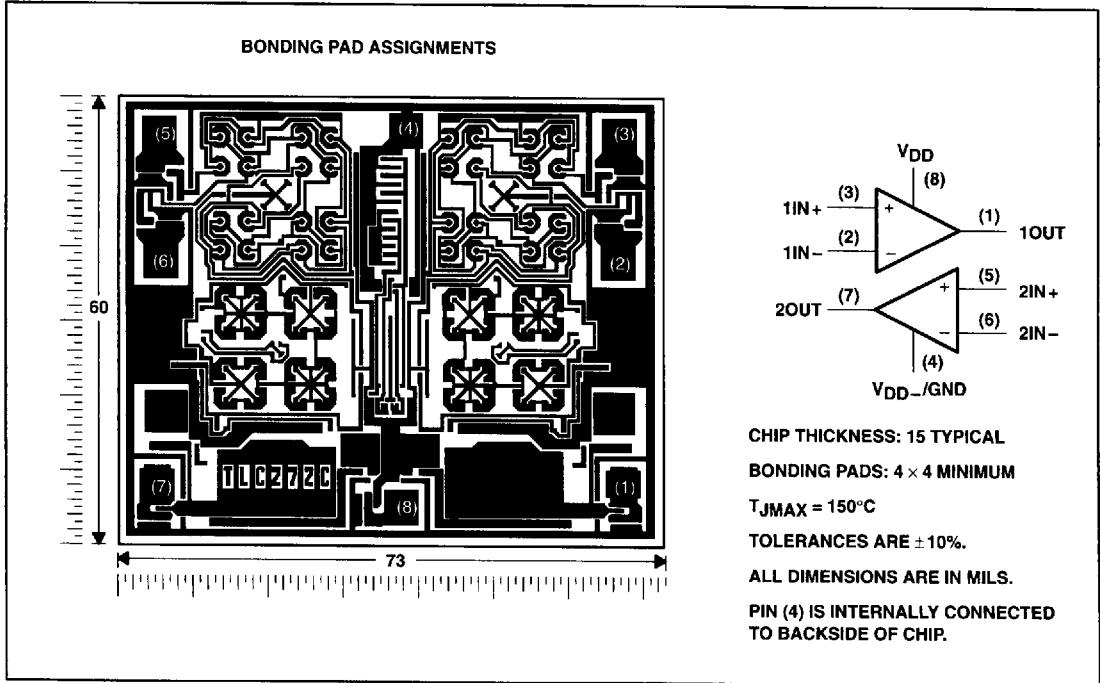


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TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
 TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**TLC252Y, TLC25L2Y, and TLC25M2Y chip information**

These chips, properly assembled, display characteristics similar to the TLC252/25\_2. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips may be mounted with conductive epoxy or a gold-silicon preform.



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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

Supply voltage, $V_{DD}$ (see Note 1)	18 V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm 18$ V
Input voltage range, $V_I$ (any input)	-0.3 V to 18 V
Duration of short circuit at (or below) 25°C free-air temperature (see Note 3)	unlimited
Continuous total dissipation	See Dissipation Rating Table
Operating free-air temperature range, $T_A$	0°C to 70°C
Storage temperature range	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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.

- NOTES: 1. All voltage values, except differential voltages, are with respect to  $V_{DD-}/GND$ .  
2. Differential voltages are at  $IN+$ , with respect to  $IN-$ .  
3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure 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
D	725 mW	5.8 mW/°C	464 mW
P	1000 mW	8.0 mW/°C	640 mW

**recommended operating conditions**

	MIN	MAX	UNIT
Supply voltage, $V_{DD}$	1.4	16	V
Common-mode input voltage, $V_{IC}$	$V_{DD} = 1.4$ V	0	0.2
	$V_{DD} = 5$ V	-0.2	4
	$V_{DD} = 10$ V	-0.2	9
	$V_{DD} = 16$ V	-0.2	14
Operating free-air temperature, $T_A$	0	70	°C

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**electrical characteristics at specified free-air temperature,  $V_{DD} = 1.4\text{ V}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS†	TLC252_C			TLC25L2_C			TLC25M2_C			UNIT		
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX			
$V_{IO}$	Input offset voltage	$V_O = 0.2\text{ V}$ , $R_S = 50\ \Omega$	TLC25_2C	25°C	10			10			10			mV
				0°C to 70°C	12			12			12			
			TLC25_2AC	25°C	5			5			5			
				0°C to 70°C	6.5			6.5			6.5			
			TLC25_2BC	25°C	2			2			2			
				0°C to 70°C	3			3			3			
$\alpha_{VIO}$	Average temperature coefficient of input offset voltage		25°C to 70°C	1			1			1			$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$	Input offset current	$V_O = 0.2\text{ V}$	25°C	1			1			1			pA	
			0°C to 70°C	300			300			300				
$I_{IB}$	Input bias current	$V_O = 0.2\text{ V}$	25°C	1			1			1			pA	
			0°C to 70°C	600			600			600				
$V_{ICR}$	Common-mode input voltage range		25°C	0 to 0.2			0 to 0.2			0 to 0.2			V	
$V_{OM}$	Peak output voltage swing‡	$V_{ID} = 100\text{ mV}$	25°C	450	700	450	700	450	700	450	700	mV		
$A_{VD}$	Large-signal differential voltage amplification	$V_O = 100\text{ to }300\text{ mV}$ , $R_S = 50\ \Omega$	25°C	10			20			20			V/mV	
CMRR	Common-mode rejection ratio	$V_O = 0.2\text{ V}$ , $V_{IC} = V_{ICRmin}$	25°C	60	77	60	77	60	77	60	77	dB		
$I_{DD}$	Supply current	$V_O = 0.2\text{ V}$ , No load	25°C	300	375	25	34	200	250			$\mu\text{A}$		

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. Unless otherwise noted, an output load resistor is connected from the output to ground and has the following value: for low bias  $R_L = 1\text{ M}\Omega$ , for medium bias  $R_L = 100\text{ k}\Omega$ , and for high bias  $R_L = 10\text{ k}\Omega$ .

‡ The output swings to the potential of  $V_{DD-}/\text{GND}$ .

**operating characteristics,  $V_{DD} = 1.4\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS	TLC252_C			TLC25L2_C			TLC25M2_C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$B_1$	Unity-gain bandwidth	$A_V = 40\text{ dB}$ , $C_L = 10\text{ pF}$ , $R_S = 50\ \Omega$	12			12			12			kHz
SR	Slew rate at unity gain	See Figure 1	0.1			0.001			0.01			V/ $\mu\text{s}$
	Overshoot factor	See Figure 1	30%			35%			35%			

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
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**electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		$T_A$ †	TLC252C, TLC252AC, TLC252BC			UNIT
					MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	TLC252C	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 10\text{ k}\Omega$	25°C	1.1	10	mV
					Full range		12	
		TLC252AC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 10\text{ k}\Omega$	25°C	0.9	5	
					Full range		6.5	
		TLC252BC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 10\text{ k}\Omega$	25°C	0.23	2	
					Full range		3	
$\alpha_{VIO}$	Average temperature coefficient of input offset voltage			25°C to 70°C	1.8		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$	Input offset current (see Note 4)	$V_O = 2.5\text{ V}$	$V_{IC} = 2.5\text{ V}$	25°C	0.1		pA	
				70°C	7	300		
$I_{IB}$	Input bias current (see Note 4)	$V_O = 2.5\text{ V}$	$V_{IC} = 2.5\text{ V}$	25°C	0.6		pA	
				70°C	40	600		
$V_{ICR}$	Common-mode input voltage range (see Note 5)			25°C	-0.2 to 4	-0.3 to 4.2	V	
				Full range	-0.2 to 3.5		V	
$V_{OH}$	High-level output voltage	$V_{ID} = 100\text{ mV}$	$R_L = 10\text{ k}\Omega$	25°C	3.2	3.8	V	
				0°C	3	3.8		
				70°C	3	3.8		
$V_{OL}$	Low-level output voltage	$V_{ID} = -100\text{ mV}$	$I_{OL} = 0$	25°C	0	50	mV	
				0°C	0	50		
				70°C	0	50		
$A_{VD}$	Large-signal differential voltage amplification	$V_O = 0.25\text{ V to }2\text{ V}$	$R_L = 10\text{ k}\Omega$	25°C	5	23	V/mV	
				0°C	4	27		
				70°C	4	20		
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$		25°C	65	80	dB	
				0°C	60	84		
				70°C	60	85		
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{DD}$ )	$V_{DD} = 5\text{ V to }10\text{ V}$	$V_O = 1.4\text{ V}$	25°C	65	95	dB	
				0°C	60	94		
				70°C	60	96		
$I_{DD}$	Supply current (two amplifiers)	$V_O = 2.5\text{ V}$ , No load	$V_{IC} = 2.5\text{ V}$	25°C	1.4	3.2	mA	
				0°C	1.6	3.6		
				70°C	1.2	2.6		

† Full range is 0°C to 70°C.

- NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.  
5. This range also applies to each input individually.

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**electrical characteristics at specified free-air temperature,  $V_{DD} = 10\text{ V}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		$T_A$ †	TLC252C, TLC252AC, TLC252BC			UNIT
					MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	TLC252C	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 10\text{ k}\Omega$	25°C	1.1 10		mV
					Full range	12		
		TLC252AC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 10\text{ k}\Omega$	25°C	0.9 5		
					Full range	6.5		
		TLC252BC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 10\text{ k}\Omega$	25°C	0.29 2		
					Full range	3		
$\alpha_{VIO}$	Average temperature coefficient of input offset voltage			25°C to 70°C	2		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$	Input offset current (see Note 4)	$V_O = 2.5\text{ V}$	$V_{IC} = 2.5\text{ V}$	25°C	0.1		pA	
				70°C	7 300			
$I_{IB}$	Input bias current (see Note 4)	$V_O = 2.5\text{ V}$	$V_{IC} = 2.5\text{ V}$	25°C	0.6		pA	
				70°C	50 600			
$V_{ICR}$	Common-mode input voltage range (see Note 5)			25°C	-0.2 to 9	-0.3 to 9.2	V	
				Full range	-0.2 to 8.5		V	
$V_{OH}$	High-level output voltage	$V_{ID} = 100\text{ mV}$	$R_L = 10\text{ k}\Omega$	25°C	8	8.5	V	
				0°C	8	8.5		
				70°C	7.8	8.4		
$V_{OL}$	Low-level output voltage	$V_{ID} = -100\text{ mV}$	$I_{OL} = 0$	25°C	0 50		mV	
				0°C	0 50			
				70°C	0 50			
$A_{VD}$	Large-signal differential voltage amplification	$V_O = 1\text{ V to }6\text{ V}$	$R_L = 10\text{ k}\Omega$	25°C	10	36	V/mV	
				0°C	7.5	42		
				70°C	7.5	32		
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$		25°C	65	85	dB	
				0°C	60	88		
				70°C	60	88		
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{DD}$ )	$V_{DD} = 5\text{ V to }10\text{ V}$ , $V_O = 1.4\text{ V}$		25°C	60	94	dB	
				0°C	60	94		
				70°C	60	96		
$I_{DD}$	Supply current (two amplifiers)	$V_O = 5\text{ V}$ , No load	$V_{IC} = 5\text{ V}$	25°C	1.9	4	mA	
				0°C	2.3	4.4		
				70°C	1.6 3.4			

† Full range is 0°C to 70°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.  
5. This range also applies to each input individually.

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
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**operating characteristics,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS		$T_A$	TLC252C, TLC252AC, TLC252BC			UNIT
				MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 10\text{ k}\Omega$ , See Figure 1	$C_L = 20\text{ pF}$ ,	$V_{I(PP)} = 1\text{ V}$	25°C	3.6		V/ $\mu$ s
				0°C	4		
				70°C	3		
			$V_{I(PP)} = 2.5\text{ V}$	25°C	2.9		
				0°C	3.1		
				70°C	2.5		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$ , $R_S = 20\ \Omega$ ,	See Figure 2	25°C	25		nV/ $\sqrt{\text{Hz}}$	
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , See Figure	$C_L = 20\text{ pF}$ ,	$R_L = 100\text{ k}\Omega$ ,	25°C	320		kHz
				0°C	340		
				70°C	260		
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ ,	$C_L = 20\text{ pF}$ ,	See Figure 3	25°C	1.7		MHz
				0°C	2		
				70°C	1.3		
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , See Figure 3	$f = B_1$ ,	$C_L = 20\text{ pF}$ ,	25°C	46°		
				0°C	47°		
				70°C	43°		

**operating characteristics,  $V_{DD} = 10\text{ V}$**

PARAMETER	TEST CONDITIONS		$T_A$	TLC252C, TLC252AC, TLC252BC			UNIT
				MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 10\text{ k}\Omega$ , See Figure 1	$C_L = 20\text{ pF}$ ,	$V_{I(PP)} = 1\text{ V}$	25°C	5.3		V/ $\mu$ s
				0°C	5.9		
				70°C	4.3		
			$V_{I(PP)} = 5.5\text{ V}$	25°C	4.6		
				0°C	5.1		
				70°C	3.8		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$ , $R_S = 20\ \Omega$ ,	See Figure 2	25°C	25		nV/ $\sqrt{\text{Hz}}$	
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , See Figure 1	$C_L = 20\text{ pF}$ ,	$R_L = 100\text{ k}\Omega$ ,	25°C	200		kHz
				0°C	220		
				70°C	140		
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ ,	$C_L = 20\text{ pF}$ ,	See Figure 3	25°C	2.2		MHz
				0°C	2.5		
				70°C	1.8		
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , See Figure 3	$f = B_1$ ,	$C_L = 20\text{ pF}$ ,	25°C	49°		
				0°C	50°		
				70°C	46°		

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		$T_A$ †	TLC25L2C TLC25L2AC TLC25L2BC		UNIT	
					MIN	TYP		MAX
$V_{IO}$	Input offset voltage	TLC252C	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 1\text{ M}\Omega$	25°C	1.1	10	mV
					Full range		12	
		TLC252AC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 1\text{ M}\Omega$	25°C	0.9	5	
					Full range		6.5	
		TLC252BC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 1\text{ M}\Omega$	25°C	0.204	2	
					Full range		3	
$\alpha_{VIO}$	Average temperature coefficient of input offset voltage			25°C to 70°C	1.1		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$	Input offset current (see Note 4)	$V_O = 2.5\text{ V}$	$V_{IC} = 2.5\text{ V}$	25°C	0.1		pA	
				70°C	7	300		
$I_{IB}$	Input bias current (see Note 4)	$V_O = 2.5\text{ V}$	$V_{IC} = 2.5\text{ V}$	25°C	0.6		pA	
				70°C	50	600		
$V_{ICR}$	Common-mode input voltage range (see Note 5)			25°C	-0.2 to 4	-0.3 to 4.2	V	
				Full range	-0.2 to 3.5		V	
$V_{OH}$	High-level output voltage	$V_{ID} = 100\text{ mV}$	$R_L = 1\text{ M}\Omega$	25°C	3.2	4.1	V	
				0°C	3	4.1		
				70°C	3	4.2		
$V_{OL}$	Low-level output voltage	$V_{ID} = -100\text{ mV}$	$I_{OL} = 0$	25°C		0 50	mV	
				0°C		0 50		
				70°C		0 50		
$A_{VD}$	Large-signal differential voltage amplification	$V_O = 0.25\text{ V to }2\text{ V}$	$R_L = 1\text{ M}\Omega$	25°C	50	700	V/mV	
				0°C	50	700		
				70°C	50	380		
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$		25°C	65	94	dB	
				0°C	60	95		
				70°C	60	95		
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{DD}$ )	$V_{DD} = 5\text{ V to }10\text{ V}$	$V_O = 1.4\text{ V}$	25°C	70	97	dB	
				0°C	60	97		
				70°C	60	98		
$I_{DD}$	Supply current (two amplifiers)	$V_O = 2.5\text{ V}$ , No load	$V_{IC} = 2.5\text{ V}$	25°C	20	34	$\mu\text{A}$	
				0°C	24	42		
				70°C	16	28		

† Full range is 0°C to 70°C.

- NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.  
5. This range also applies to each input individually.

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**electrical characteristics at specified free-air temperature,  $V_{DD} = 10\text{ V}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		$T_A$ †	TLC25L2C TLC25L2AC TLC25L2BC			UNIT
					MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	TLC252C	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 1\text{ M}\Omega$	25°C	1.1 10		mV
					Full range	12		
		TLC252AC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 1\text{ M}\Omega$	25°C	0.9 5		
					Full range	6.5		
		TLC252BC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 1\text{ M}\Omega$	25°C	0.235 2		
					Full range	3		
$\alpha_{VIO}$	Average temperature coefficient of input offset voltage			25°C to 70°C	1		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$	Input offset current (see Note 4)	$V_O = 5\text{ V}$	$V_{IC} = 5\text{ V}$	25°C	0.1		pA	
				70°C	8 300			
$I_{IB}$	Input bias current (see Note 4)	$V_O = 5\text{ V}$	$V_{IC} = 5\text{ V}$	25°C	0.7		pA	
				70°C	50 600			
$V_{ICR}$	Common-mode input voltage range (see Note 5)			25°C	-0.2 to 9	-0.3 to 9.2	V	
				Full range	-0.2 to 8.5		V	
$V_{OH}$	High-level output voltage	$V_{ID} = 100\text{ mV}$	$R_L = 1\text{ M}\Omega$	25°C	8 8.9		V	
				0°C	7.8 8.9			
				70°C	7.8 8.9			
$V_{OL}$	Low-level output voltage	$V_{ID} = -100\text{ mV}$	$I_{OL} = 0$	25°C	0 50		mV	
				0°C	0 50			
				70°C	0 50			
$A_{VD}$	Large-signal differential voltage amplification	$V_O = 1\text{ V to }6\text{ V}$	$R_L = 1\text{ M}\Omega$	25°C	50 860		V/mV	
				0°C	50 1025			
				70°C	50 660			
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR\text{min}}$		25°C	65 97		dB	
				0°C	60 97			
				70°C	60 97			
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{DD}$ )	$V_{DD} = 5\text{ V to }10\text{ V}$ , $V_O = 1.4\text{ V}$		25°C	70 97		dB	
				0°C	60 97			
				70°C	60 98			
$I_{DD}$	Supply current (two amplifiers)	$V_O = 5\text{ V}$ , No load	$V_{IC} = 5\text{ V}$	25°C	29 46		$\mu\text{A}$	
				0°C	36 66			
				70°C	22 40			

† Full range is 0°C to 70°C.

- NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.  
5. This range also applies to each input individually.

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**operating characteristics,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS			$T_A$	TLC25L2C TLC25L2AC TLC25L2BC			UNIT
					MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 1\text{ M}\Omega$ , See Figure 1	$C_L = 20\text{ pF}$	$V_{I(PP)} = 1\text{ V}$	25°C	0.03		V/ $\mu$ s	
				0°C	0.04			
				70°C	0.03			
			$V_{I(PP)} = 2.5\text{ V}$	25°C	0.03			
				0°C	0.03			
				70°C	0.02			
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$	$R_S = 20\ \Omega$	See Figure 2	25°C	68		nV/ $\sqrt{\text{Hz}}$	
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , See Figure	$C_L = 20\text{ pF}$	$R_L = 1\text{ M}\Omega$	25°C	5		kHz	
				0°C	6			
				70°C	4.5			
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$	$C_L = 20\text{ pF}$	See Figure 3	25°C	85		MHz	
				0°C	100			
				70°C	65			
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , See Figure 3	$f = B_1$	$C_L = 20\text{ pF}$	25°C	34°			
				0°C	36°			
				70°C	30°			

**operating characteristics,  $V_{DD} = 10\text{ V}$**

PARAMETER	TEST CONDITIONS			$T_A$	TLC25L2C TLC25L2AC TLC25L2BC			UNIT
					MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 1\text{ M}\Omega$ , See Figure 1	$C_L = 20\text{ pF}$	$V_{I(PP)} = 1\text{ V}$	25°C	0.05		V/ $\mu$ s	
				0°C	0.05			
				70°C	0.04			
			$V_{I(PP)} = 5.5\text{ V}$	25°C	0.04			
				0°C	0.05			
				70°C	0.04			
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$	$R_S = 20\ \Omega$	See Figure 2	25°C	68		nV/ $\sqrt{\text{Hz}}$	
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , See Figure 1	$C_L = 20\text{ pF}$	$R_L = 1\text{ M}\Omega$	25°C	1		kHz	
				0°C	1.3			
				70°C	0.9			
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$	$C_L = 20\text{ pF}$	See Figure 3	25°C	110		MHz	
				0°C	125			
				70°C	90			
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , See Figure 3	$f = B_1$	$C_L = 20\text{ pF}$	25°C	38°			
				0°C	40°			
				70°C	34°			

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	$T_A$ †	TLC25M2C TLC25M2AC TLC25M2BC			UNIT
				MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	TLC252C $V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C	1.1		10	mV
			Full range			12	
		TLC252AC $V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C	0.9		5	
			Full range			6.5	
		TLC252BC $V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C	0.22		2	
			Full range			3	
$\alpha_{VIO}$	Average temperature coefficient of input offset voltage		25°C to 70°C	1.7		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$	Input offset current (see Note 4)	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$	25°C	0.1		pA	
			70°C	7 300			
$I_{IB}$	Input bias current (see Note 4)	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$	25°C	0.6		pA	
			70°C	40 600			
$V_{ICR}$	Common-mode input voltage range (see Note 5)		25°C	-0.2 to 4	-0.3 to 4.2	V	
			Full range	-0.2 to 3.5		V	
$V_{OH}$	High-level output voltage	$V_{ID} = 100\text{ mV}$ , $R_L = 100\text{ k}\Omega$	25°C	3.2	3.9	V	
			0°C	3	3.9		
			70°C	3	4		
$V_{OL}$	Low-level output voltage	$V_{ID} = -100\text{ mV}$ , $I_{OL} = 0$	25°C	0 50		mV	
			0°C	0 50			
			70°C	0 50			
$A_{VD}$	Large-signal differential voltage amplification	$V_O = 0.25\text{ V to }2\text{ V}$ , $R_L = 100\text{ k}\Omega$	25°C	25	170	V/mV	
			0°C	15	200		
			70°C	15	140		
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C	65	91	dB	
			0°C	60	91		
			70°C	60	92		
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{DD}$ )	$V_{DD} = 5\text{ V to }10\text{ V}$ , $V_O = 1.4\text{ V}$	25°C	70	93	dB	
			0°C	60	92		
			70°C	60	94		
$I_{DD}$	Supply current (two amplifiers)	$V_O = 2.5\text{ V}$ , No load $V_{IC} = 2.5\text{ V}$	25°C	210	560	$\mu\text{A}$	
			0°C	250	640		
			70°C	170	440		

† Full range is 0°C to 70°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.  
5. This range also applies to each input individually.

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**electrical characteristics at specified free-air temperature,  $V_{DD} = 10\text{ V}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		$T_A$ †	TLC25M2C TLC25M2AC TLC25M2BC			UNIT
					MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	TLC252C	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C	1.1	10	mV
					Full range		12	
		TLC252AC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C	0.9	5	
					Full range		6.5	
TLC252BC	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$	$V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C	0.224	2			
			Full range		3			
$\alpha_{VIO}$	Average temperature coefficient of input offset voltage			25°C to 70°C	2.1		$\mu\text{V}/^\circ\text{C}$	
$I_{IO}$	Input offset current (see Note 4)	$V_O = 5\text{ V}$	$V_{IC} = 5\text{ V}$	25°C	0.1		pA	
				70°C	7	300		
$I_{IB}$	Input bias current (see Note 4)	$V_O = 5\text{ V}$	$V_{IC} = 5\text{ V}$	25°C	0.7		pA	
				70°C	50	600		
$V_{ICR}$	Common-mode input voltage range (see Note 5)			25°C	-0.2 to 9	-0.3 to 9.2	V	
				Full range	-0.2 to 8.5		V	
$V_{OH}$	High-level output voltage	$V_{ID} = 100\text{ mV}$	$R_L = 100\text{ k}\Omega$	25°C	8	8.7	V	
				0°C	7.8	8.7		
				70°C	7.8	8.7		
$V_{OL}$	Low-level output voltage	$V_{ID} = -100\text{ mV}$	$I_{OL} = 0$	25°C	0	50	mV	
				0°C	0	50		
				70°C	0	50		
$A_{VD}$	Large-signal differential voltage amplification	$V_O = 1\text{ V to }6\text{ V}$	$R_L = 100\text{ k}\Omega$	25°C	25	275	V/mV	
				0°C	15	320		
				70°C	15	230		
CMRR	Common-mode rejection ratio		$V_{IC} = V_{ICRmin}$	25°C	65	94	dB	
				0°C	60	94		
				70°C	60	94		
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{DD}$ )	$V_{DD} = 5\text{ V to }10\text{ V}$	$V_O = 1.4\text{ V}$	25°C	70	93	dB	
				0°C	60	92		
				70°C	60	94		
$I_{DD}$	Supply current (two amplifiers)	$V_O = 5\text{ V}$ , No load	$V_{IC} = 5\text{ V}$	25°C	285	600	$\mu\text{A}$	
				0°C	345	800		
				70°C	220	560		

† Full range is 0°C to 70°C.

- NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.  
5. This range also applies to each input individually.

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**operating characteristics,  $V_{DD} = 5\text{ V}$**

PARAMETER	TEST CONDITIONS			$T_A$	TLC25M2C TLC25M2AC TLC25M2BC			UNIT
					MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , See Figure 1	$C_L = 20\text{ pF}$	See Figure 1	$V_{I(PP)} = 1\text{ V}$	25°C	0.43		V/ $\mu$ s
					0°C	0.46		
					70°C	0.36		
				$V_{I(PP)} = 2.5\text{ V}$	25°C	0.40		
					0°C	0.43		
					70°C	0.34		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$	$R_S = 20\ \Omega$	See Figure 2	25°C	32		nV/ $\sqrt{\text{Hz}}$	
BOM Maximum output-swing bandwidth	$V_O = V_{OH}$ , See Figure	$C_L = 20\text{ pF}$	$R_L = 100\text{ k}\Omega$	25°C	55		kHz	
				0°C	60			
				70°C	50			
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$	$C_L = 20\text{ pF}$	See Figure 3	25°C	525		MHz	
				0°C	600			
				70°C	400			
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , See Figure 3	$f = B_1$	$C_L = 20\text{ pF}$	25°C	40°			
				0°C	41°			
				70°C	39°			

**operating characteristics,  $V_{DD} = 10\text{ V}$**

PARAMETER	TEST CONDITIONS			$T_A$	TLC25M2C TLC25M2AC TLC25M2BC			UNIT
					MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , See Figure 1	$C_L = 20\text{ pF}$	See Figure 1	$V_{I(PP)} = 1\text{ V}$	25°C	0.62		V/ $\mu$ s
					0°C	0.67		
					70°C	0.51		
				$V_{I(PP)} = 5.5\text{ V}$	25°C	0.56		
					0°C	0.61		
					70°C	0.46		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$	$R_S = 20\ \Omega$	See Figure 2	25°C	32		nV/ $\sqrt{\text{Hz}}$	
BOM Maximum output-swing bandwidth	$V_O = V_{OH}$ , See Figure 1	$C_L = 20\text{ pF}$	$R_L = 100\text{ k}\Omega$	25°C	35		kHz	
				0°C	40			
				70°C	30			
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$	$C_L = 20\text{ pF}$	See Figure 3	25°C	635		MHz	
				0°C	710			
				70°C	510			
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , See Figure 3	$f = B_1$	$C_L = 20\text{ pF}$	25°C	43°			
				0°C	44°			
				70°C	42°			

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**electrical characteristics,  $V_{DD} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLC252Y			TLC25L2Y			TLC25M2Y			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 1.4\text{ V}$ , $V_{IC} = 0\text{ V}$ , $R_S = 50\ \Omega$ , See Note 6	1.1	10		1.1	10		1.1	10		mV
$\alpha_{VIO}$ Average temperature coefficient of input offset voltage		1.8			1.1			1.7			$\mu\text{V}/^\circ\text{C}$
$I_{IO}$ Input offset current (see Note 4)	$V_O = V_{DD}/2$ , $V_{IC} = V_{DD}/2$	0.1			0.1			0.1			pA
$I_{IB}$ Input bias current (see Note 4)	$V_O = V_{DD}/2$ , $V_{IC} = V_{DD}/2$	0.6			0.6			0.6			pA
$V_{ICR}$ Common-mode input voltage range (see Note 5)		-0.2 to 4	-0.3 to 4.2		-0.2 to 4	-0.3 to 4.2		-0.2 to 4	-0.3 to 4.2		V
$V_{OH}$ High-level output voltage	$V_{ID} = 100\text{ mV}$ , See Note 6	3.2	3.8		3.2	4.1		3.2	3.9		V
$V_{OL}$ Low-level output voltage	$V_{ID} = -100\text{ mV}$ , $I_{OL} = 0$	0	50		0	50		0	50		mV
$A_{VD}$ Large-signal differential voltage amplification	$V_O = 0.25\text{ V}$ , See Note 6	5	23		50	700		25	170		V/mV
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	65	80		65	94		65	91		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 5\text{ V to }10\text{ V}$ , $V_O = 1.4\text{ V}$	65	95		70	97		70	93		dB
$I_{DD}$ Supply current	$V_O = V_{DD}/2$ , $V_{IC} = V_{DD}/2$ , No load	1.4	3.2		0.02	0.034		0.21	0.56		mA

**operating characteristics,  $V_{DD} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	TLC252Y			TLC25L2Y			TLC25M2Y			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Slew rate at unity gain	$C_L = 20\text{ pF}$ , See Note 6	$V_{I(PP)} = 1\text{ V}$ $V_{I(PP)} = 2.5\text{ V}$			3.6			0.03			V/ $\mu\text{s}$
					2.9			0.03			
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$ , $R_S = 20\ \Omega$	2.5			68			32			nV/ $\sqrt{\text{Hz}}$
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , $R_L = 10\text{ k}\Omega$ , $C_L = 20\text{ pF}$	320			5			55			kHz
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , $C_L = 20\text{ pF}$	1.7			0.085			0.525			MHz
$\phi_m$ Phase margin	$f = B_1$ , $C_L = 20\text{ pF}$ , $V_I = 10\text{ mV}$	46°			34°			40°			

- NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.  
5. This range also applies to each input individually.  
6. For low-bias mode,  $R_L = 1\text{ M}\Omega$ ; for medium-bias mode,  $R_L = 100\text{ k}\Omega$ , and for high-bias mode,  $R_L = 10\text{ k}\Omega$ .

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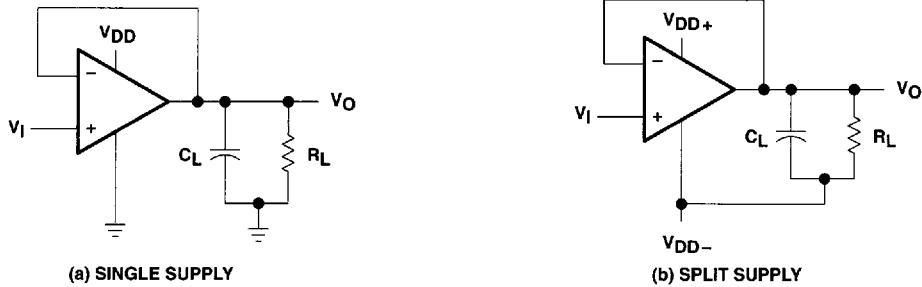
**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y**  
**LinCMOS™ DUAL OPERATIONAL AMPLIFIERS**

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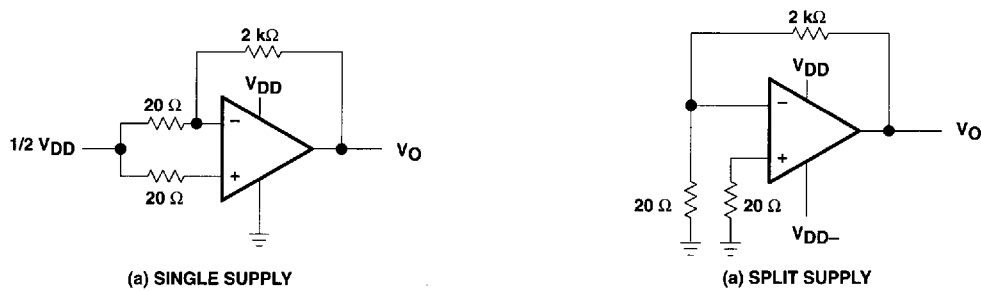
**PARAMETER MEASUREMENT INFORMATION**

**single-supply versus split-supply test circuits**

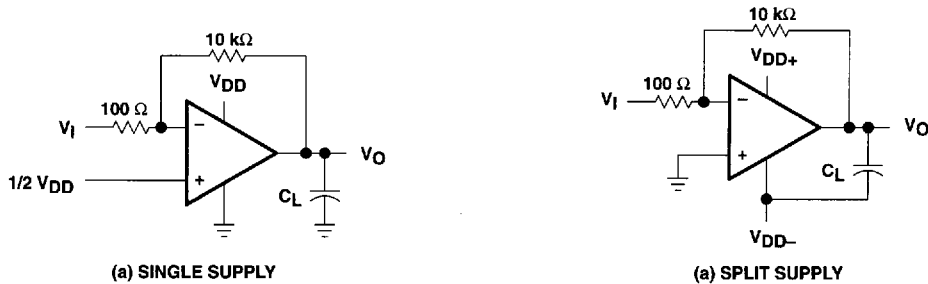
Because the TLC252, TLC25L2, and TLC25M2 are optimized for single-supply operation, circuit configurations used for the various tests often present some inconvenience since the input signal, in many cases, must be offset from ground. This inconvenience can be avoided by testing the device with split supplies and the output load tied to the negative rail. A comparison of single-supply versus split-supply test circuits is shown below. The use of either circuit gives the same result.



**Figure 1. Unity-Gain Amplifier**



**Figure 2. Noise-Test Circuit**



**Figure 3. Gain-of-100 Inverting Amplifier**

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TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
 TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
$I_{DD}$	Supply current	vs Supply voltage	4
		vs Free-air temperature	5
$A_{VD}$	Large-signal differential voltage amplification	Low bias vs Frequency	6
		Medium bias vs Frequency	7
		High bias vs Frequency	8
	Phase shift	Low bias vs Frequency	6
		Medium bias vs Frequency	7
		High bias vs Frequency	8

SUPPLY CURRENT  
 vs  
 SUPPLY VOLTAGE

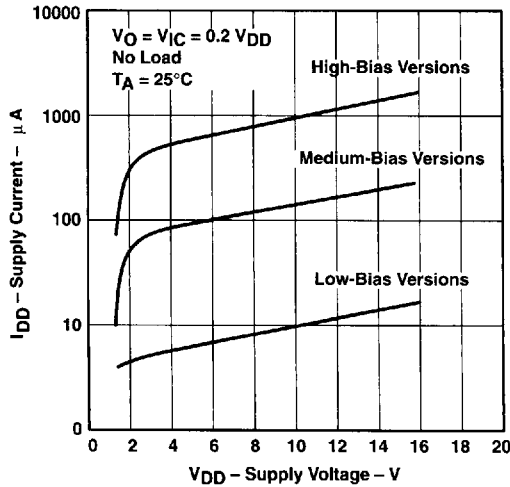


Figure 4

SUPPLY CURRENT  
 vs  
 FREE-AIR TEMPERATURE

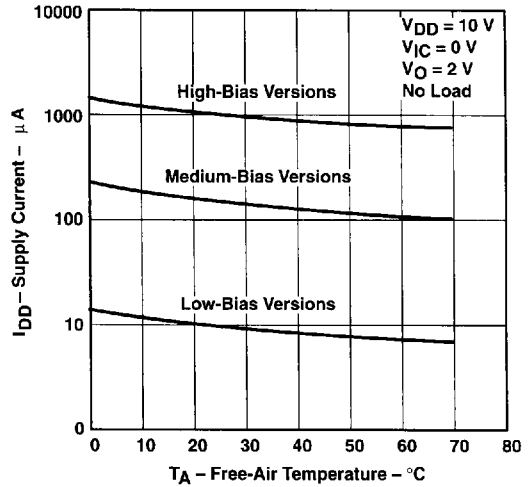


Figure 5

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TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
 TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**TYPICAL CHARACTERISTICS**

**LOW-BIAS LARGE-SIGNAL  
 DIFFERENTIAL VOLTAGE AMPLIFICATION  
 AND PHASE SHIFT  
 vs  
 FREQUENCY**

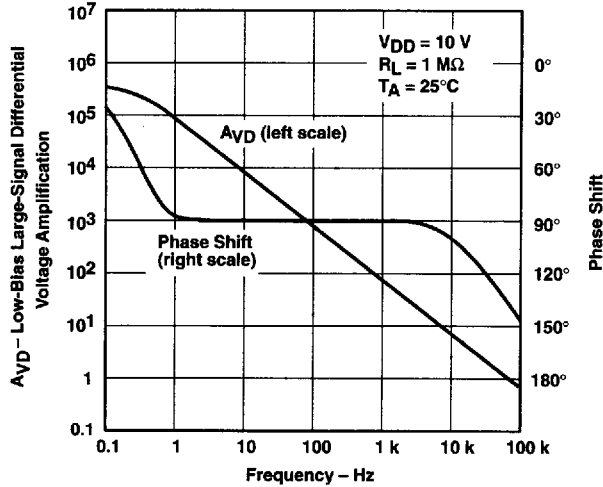


Figure 6

**MEDIUM-BIAS LARGE-SIGNAL  
 DIFFERENTIAL VOLTAGE AMPLIFICATION  
 AND PHASE SHIFT  
 vs  
 FREQUENCY**

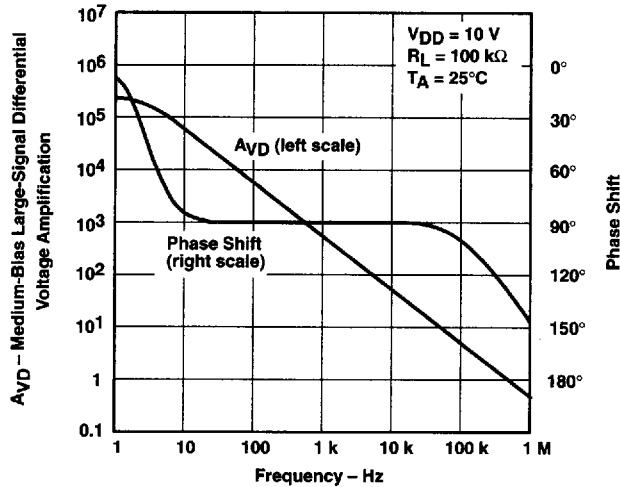


Figure 7

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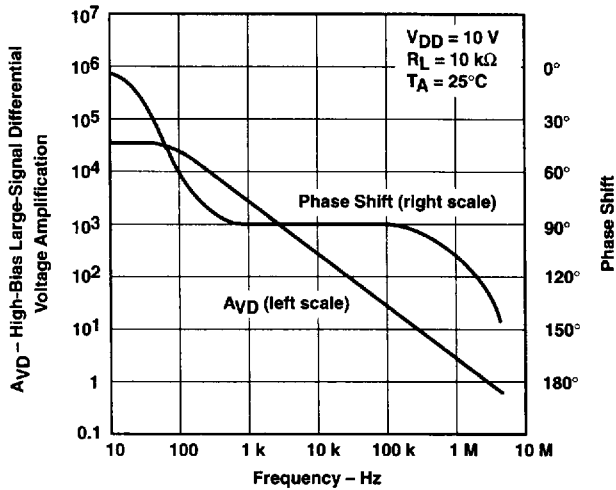


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**TYPICAL CHARACTERISTICS**

**HIGH-BIAS LARGE-SIGNAL  
 DIFFERENTIAL VOLTAGE AMPLIFICATION  
 AND PHASE SHIFT**

vs  
**FREQUENCY**



**Figure 8**

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**TLC252, TLC252A, TLC252B, TLC252Y, TLC25L2, TLC25L2A, TLC25L2B  
TLC25L2Y, TLC25M2, TLC25M2A, TLC25M2B, TLC25M2Y  
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**APPLICATION INFORMATION**

**latch-up avoidance**

Junction-isolated CMOS circuits have an inherent parasitic PNP structure that can function as an SCR. Under certain conditions, this SCR may be triggered into a low-impedance state, resulting in excessive supply current. To avoid such conditions, no voltage greater than 0.3 V beyond the supply rails should be applied to any pin. In general, the operational amplifier supplies should be applied simultaneously with, or before, application of any input signals.

**output stage considerations**

The amplifier's output stage consists of a source-follower-connected pullup transistor and an open-drain pulldown transistor. The high-level output voltage ( $V_{OH}$ ) is virtually independent of the  $I_{DD}$  selection and increases with higher values of  $V_{DD}$  and reduced output loading. The low-level output voltage ( $V_{OL}$ ) decreases with reduced output current and higher input common-mode voltage. With no load,  $V_{OL}$  is essentially equal to the potential of  $V_{DD-}/GND$ .

**supply configurations**

Even though the TLC252/25\_2C series is characterized for single-supply operation, it can be used effectively in a split-supply configuration if the input common-mode voltage ( $V_{ICR}$ ), output swing ( $V_{OL}$  and  $V_{OH}$ ), and supply voltage limits are not exceeded.

**circuit layout precautions**

The user is cautioned that whenever extremely high circuit impedances are used, care must be exercised in layout, construction, board cleanliness, and supply filtering to avoid hum and noise pickup, as well as excessive dc leakages.

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 **TEXAS  
INSTRUMENTS**