

## LinCMOS™ PRECISION QUAD OPERATIONAL AMPLIFIERS

Check for Samples: [TLC27M4](#), [TLC27M4A](#), [TLC27M4B](#), [TLC27M4Y](#), [TLC27M9](#)

### FEATURES

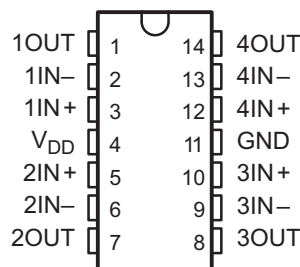
- Trimmed Offset Voltage
  - TLC27M9 . . . 900  $\mu\text{V}$  Max at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{ V}$
- Input Offset Voltage Drift . . . Typically 0.1  $\mu\text{V}/\text{Month}$ , Including the First 30 Days
- Wide Range of Supply Voltages Over Specified Temperature Range:
  - $0^\circ\text{C}$  to  $70^\circ\text{C}$  . . . 3 V to 16 V
  - $-40^\circ\text{C}$  to  $85^\circ\text{C}$  . . . 4 V to 16 V
  - $-55^\circ\text{C}$  to  $125^\circ\text{C}$  . . . 4 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Low Noise . . . Typically 32  $\text{nV}/\sqrt{\text{Hz}}$  at  $f = 1\text{ kHz}$
- Low Power . . . Typically 2.1 mW at  $T_A = 25^\circ\text{C}$ ,  $V_{DD} = 5\text{ V}$
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . .  $10^{12}\ \Omega$  Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

### DESCRIPTION

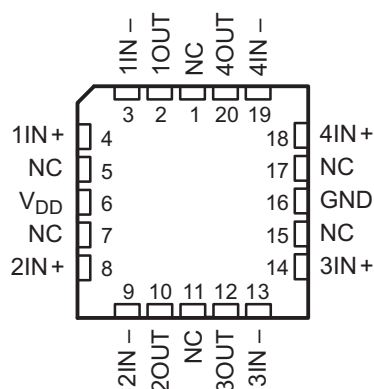
The TLC27M4 and TLC27M9 quad operational amplifiers combine a wide range of input offset voltage grades with low offset voltage drift, high input impedance, low noise, and speeds comparable to that of general-purpose bipolar devices. These devices use Texas Instruments silicon-gate LinCMOS™ technology, which provides offset voltage stability far exceeding the stability available with conventional metal-gate processes.

The extremely high input impedance, low bias currents, make these cost-effective devices ideal for applications that have previously been reserved for general-purpose bipolar products, but with only a fraction of the power consumption.

**D, J, N, OR PW PACKAGE  
(TOP VIEW)**

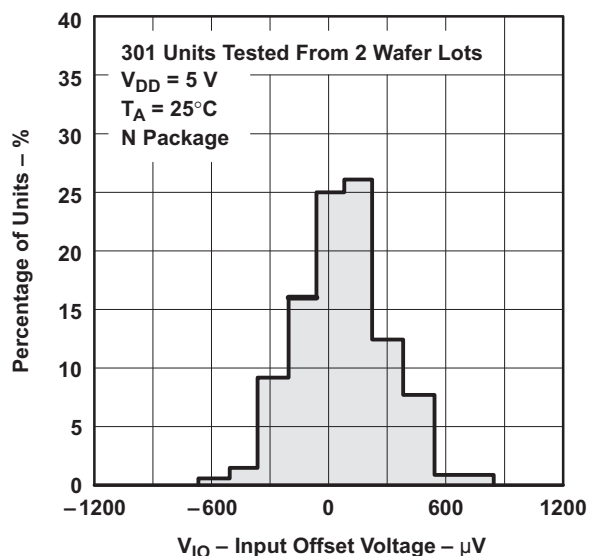


**FK PACKAGE  
(TOP VIEW)**



NC – No internal connection

**DISTRIBUTION OF TLC27M9  
INPUT OFFSET VOLTAGE**



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Four offset voltage grades are available (C-suffix and I-suffix types), ranging from the low-cost TLC27M4 (10 mV) to the high-precision TLC27M9 (900  $\mu$ V). These advantages, in combination with good common-mode rejection and supply voltage rejection, make these devices a good choice for new state-of-the-art designs as well as for upgrading existing designs.

In general, many features associated with bipolar technology are available on LinCMOS™ operational amplifiers, without the power penalties of bipolar technology. General applications such as transducer interfacing, analog calculations, amplifier blocks, active filters, and signal buffering are easily designed with the TLC27M4 and TLC27M9. The devices also exhibit low voltage single-supply operation, and low power consumption, making them ideally suited for remote and inaccessible battery-powered applications. The common-mode input voltage range includes the negative rail.

A wide range of packaging options is available, including small-outline and chip-carrier versions for high-density system applications.

The device inputs and outputs are designed to withstand –100-mA surge currents without sustaining latch-up.

The TLC27M4 and TLC27M9 incorporate internal ESD-protection circuits that prevent functional failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015; however, care should be exercised in handling these devices, as exposure to ESD may result in the degradation of the device parametric performance.

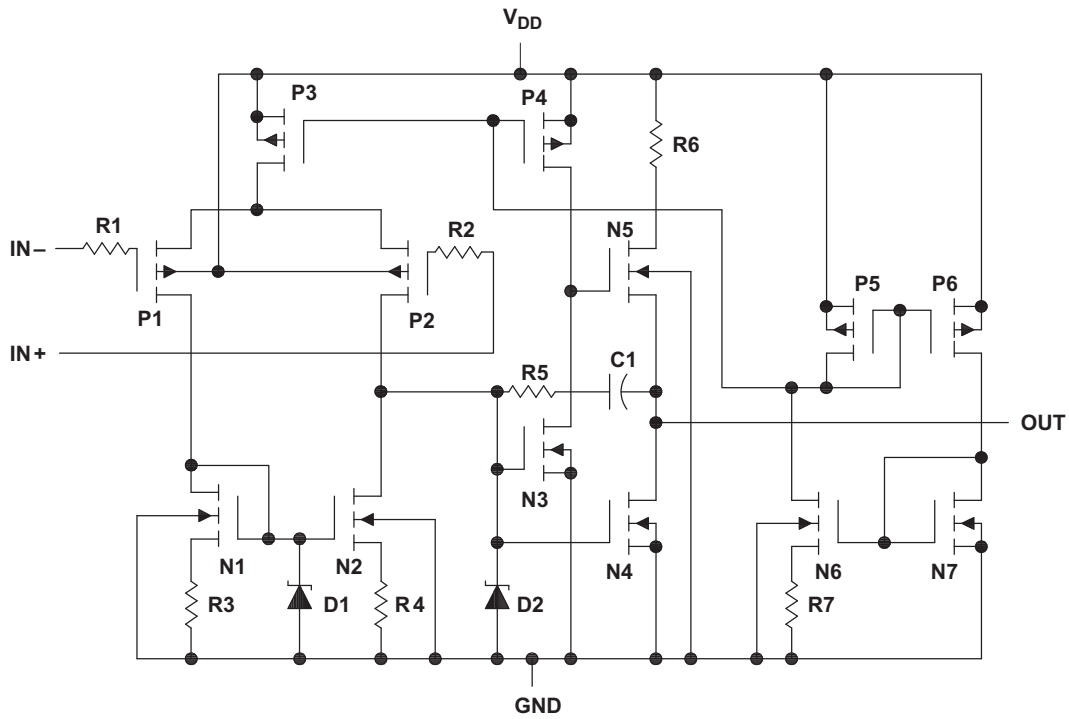
The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C.

#### AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	PACKAGE					CHIP FORM (Y)
		SMALL OUTLINE (D) <sup>(1)</sup>	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	TSSOP (PW) <sup>(1)</sup>	
0°C to 70°C	900 $\mu$ V	TLC27M9CD	—	—	TLC27M9CN	—	—
	2 mV	TLC27M4BCD	—	—	TLC27M4BCN	—	—
	5 mV	TLC27M4ACD	—	—	TLC27M4ACN	—	—
	10 mV	TLC27M4CD	—	—	TLC27M4CN	TLC27M4CPW	TLC27M4Y
–40°C to 85°C	900 $\mu$ V	TLC27M9ID	—	—	TLC27M9IN	—	—
	2 mV	TLC27M4BID	—	—	TLC27M4BIN	—	—
	5 mV	TLC27M4AID	—	—	TLC27M4AIN	—	—
	10 mV	TLC27M4ID	—	—	TLC27M4IN	TLC27M41PW	—
–55°C to 125°C	900 $\mu$ V	TLC27M9MD	TLC27M9MFK	TLC27M9MJ	TLC27M9MN	—	—
	10 mV	TLC27M4MD	TLC27M4MFK	TLC27M4MJ	TLC27M4MN	—	—

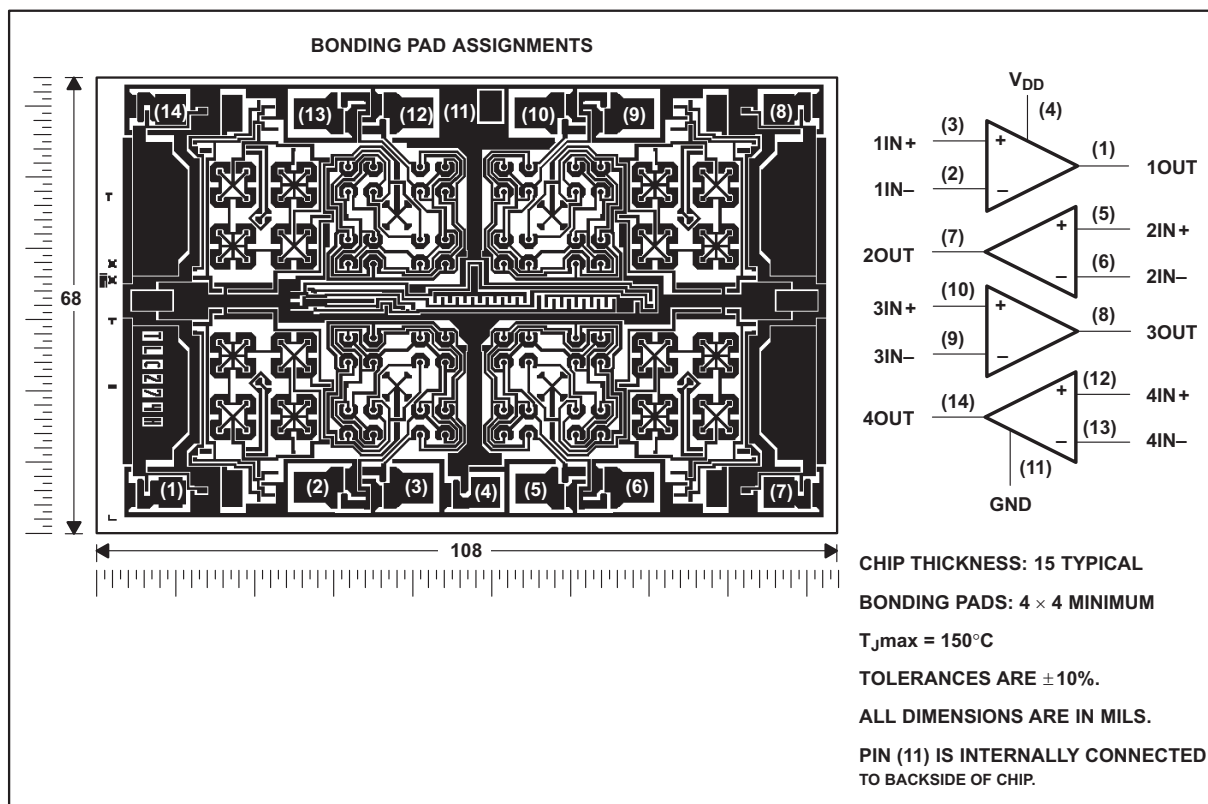
(1) The D and PW package is available taped and reeled. Add R suffix to the device type (e.g., TLC279CDR).

# **EQUIVALENT SCHEMATIC (EACH AMPLIFIER)**



## TLC27M4Y chip information

This chip, when properly assembled, displays characteristics similar to the TLC27M4C. 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.



## ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

	VALUE	UNIT
Supply voltage, $V_{DD}$ <sup>(2)</sup>	18	V
Differential input voltage, $V_{ID}$ <sup>(3)</sup>	$\pm V_{DD}$	
Input voltage range, $V_I$ (any input)	$-0.3\text{ V to }V_{DD}$	
Input current, $I_I$	$\pm 5$	mA
Output current, $I_O$ (each output)	$\pm 30$	mA
Total current into $V_{DD}$	45	mA
Total current out of GND	45	mA
Duration of short-circuit current at (or below) $25^\circ\text{C}$ <sup>(4)</sup>	unlimited	
Continuous total dissipation	See Dissipation Rating Table	
Operating free-air temperature, $T_A$	C suffix	0 to 70
	I suffix	$-40$ to 85
	M suffix	$-55$ to 125
Storage temperature range	$-65$ to 150	$^\circ\text{C}$
Case temperature for 60 seconds: FK package	260	$^\circ\text{C}$
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, N, or PW package	260	$^\circ\text{C}$
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300	$^\circ\text{C}$

- (1) 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.
- (2) All voltage values, except differential voltages, are with respect to network ground.
- (3) Differential voltages are at  $IN+$  with respect to  $IN-$ .
- (4) 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 (see application section).

## DISSIPATION RATINGS

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	950 mW	7.6 mW/ $^\circ\text{C}$	608 mW	494 mW	—
FK	1375 mW	11.0 mW/ $^\circ\text{C}$	880 mW	715 mW	275 mW
J	1375 mW	11.0 mW/ $^\circ\text{C}$	880 mW	715 mW	275 mW
N	1575 mW	12.6 mW/ $^\circ\text{C}$	1008 mW	819 mW	—
PW	700 mW	5.6 mW/ $^\circ\text{C}$	448 mW	—	—

## RECOMMENDED OPERATING CONDITIONS

	MIN	MAX	MIN	MAX	MIN	MAX	UNIT
Supply voltage, $V_{DD}$	3	16	4	16	4	16	V
Common mode input voltage, $V_{IC}$	$V_{DD} = 5\text{ V}$		$-0.2$	3.5	$-0.2$	3.5	V
	$V_{DD} = 10\text{ V}$		$-0.2$	8.5	$-0.2$	8.5	
Operating free-air temperature, $T_A$	0	70	$-40$	85	$-55$	125	$^\circ\text{C}$

**ELECTRICAL CHARACTERISTICS**at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T <sub>A</sub> <sup>(1)</sup>	TLC27M4C TLC27M4AC TLC27M4BC TLC27M9C			UNIT
					MIN	TYP	MAX	
V <sub>IO</sub>	Input offset voltage	TLC27M4C	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω, V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	1.1	10	mV	
				Full range		12		
		TLC27M4AC	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω, V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	0.9	5		
				Full range		6.5		
	TLC274BC	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω, V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	250	2000	μV		
			Full range		3000			
		TLC279C	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω, V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	210		900	
				Full range			1500	
α <sub>VIO</sub>	Average temperature coefficient of input offset voltage			25°C to 70°C	1.7		μV/°C	
I <sub>IO</sub>	Input offset current <sup>(2)</sup>	V <sub>O</sub> = 2.5 V, V <sub>IC</sub> = 2.5 V	25°C	0.1		pA		
			70°C	7	300			
I <sub>IB</sub>	Input bias current <sup>(2)</sup>	V <sub>O</sub> = 2.5 V, V <sub>IC</sub> = 2.5 V	25°C	0.6		pA		
			70°C	40	600			
V <sub>ICR</sub>	Common-mode input voltage range <sup>(3)</sup>		25°C	-0.2 to 4	-0.3 to 4.2	V		
			Full range	-0.2 to 3.5		V		
V <sub>OH</sub>	High-level output voltage	V <sub>ID</sub> = 100 mV, R <sub>L</sub> = 100 kΩ	25°C	3.2	3.9	V		
			0°C	3	3.9			
			70°C	3	4			
V <sub>OL</sub>	Low-level output voltage	V <sub>ID</sub> = -100 mV, I <sub>OL</sub> = 0	25°C	0	50	mV		
			0°C	0	50			
			70°C	0	50			
A <sub>VD</sub>	Large-signal differential voltage amplification	V <sub>O</sub> = 0.25 V to 2 V, R <sub>L</sub> = 100 kΩ	25°C	25	170	V/mV		
			0°C	15	200			
			70°C	15	140			
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min	25°C	65	91	dB		
			0°C	60	91			
			70°C	60	92			
k <sub>SVR</sub>	Supply-voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	V <sub>DD</sub> = 5 V to 10 V, V <sub>O</sub> = 1.4 V	25°C	70	93	dB		
			0°C	60	92			
			70°C	60	94			
I <sub>DD</sub>	Supply current (four amplifiers)	V <sub>O</sub> = 2.5 V, No load V <sub>IC</sub> = 2.5 V,	25°C	420	1120	μA		
			0°C	500	1280			
			70°C	340	880			

(1) Full range is 0°C to 70°C.

(2) The typical values of input bias current and input offset current below 5 pA were determined mathematically.

(3) This range also applies to each input individually.

## ELECTRICAL CHARACTERISTICS

at specified free-air temperature,  $V_{DD} = 10\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T <sub>A</sub> <sup>(1)</sup>	TLC27M4C TLC27M4AC TLC27M4BC TLC27M9C			UNIT
					MIN	TYP	MAX	
V <sub>IO</sub>	Input offset voltage	TLC27M4C	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω,	V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	1.1	10	mV
					Full range	12		
		TLC27M4AC	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω,	V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	0.9	5	
					Full range	6.5		
		TLC274BC	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω,	V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	260	2000	µV
					Full range	3000		
		TLC279C	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω,	V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	220	1200	
					Full range	1900		
α <sub>VIO</sub>	Average temperature coefficient of input offset voltage			25°C to 70°C	2.1		µV/°C	
I <sub>IO</sub>	Input offset current <sup>(2)</sup>	V <sub>O</sub> = 5 V,	V <sub>IC</sub> = 5 V	25°C	0.1		pA	
				70°C	7	300		
I <sub>IB</sub>	Input bias current <sup>(2)</sup>	V <sub>O</sub> = 5 V,	V <sub>IC</sub> = 5 V	25°C	0.7		pA	
				70°C	50	600		
V <sub>ICR</sub>	Common-mode input voltage range <sup>(3)</sup>			25°C	−0.2 to 9	−0.3 to 9.2	V	
				Full range	−0.2 to 8.5		V	
V <sub>OH</sub>	High-level output voltage	V <sub>ID</sub> = 100 mV,	R <sub>L</sub> = 100 kΩ	25°C	8	8.7	V	
				0°C	7.8	8.7		
				70°C	7.8	8.7		
V <sub>OL</sub>	Low-level output voltage	V <sub>ID</sub> = −100 mV,	I <sub>OL</sub> = 0	25°C	0	50	mV	
				0°C	0	50		
				70°C	0	50		
A <sub>VD</sub>	Large-signal differential voltage amplification	V <sub>O</sub> = 1 V to 6 V,	R <sub>L</sub> = 100 kΩ	25°C	25	275	V/mV	
				0°C	15	320		
				70°C	15	230		
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min		25°C	65	94	dB	
				0°C	60	94		
				70°C	60	94		
k <sub>SVR</sub>	Supply-voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	V <sub>DD</sub> = 5 V to 10 V, V <sub>O</sub> = 1.4 V		25°C	70	93	dB	
				0°C	60	92		
				70°C	60	94		
I <sub>DD</sub>	Supply current (four amplifiers)	V <sub>O</sub> = 5 V, No load	V <sub>IC</sub> = 5 V,	25°C	570	1200	µA	
				0°C	690	1600		
				70°C	440	1120		

(1) Full range is 0°C to 70°C.

(2) The typical values of input bias current and input offset current below 5 pA were determined mathematically.

(3) This range also applies to each input individually.

**ELECTRICAL CHARACTERISTICS**at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		$T_A^{(1)}$	TLC27M4I TLC27M4AI TLC27M4BI TLC27M9I			UNIT
					MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	TLC27M4I	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C		1.1	10	mV
				Full range			13	
	TLC27M4AI	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	$V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C		0.9	5	
				Full range			6.5	
	TLC27M4BI	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	$V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C		250	2000	$\mu\text{V}$
				Full range			3000	
	TLC27M9I	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	$V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$	25°C		210	900	
				Full range			2000	
$\alpha_{VIO}$	Average temperature coefficient of input offset voltage			25°C to 85°C		1.7		$\mu\text{V}/^\circ\text{C}$
$I_{IO}$	Input offset current <sup>(2)</sup>	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$	$V_{IC} = 2.5\text{ V}$	25°C		0.1		pA
				85°C		24	1000	
$I_{IB}$	Input bias current <sup>(2)</sup>	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$	$V_{IC} = 2.5\text{ V}$	25°C		0.6		pA
				85°C		200	2000	
$V_{ICR}$	Common-mode input voltage range <sup>(3)</sup>			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	$V_{ID} = 100\text{ mV}$ , $R_L = 100\text{ k}\Omega$	$R_L = 100\text{ k}\Omega$	25°C		3.2	3.9	V
				-40°C		3	3.9	
				85°C		3	4	
$V_{OL}$	Low-level output voltage	$V_{ID} = -100\text{ mV}$ , $I_{OL} = 0$	$I_{OL} = 0$	25°C		0	50	mV
				-40°C		0	50	
				85°C		0	50	
$A_{VD}$	Large-signal differential voltage amplification	$V_O = 0.25\text{ V to } 2\text{ V}$ , $R_L = 100\text{ k}\Omega$	$R_L = 100\text{ k}\Omega$	25°C		25	170	V/mV
				-40°C		15	270	
				85°C		15	130	
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$		25°C		65	91	dB
				-40°C		60	90	
				85°C		60	90	
$k_{SVR}$	Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 5\text{ V to } 10\text{ V}$ , $V_O = 1.4\text{ V}$	$V_O = 1.4\text{ V}$	25°C		70	93	dB
				-40°C		60	91	
				85°C		60	94	
$I_{DD}$	Supply current (four amplifiers)	$V_O = 2.5\text{ V}$ , No load	$V_{IC} = 2.5\text{ V}$	25°C		420	1120	$\mu\text{A}$
				-40°C		630	1600	
				85°C		320	800	

(1) Full range is -40°C to 85°C.

(2) The typical values of input bias current and input offset current below 5 pA were determined mathematically.

(3) This range also applies to each input individually.



## ELECTRICAL CHARACTERISTICS

at specified free-air temperature,  $V_{DD} = 10\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T <sub>A</sub> <sup>(1)</sup>	TLC27M4I TLC27M4AI TLC27M4BI TLC27M9I			UNIT		
					MIN	TYP	MAX			
V <sub>IO</sub>	Input offset voltage	TLC27M4I	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω,	V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	1.1	10	mV		
					Full range	13				
		TLC27M4AI	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω,	V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	0.9	5			
					Full range	7				
	TLC27M4BI	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω,	V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	260	2000	μV			
				Full range	3500					
				TLC27M9I	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω,	V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ		25°C	220	1200
								Full range	2900	
α <sub>VIO</sub>	Average temperature coefficient of input offset voltage				25°C to 85°C	2.1		μV/°C		
I <sub>IO</sub>	Input offset current <sup>(2)</sup>	V <sub>O</sub> = 5 V,	V <sub>IC</sub> = 5 V	25°C	0.1		pA			
				85°C	26	1000				
I <sub>IB</sub>	Input bias current <sup>(2)</sup>	V <sub>O</sub> = 5 V,	V <sub>IC</sub> = 5 V	25°C	0.7		pA			
				85°C	220	2000				
V <sub>ICR</sub>	Common-mode input voltage range <sup>(3)</sup>			25°C	−0.2 to 9	−0.3 to 9.2	V			
				Full range	−0.2 to 8.5		V			
V <sub>OH</sub>	High-level output voltage	V <sub>ID</sub> = 100 mV,	R <sub>L</sub> = 100 kΩ	25°C	8	8.7	V			
				−40°C	7.8	8.7				
				85°C	7.8	8.7				
V <sub>OL</sub>	Low-level output voltage	V <sub>ID</sub> = −100 mV,	I <sub>OL</sub> = 0	25°C	0	50	mV			
				−40°C	0	50				
				85°C	0	50				
A <sub>VD</sub>	Large-signal differential voltage amplification	V <sub>O</sub> = 1 V to 6 V,	R <sub>L</sub> = 100 kΩ	25°C	25	275	V/mV			
				−40°C	15	390				
				85°C	15	220				
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICRmin</sub>		25°C	65	94	dB			
				−40°C	60	93				
				85°C	60	94				
k <sub>SVR</sub>	Supply-voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	V <sub>DD</sub> = 5 V to 10 V, V <sub>O</sub> = 1.4 V		25°C	70	93	dB			
				−40°C	60	91				
				85°C	60	94				
I <sub>DD</sub>	Supply current (four amplifiers)	V <sub>O</sub> = 5 V, No load	V <sub>IC</sub> = 5 V,	25°C	570	1200	μA			
				−40°C	900	1800				
				85°C	410	1040				

(1) Full range is -40°C to 85°C.

(2) The typical values of input bias current and input offset current below 5 pA were determined mathematically.

(3) This range also applies to each input individually.

**ELECTRICAL CHARACTERISTICS**at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T <sub>A</sub> <sup>(1)</sup>	TLC27M4M TLC27M9M			UNIT
					MIN	TYP	MAX	
V <sub>IO</sub>	Input offset voltage	TLC27M4M	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω, V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	1.1 10		mV	
				Full range	12			
	TLC27M9M	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω, V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	210 900		μV		
			Full range	3750				
α <sub>VIO</sub>	Average temperature coefficient of input offset voltage			25°C to 125°C		1.7		μV/°C
I <sub>IO</sub>	Input offset current <sup>(2)</sup>		V <sub>O</sub> = 2.5 V, V <sub>IC</sub> = 2.5 V	25°C	0.1		pA	
				125°C	1.4 15		nA	
I <sub>IB</sub>	Input bias current <sup>(2)</sup>		V <sub>O</sub> = 2.5 V, V <sub>IC</sub> = 2.5 V	25°C	0.6		pA	
				85°C	9 35		nA	
V <sub>ICR</sub>	Common-mode input voltage range <sup>(3)</sup>			25°C	0 −0.3 to to 4 4.2		V	
				Full range	0 to 3.5		V	
V <sub>OH</sub>	High-level output voltage		V <sub>ID</sub> = 100 mV, R <sub>L</sub> = 100 kΩ	25°C	3.2 3.9		V	
				−55°C	3 3.9			
				125°C	3 4			
V <sub>OL</sub>	Low-level output voltage		V <sub>ID</sub> = −100 mV, I <sub>OL</sub> = 0	25°C	0 50		mV	
				−55°C	0 50			
				125°C	0 50			
A <sub>VD</sub>	Large-signal differential voltage amplification		V <sub>O</sub> = 0.25 V to 2 V, R <sub>L</sub> = 100 kΩ	25°C	25 170		V/mV	
				−55°C	15 270			
				125°C	15 120			
CMRR	Common-mode rejection ratio		V <sub>IC</sub> = V <sub>ICRmin</sub>	25°C	65 91		dB	
				−55°C	60 89			
				125°C	60 91			
k <sub>SVR</sub>	Supply-voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )		V <sub>DD</sub> = 5 V to 10 V, V <sub>O</sub> = 1.4 V	25°C	70 93		dB	
				−55°C	60 91			
				125°C	60 94			
I <sub>DD</sub>	Supply current (four amplifiers)		V <sub>O</sub> = 2.5 V, No load V <sub>IC</sub> = 2.5 V,	25°C	420 1120		μA	
				−55°C	680 1760			
				125°C	280 720			

(1) Full range is -55°C to 125°C.

(2) The typical values of input bias current and input offset current below 5 pA were determined mathematically.

(3) This range also applies to each input individually.

## ELECTRICAL CHARACTERISTICS

at specified free-air temperature,  $V_{DD} = 10\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T <sub>A</sub> <sup>(1)</sup>	TLC27M4M TLC27M9M			UNIT
					MIN	TYP	MAX	
V <sub>IO</sub>	Input offset voltage	TLC27M4M	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω, V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	1.1	10	mV	
				Full range	12			
		TLC27M9M	V <sub>O</sub> = 1.4 V, R <sub>S</sub> = 50 Ω, V <sub>IC</sub> = 0, R <sub>L</sub> = 100 kΩ	25°C	220	1200	μV	
				Full range	4300			
α <sub>VIO</sub>	Average temperature coefficient of input offset voltage			25°C to 125°C	2.1		μV/°C	
I <sub>IO</sub>	Input offset current <sup>(2)</sup>	V <sub>O</sub> = 5 V, V <sub>IC</sub> = 5 V		25°C	0.1		pA	
				125°C	1.8	15	nA	
I <sub>IB</sub>	Input bias current <sup>(2)</sup>	V <sub>O</sub> = 5 V, V <sub>IC</sub> = 5 V		25°C	0.7		pA	
				125°C	10	35	nA	
V <sub>ICR</sub>	Common-mode input voltage range <sup>(3)</sup>			25°C	0 to 9	−0.3 to 9.2	V	
				Full range	−0.2 to 8.5		V	
V <sub>OH</sub>	High-level output voltage	V <sub>ID</sub> = 100 mV, R <sub>L</sub> = 100 kΩ		25°C	8	8.7	V	
				−55°C	7.8	8.6		
				125°C	7.8	8.8		
V <sub>OL</sub>	Low-level output voltage	V <sub>ID</sub> = −100 mV, I <sub>OL</sub> = 0		25°C	0	50	mV	
				−55°C	0	50		
				125°C	0	50		
A <sub>VD</sub>	Large-signal differential voltage amplification	V <sub>O</sub> = 1 V to 6 V, R <sub>L</sub> = 100 kΩ		25°C	25	275	V/mV	
				−55°C	15	420		
				125°C	15	190		
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min		25°C	65	94	dB	
				−55°C	60	93		
				125°C	60	93		
k <sub>SVR</sub>	Supply-voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )	V <sub>DD</sub> = 5 V to 10 V, V <sub>O</sub> = 1.4 V		25°C	70	93	dB	
				−55°C	60	91		
				125°C	60	94		
I <sub>DD</sub>	Supply current (four amplifiers)	V <sub>O</sub> = 5 V, No load V <sub>IC</sub> = 5 V,		25°C	570	1200	μA	
				−55°C	980	2000		
				125°C	360	960		

(1) Full range is -55°C to 70°C.

(2) The typical values of input bias current and input offset current below 5 pA were determined mathematically.

(3) This range also applies to each input individually.

**ELECTRICAL CHARACTERISTICS** $V_{DD} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLC27M4Y			UNIT
		MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$		1.1	10	mV
$\alpha_{VIO}$ Temperature coefficient of input offset voltage	$T_A = 25^\circ\text{C}$ to $70^\circ\text{C}$		1.7		$\mu\text{V}/^\circ\text{C}$
$I_{IO}$ Input offset current <sup>(1)</sup>	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$		0.1		pA
$I_{IB}$ Input bias current <sup>(1)</sup>	$V_O = 2.5\text{ V}$ , $V_{IC} = 2.5\text{ V}$		0.6		pA
$V_{ICR}$ Common-mode input voltage range <sup>(2)</sup>		–0.2 to 4	–0.3 to 4.2		V
$V_{OH}$ High-level output voltage	$V_{ID} = 100\text{ mV}$ , $R_L = 100\text{ k}\Omega$	3.2	3.9		V
$V_{OL}$ Low-level output voltage	$V_{ID} = -100\text{ mV}$ , $I_{OL} = 0$		0	50	mV
$A_{VD}$ Large-signal differential voltage amplification	$V_O = 0.25\text{ V}$ to $2\text{ V}$ , $R_L = 100\text{ k}\Omega$	25	170		V/mV
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	65	91		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 5\text{ V}$ to $10\text{ V}$ , $V_O = 1.4\text{ V}$	70	93		dB
$I_{DD}$ Supply current (four amplifiers)	$V_O = 2.5\text{ V}$ , No load $V_{IC} = 2.5\text{ V}$		420	1120	$\mu\text{A}$

(1) The typical values of input bias current and input offset current below 5 pA were determined mathematically.

(2) This range also applies to each input individually.

**ELECTRICAL CHARACTERISTICS** $V_{DD} = 10\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TLC27M4Y			UNIT
		MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 1.4\text{ V}$ , $R_S = 50\ \Omega$ , $V_{IC} = 0$ , $R_L = 100\text{ k}\Omega$		1.1	10	mV
$\alpha_{VIO}$ Temperature coefficient of input offset voltage	$T_A = 25^\circ\text{C}$ to $70^\circ\text{C}$		1.7		$\mu\text{V}/^\circ\text{C}$
$I_{IO}$ Input offset current <sup>(1)</sup>	$V_O = 5\text{ V}$ , $V_{IC} = 5\text{ V}$		0.1		pA
$I_{IB}$ Input bias current <sup>(1)</sup>	$V_O = 5\text{ V}$ , $V_{IC} = 5\text{ V}$		0.6		pA
$V_{ICR}$ Common-mode input voltage range <sup>(2)</sup>		–0.2 to 9	–0.3 to 9.2		V
$V_{OH}$ High-level output voltage	$V_{ID} = 100\text{ mV}$ , $R_L = 100\text{ k}\Omega$	8	8.7		V
$V_{OL}$ Low-level output voltage	$V_{ID} = -100\text{ mV}$ , $I_{OL} = 0$		0	50	mV
$A_{VD}$ Large-signal differential voltage amplification	$V_O = 1\text{ V}$ to $6\text{ V}$ , $R_L = 100\text{ k}\Omega$	25	275		V/mV
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	65	94		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ )	$V_{DD} = 5\text{ V}$ to $10\text{ V}$ , $V_O = 1.4\text{ V}$	70	93		dB
$I_{DD}$ Supply current (four amplifiers)	$V_O = 5\text{ V}$ , No load $V_{IC} = 5\text{ V}$		570	1200	$\mu\text{A}$

(1) The typical values of input bias current and input offset current below 5 pA were determined mathematically.

(2) This range also applies to each input individually.

## OPERATING CHARACTERISTICS

at specified free-air temperature,  $V_{DD} = 5\text{ V}$ 

PARAMETER	TEST CONDITIONS	$T_A$	TLC27M4C TLC27M4AC TLC27M4BC TLC27M9C			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	$V_{IPP} = 1\text{ V}$	25°C	0.43		V/ $\mu$ s
			0°C	0.46		
			70°C	0.36		
	$V_{IPP} = 2.5\text{ V}$	25°C		0.40		
		0°C		0.43		
		70°C		0.34		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$ , See <a href="#">Figure 2</a>	$R_S = 20\text{ }\Omega$	25°C	32		nV/ $\sqrt{\text{Hz}}$
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , $R_L = 100\text{ k}\Omega$ , See <a href="#">Figure 1</a>	$C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	25°C	55		kHz
			0°C	60		
			70°C	50		
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , See <a href="#">Figure 3</a>	$C_L = 20\text{ pF}$	25°C	525		kHz
			0°C	610		
			70°C	400		
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 3</a>	$f = B_1$ , See <a href="#">Figure 3</a>	25°C	40°		
			0°C	41°		
			70°C	39°		

## OPERATING CHARACTERISTICS

at specified free-air temperature,  $V_{DD} = 10\text{ V}$ 

PARAMETER	TEST CONDITIONS	$T_A$	TLC27M4C TLC27M4AC TLC27M4BC TLC27M9C			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	$V_{IPP} = 1\text{ V}$	25°C	0.62		V/ $\mu$ s
			0°C	0.67		
			70°C	0.51		
	$V_{IPP} = 5.5\text{ V}$	25°C		0.56		
		0°C		0.61		
		70°C		0.46		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$ , See <a href="#">Figure 2</a>	$R_S = 20\text{ }\Omega$	25°C	32		nV/ $\sqrt{\text{Hz}}$
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , $R_L = 100\text{ k}\Omega$ , See <a href="#">Figure 1</a>	$C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	25°C	35		kHz
			0°C	40		
			70°C	30		
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , See <a href="#">Figure 3</a>	$C_L = 20\text{ pF}$	25°C	635		kHz
			0°C	710		
			70°C	510		
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 3</a>	$f = B_1$ , See <a href="#">Figure 3</a>	25°C	43°		
			0°C	44°		
			70°C	42°		

**OPERATING CHARACTERISTICS**at specified free-air temperature,  $V_{DD} = 5\text{ V}$ 

PARAMETER	TEST CONDITIONS	$T_A$	TLC27M4I TLC27M4AI TLC27M4BI TLC27M9I			UNIT
			MIN	TYP	MAX	
SR      Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	$V_{IPP} = 1\text{ V}$	25°C	0.43		V/ $\mu\text{s}$
			–40°C	0.51		
			85°C	0.35		
	$V_{IPP} = 2.5\text{ V}$	25°C		0.40		
		–40°C		0.48		
		85°C		0.32		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$ , See <a href="#">Figure 2</a>	$R_S = 20\text{ }\Omega$	25°C	32		nV/ $\sqrt{\text{Hz}}$
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , $R_L = 100\text{ k}\Omega$ , See <a href="#">Figure 1</a>	$C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	25°C	55		kHz
			–40°C	75		
			85°C	45		
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , See <a href="#">Figure 3</a>	$C_L = 20\text{ pF}$	25°C	525		kHz
			–40°C	770		
			85°C	370		
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 3</a>	$f = B_1$ , See <a href="#">Figure 3</a>	25°C	40°		
			–40°C	43°		
			85°C	38°		

**OPERATING CHARACTERISTICS**at specified free-air temperature,  $V_{DD} = 10\text{ V}$ 

PARAMETER	TEST CONDITIONS	$T_A$	TLC27M4I TLC27M4AI TLC27M4BI TLC27M9I			UNIT
			MIN	TYP	MAX	
SR      Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	$V_{IPP} = 1\text{ V}$	25°C	0.62		V/ $\mu\text{s}$
			–40°C	0.77		
			85°C	0.47		
	$V_{IPP} = 5.5\text{ V}$	25°C		0.56		
		–40°C		0.70		
		85°C		0.44		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$ , See <a href="#">Figure 2</a>	$R_S = 20\text{ }\Omega$	25°C	32		nV/ $\sqrt{\text{Hz}}$
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , $R_L = 100\text{ k}\Omega$ , See <a href="#">Figure 1</a>	$C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	25°C	35		kHz
			–40°C	45		
			85°C	25		
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , See <a href="#">Figure 3</a>	$C_L = 20\text{ pF}$	25°C	635		kHz
			–40°C	880		
			85°C	480		
$\phi_m$ Phase margin	$V_I = 10\text{ mV}$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 3</a>	$f = B_1$ , See <a href="#">Figure 3</a>	25°C	43°		
			–40°C	46°		
			85°C	41°		

## OPERATING CHARACTERISTICS

at specified free-air temperature,  $V_{DD} = 5\text{ V}$ 

PARAMETER	TEST CONDITIONS	$T_A$	TLC27M4M TLC27M9M			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	$V_{IPP} = 1\text{ V}$	25°C	0.43		V/ $\mu$ s
			–55°C	0.54		
			125°C	0.29		
	$V_{IPP} = 2.5\text{ V}$	25°C		0.40		
		–55°C		0.50		
		125°C		0.28		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$ , See <a href="#">Figure 2</a>	$R_S = 20\text{ }\Omega$	25°C	32		nV/ $\sqrt{\text{Hz}}$
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , $R_L = 100\text{ k}\Omega$ , See <a href="#">Figure 1</a>	$C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	25°C	56		kHz
			–55°C	80		
			125°C	40		
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , See <a href="#">Figure 3</a>	$C_L = 20\text{ pF}$	25°C	525		kHz
			–55°C	850		
			125°C	330		
$\Phi_m$ Phase margin	$V_I = 10\text{ mV}$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 3</a>	$f = B_1$ , See <a href="#">Figure 3</a>	25°C	40°		
			–55°C	44°		
			125°C	36°		

## OPERATING CHARACTERISTICS

at specified free-air temperature,  $V_{DD} = 10\text{ V}$ 

PARAMETER	TEST CONDITIONS	$T_A$	TLC27M4M TLC27M9M			UNIT
			MIN	TYP	MAX	
SR Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	$V_{IPP} = 1\text{ V}$	25°C	0.62		V/ $\mu$ s
			–55°C	0.81		
			125°C	0.38		
	$V_{IPP} = 5.5\text{ V}$	25°C		0.56		
		–55°C		0.73		
		125°C		0.35		
$V_n$ Equivalent input noise voltage	$f = 1\text{ kHz}$ , See <a href="#">Figure 2</a>	$R_S = 20\text{ }\Omega$	25°C	32		nV/ $\sqrt{\text{Hz}}$
$B_{OM}$ Maximum output-swing bandwidth	$V_O = V_{OH}$ , $R_L = 100\text{ k}\Omega$ , See <a href="#">Figure 1</a>	$C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	25°C	35		kHz
			–55°C	50		
			125°C	20		
$B_1$ Unity-gain bandwidth	$V_I = 10\text{ mV}$ , See <a href="#">Figure 3</a>	$C_L = 20\text{ pF}$	25°C	635		kHz
			–55°C	960		
			125°C	440		
$\Phi_m$ Phase margin	$V_I = 10\text{ mV}$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 3</a>	$f = B_1$ , See <a href="#">Figure 3</a>	25°C	43°		
			–55°C	47°		
			125°C	39°		

**OPERATING CHARACTERISTICS**at specified free-air temperature,  $V_{DD} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ 

PARAMETER		TEST CONDITIONS		TLC27M4Y			UNIT
				MIN	TYP	MAX	
SR	Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	$V_{IPP} = 1\text{ V}$		0.43		V/ $\mu\text{s}$
			$V_{IPP} = 2.5\text{ V}$		0.40		
$V_n$	Equivalent input noise voltage	$f = 1\text{ kHz}$ , See <a href="#">Figure 2</a>	$R_S = 20\text{ }\Omega$		32		nV/ $\sqrt{\text{Hz}}$
$B_{OM}$	Maximum output-swing bandwidth	$V_O = V_{OH}$ , $R_L = 100\text{ k}\Omega$ ,	$C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>		55		kHz
$B_1$	Unity-gain bandwidth	$V_I = 10\text{ mV}$ , See <a href="#">Figure 3</a>	$C_L = 20\text{ pF}$		525		kHz
$\phi_m$	Phase margin	$V_I = 10\text{ mV}$ , $C_L = 20\text{ pF}$ ,	$f = B_1$ , See <a href="#">Figure 3</a>		40°		

**OPERATING CHARACTERISTICS**at specified free-air temperature,  $V_{DD} = 10\text{ V}$ ,  $T_A = 25^\circ\text{C}$ 

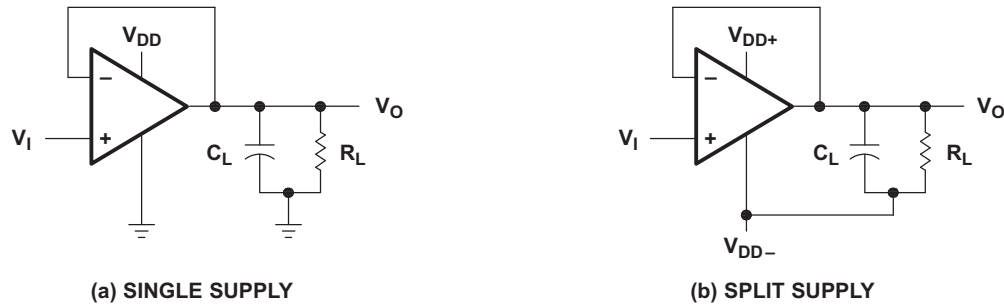
PARAMETER		TEST CONDITIONS		TLC27M4Y			UNIT
				MIN	TYP	MAX	
SR	Slew rate at unity gain	$R_L = 100\text{ k}\Omega$ , $C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>	$V_{IPP} = 1\text{ V}$		0.62		V/ $\mu\text{s}$
			$V_{IPP} = 5.5\text{ V}$		0.56		
$V_n$	Equivalent input noise voltage	$f = 1\text{ kHz}$ , See <a href="#">Figure 2</a>	$R_S = 20\text{ }\Omega$		32		nV/ $\sqrt{\text{Hz}}$
$B_{OM}$	Maximum output-swing bandwidth	$V_O = V_{OH}$ , $R_L = 100\text{ k}\Omega$ ,	$C_L = 20\text{ pF}$ , See <a href="#">Figure 1</a>		35		kHz
$B_1$	Unity-gain bandwidth	$V_I = 10\text{ mV}$ , See <a href="#">Figure 3</a>	$C_L = 20\text{ pF}$		635		kHz
$\phi_m$	Phase margin	$V_I = 10\text{ mV}$ , $C_L = 20\text{ pF}$ ,	$f = B_1$ , See <a href="#">Figure 3</a>		43°		



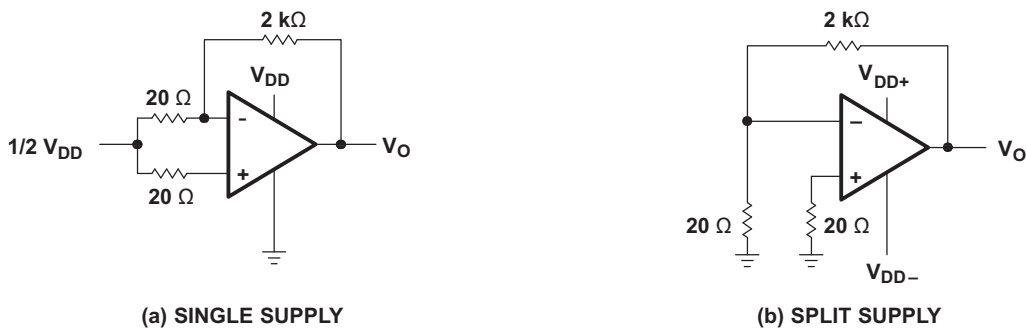
## PARAMETER MEASUREMENT INFORMATION

### Single-Supply versus Split-Supply Test Circuits

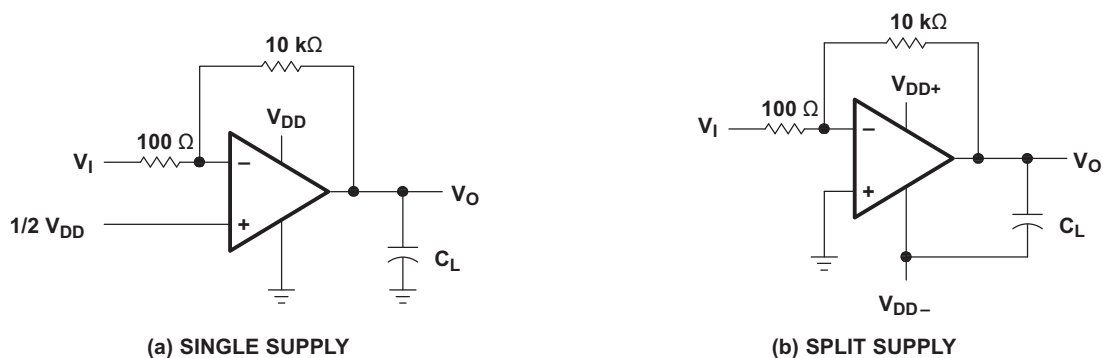
Because the TLC27M4 and TLC27M9 are optimized for single-supply operation, circuit configurations used for the various tests often present some inconvenience since the input signal, in many cases, must be offset from ground. This inconvenience can be avoided by testing the device with split supplies 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**

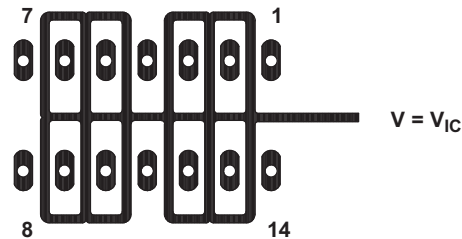
## PARAMETER MEASUREMENT INFORMATION (continued)

### Input Bias Current

Because of the high input impedance of the TLC27M4 and TLC27M9 operational amplifiers, attempts to measure the input bias current can result in erroneous readings. The bias current at normal room ambient temperature is typically less than 1 pA, a value that is easily exceeded by leakages on the test socket. Two suggestions are offered to avoid erroneous measurements:

1. Isolate the device from other potential leakage sources. Use a grounded shield around and between the device inputs (see [Figure 4](#)). Leakages that would otherwise flow to the inputs are shunted away.
2. Compensate for the leakage of the test socket by actually performing an input bias current test (using a picoammeter) with no device in the test socket. The actual input bias current can then be calculated by subtracting the open-socket leakage readings from the readings obtained with a device in the test socket.

One word of caution—many automatic testers as well as some bench-top operational amplifier testers use the servo-loop technique with a resistor in series with the device input to measure the input bias current; the voltage drop across the series resistor is measured and the bias current is calculated. This method requires that a device be inserted into the test socket to obtain a correct reading; therefore, an open-socket reading is not feasible using this method.



**Figure 4. Isolation Metal Around Device Inputs  
(J and N packages)**

### Low-Level Output Voltage

To obtain low-supply-voltage operation, some compromise was necessary in the input stage. This compromise results in the device low-level output being dependent on both the common-mode input voltage level as well as the differential input voltage level. When attempting to correlate low-level output readings with those quoted in the electrical specifications, these two conditions should be observed. If conditions other than these are to be used, please refer to [Figure 14](#) through [Figure 19](#) in the *Typical Characteristics* of this data sheet.

### Input Offset Voltage Temperature Coefficient

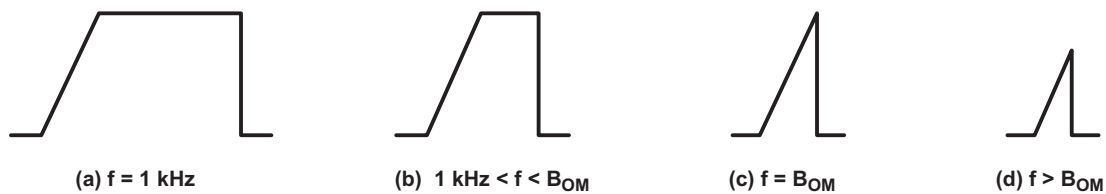
Erroneous readings often result from attempts to measure temperature coefficient of input offset voltage. This parameter is actually a calculation using input offset voltage measurements obtained at two different temperatures. When one (or both) of the temperatures is below freezing, moisture can collect on both the device and the test socket. This moisture results in leakage and contact resistance, which can cause erroneous input offset voltage readings. The isolation techniques previously mentioned have no effect on the leakage since the moisture also covers the isolation metal itself, thereby rendering it useless. It is suggested that these measurements be performed at temperatures above freezing to minimize error.

## PARAMETER MEASUREMENT INFORMATION (continued)

### Full-Power Response

Full-power response, the frequency above which the operational amplifier slew rate limits the output voltage swing, is often specified two ways: full-linear response and full-peak response. The full-linear response is generally measured by monitoring the distortion level of the output, while increasing the frequency of a sinusoidal input signal until the maximum frequency is found above which the output contains significant distortion. The full-peak response is defined as the maximum output frequency, without regard to distortion, above which full peak-to-peak output swing cannot be maintained.

Because there is no industry-wide accepted value for significant distortion, the full-peak response is specified in this data sheet and is measured using the circuit of [Figure 1](#). The initial setup involves the use of a sinusoidal input to determine the maximum peak-to-peak output of the device (the amplitude of the sinusoidal wave is increased until clipping occurs). The sinusoidal wave is then replaced with a square wave of the same amplitude. The frequency is then increased until the maximum peak-to-peak output can no longer be maintained ([Figure 5](#)). A square wave is used to allow a more accurate determination of the point at which the maximum peak-to-peak output is reached.



**Figure 5. Full-Power-Response Output Signal**

### Test Time

Inadequate test time is a frequent problem, especially when testing CMOS devices in a high-volume, short-test-time environment. Internal capacitances are inherently higher in CMOS than in bipolar and BiFET devices and require longer test times than their bipolar and BiFET counterparts. The problem becomes more pronounced with reduced supply levels and lower temperatures.

**TYPICAL CHARACTERISTICS****Table of Graphs**

			<b>FIGURE</b>
$V_{IO}$	Input offset voltage	Distribution	6, 7
$\alpha_{VIO}$	Temperature coefficient of input offset voltage	Distribution	8, 9
$V_{OH}$	High-level output voltage	vs High-level output current vs Supply voltage vs Free-air temperature	10, 11 12 13
$V_{OL}$	Low-level output voltage	vs Common-mode input voltage vs Differential input voltage vs Free-air temperature vs Low-level output current	14, 15 16 17 18, 19
$A_{VD}$	Differential voltage amplification	vs Supply voltage vs Free-air temperature Free vs Frequency	20 21 32, 33
$I_{IB}$	Input bias current	vs Free-air temperature	22
$I_{IO}$	Input offset current	vs Free-air temperature	22
$V_{IC}$	Common-mode input voltage	vs Supply voltage	23
$I_{DD}$	Supply current	vs Supply voltage vs Free-air temperature	24 25
$SR$	Slew rate	vs Supply voltage vs Free-air temperature	26 27
	Normalized slew rate	vs Free-air temperature	28
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	29
$B_1$	Unity gain bandwidth	vs Free-air temperature Free vs Supply voltage	30 31
	Phase shift	vs Frequency	32, 33
$\phi_m$	Phase margin	vs Supply voltage vs Free-air temperature Free vs Load capacitance	34 35 36
$V_n$	Equivalent input noise voltage	vs Frequency	37

## TYPICAL CHARACTERISTICS

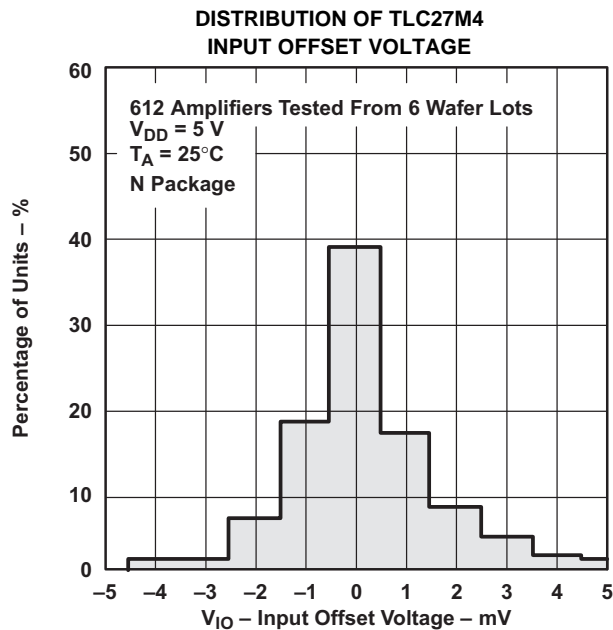


Figure 6.

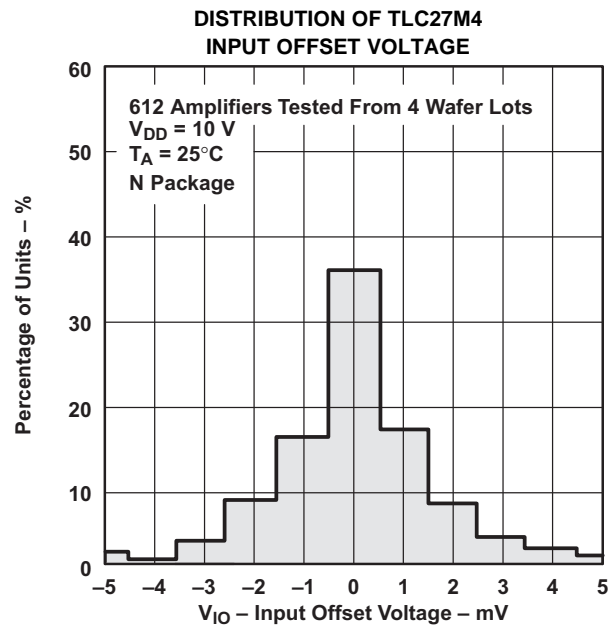


Figure 7.

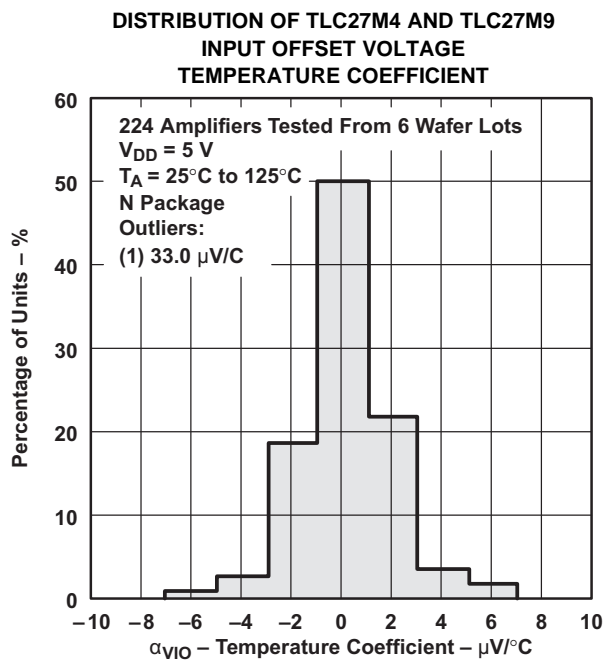


Figure 8.

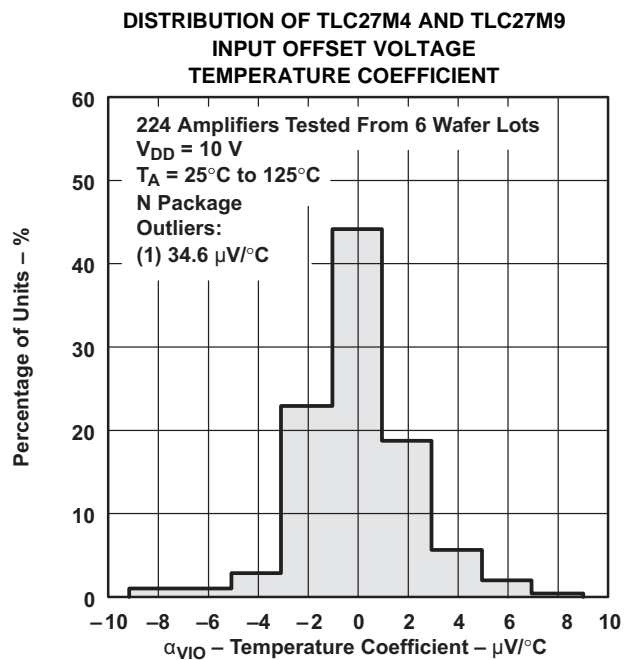


Figure 9.

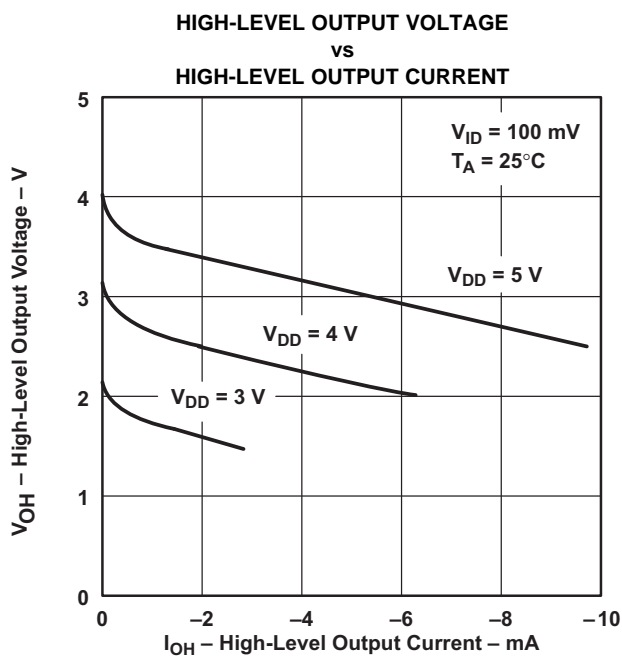
**TYPICAL CHARACTERISTICS** <sup>(1)</sup>

Figure 10.

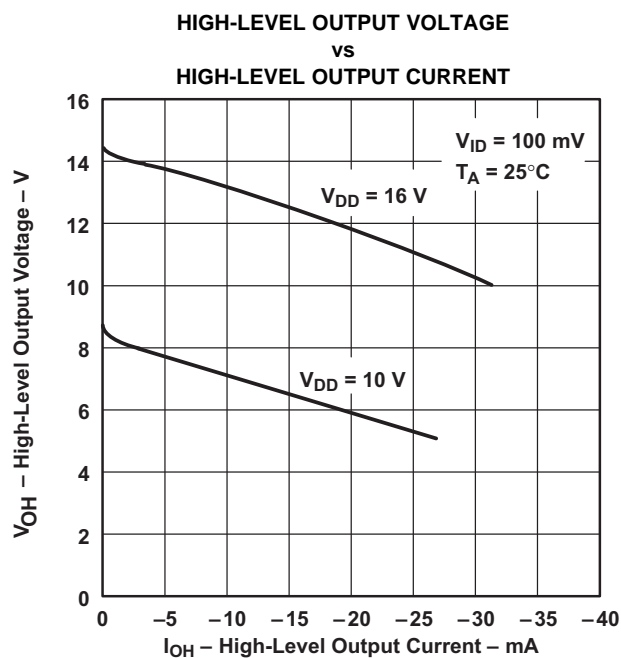


Figure 11.

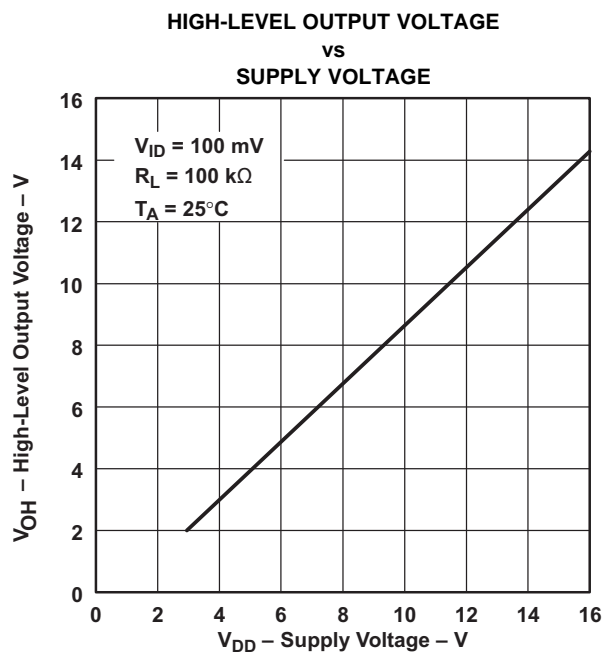


Figure 12.

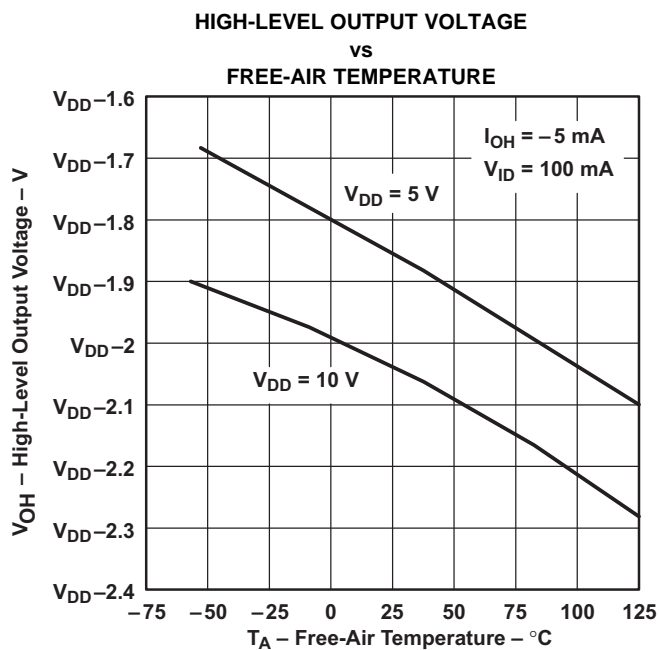


Figure 13.

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

# TYPICAL CHARACTERISTICS <sup>(1)</sup>

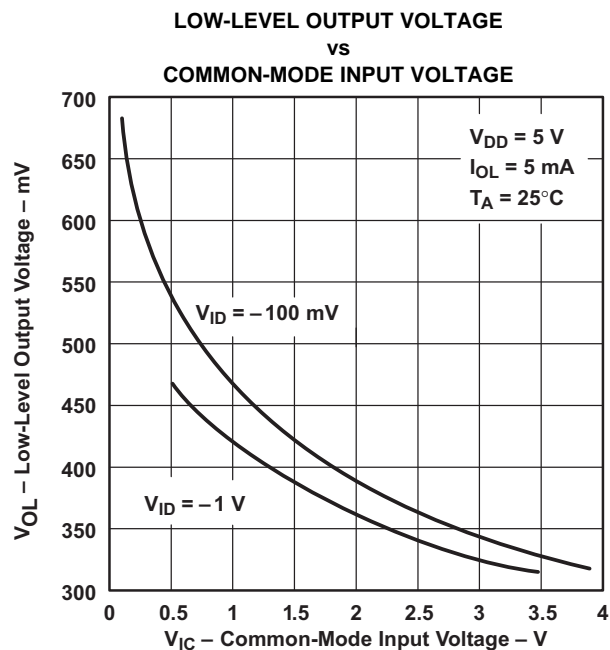


Figure 14.

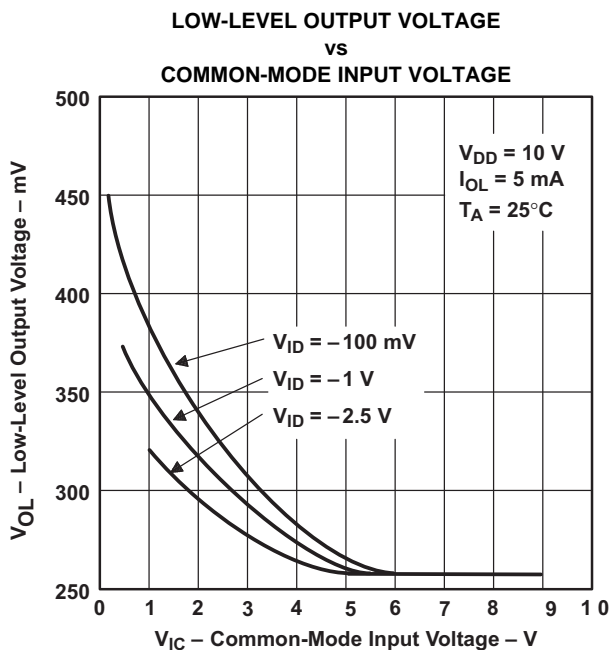


Figure 15.

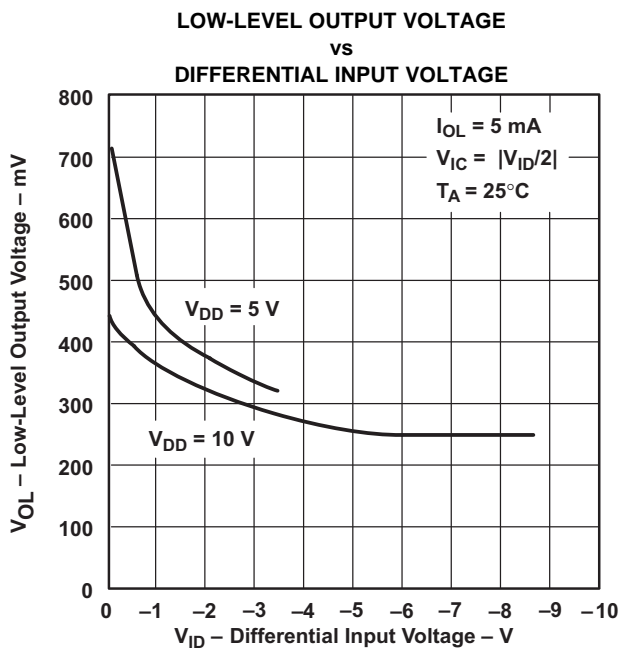


Figure 16.

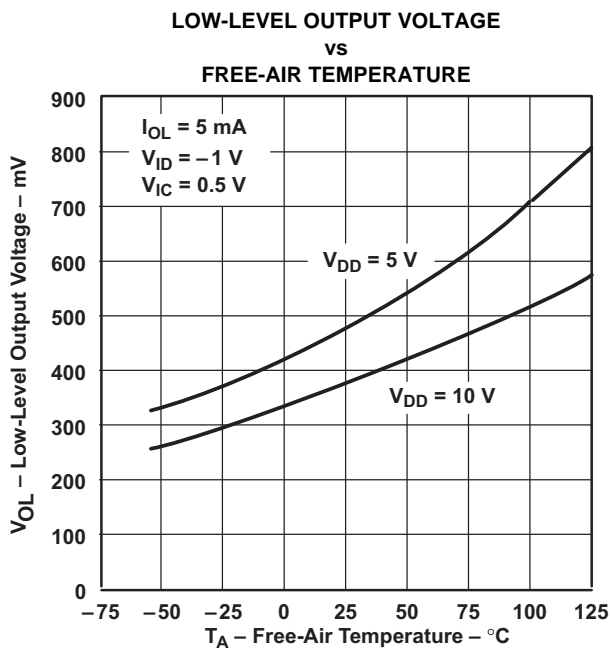


Figure 17.

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

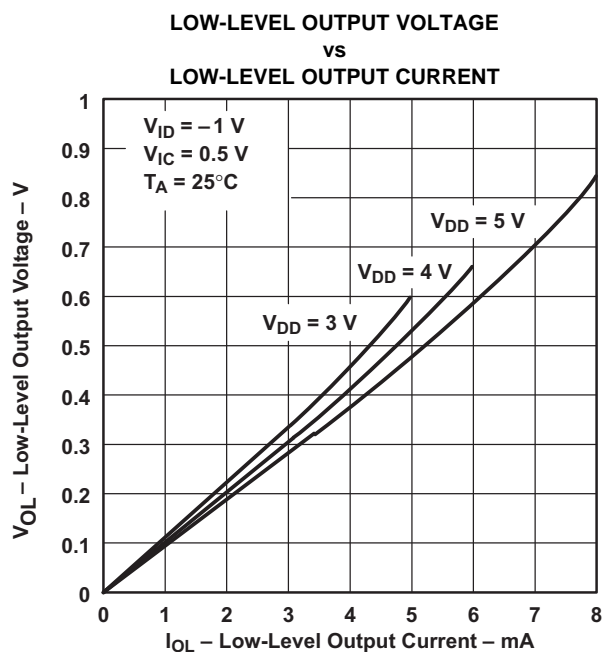
**TYPICAL CHARACTERISTICS** <sup>(1)</sup>

Figure 18.

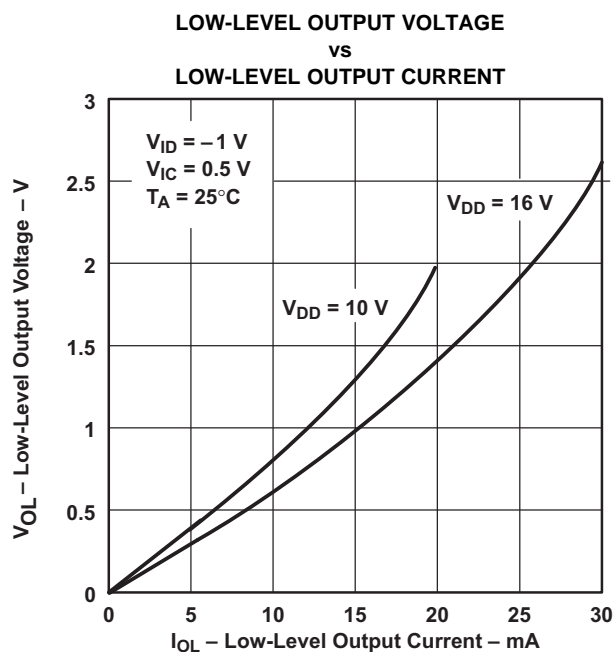


Figure 19.

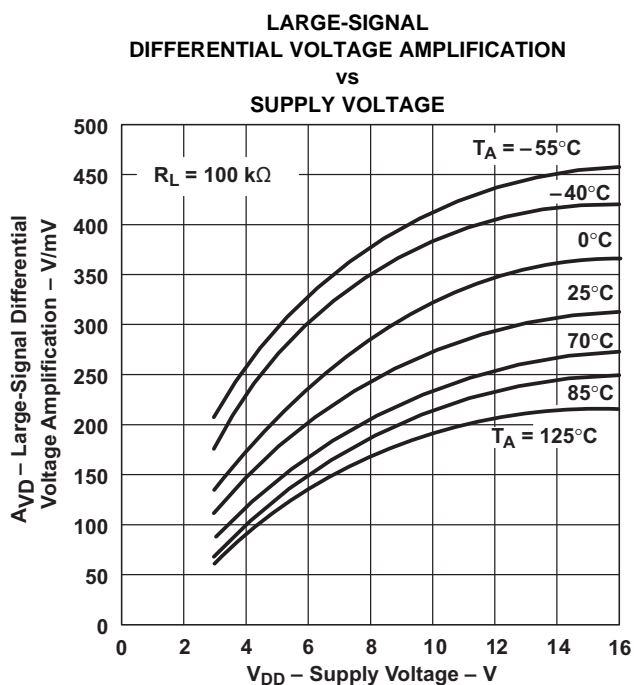


Figure 20.

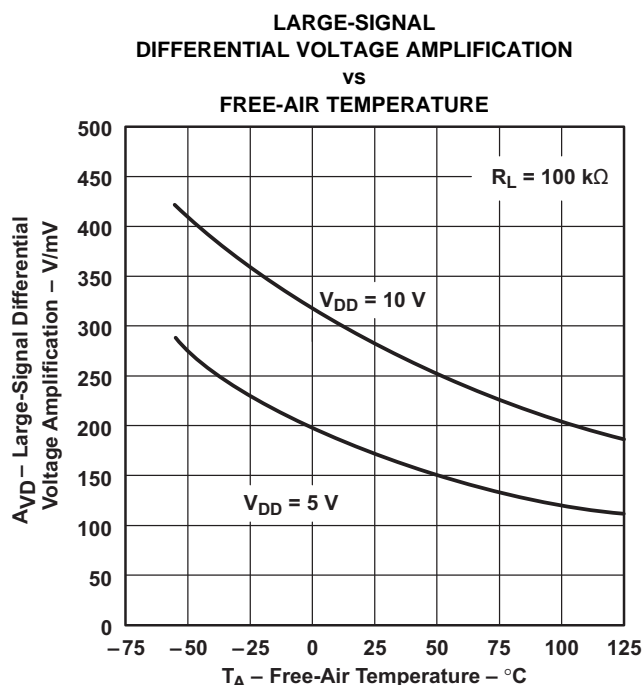


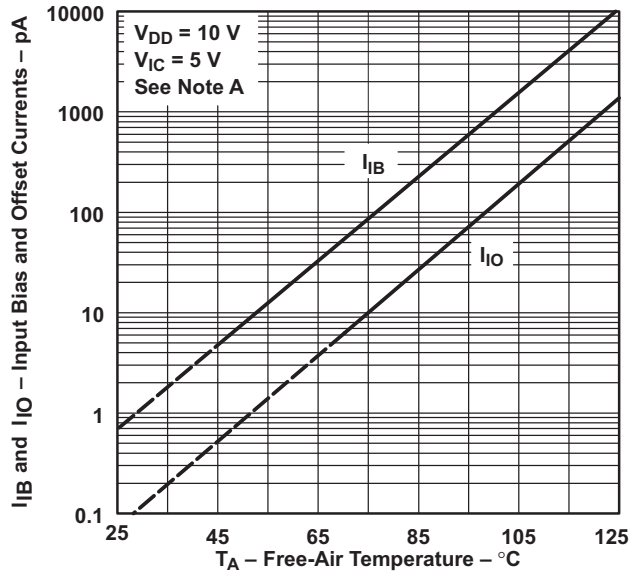
Figure 21.

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



## TYPICAL CHARACTERISTICS <sup>(1)</sup>

INPUT BIAS CURRENT AND INPUT OFFSET CURRENT  
vs  
FREE-AIR TEMPERATURE



NOTE A: The typical values of input bias current and input offset current below 5 pA were determined mathematically.

Figure 22.

COMMON-MODE  
INPUT VOLTAGE POSITIVE LIMIT  
vs  
SUPPLY VOLTAGE

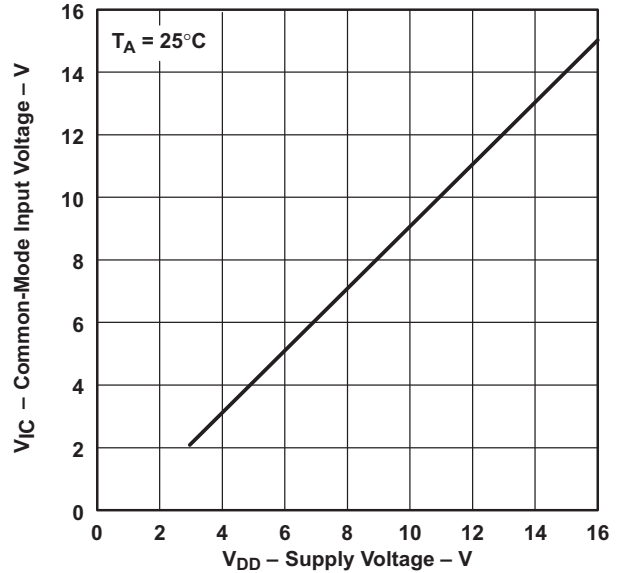


Figure 23.

SUPPLY CURRENT  
vs  
SUPPLY VOLTAGE

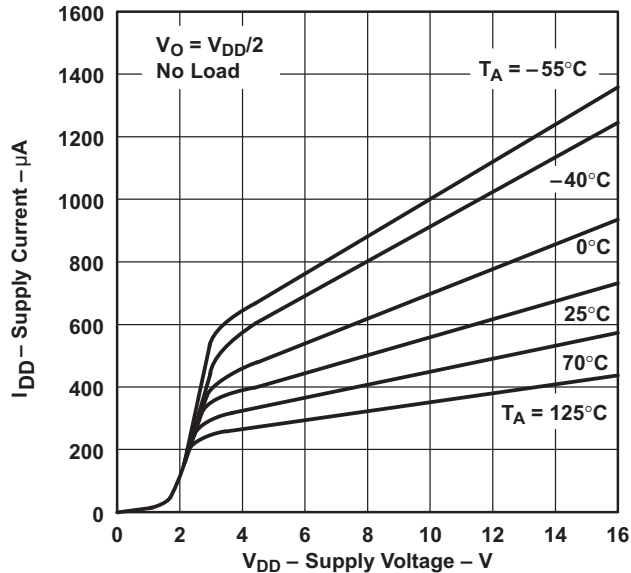


Figure 24.

SUPPLY CURRENT  
vs  
FREE-AIR TEMPERATURE

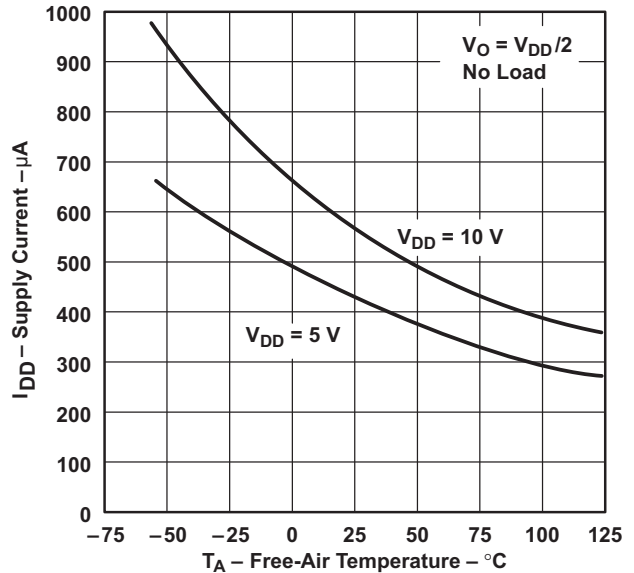


Figure 25.

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

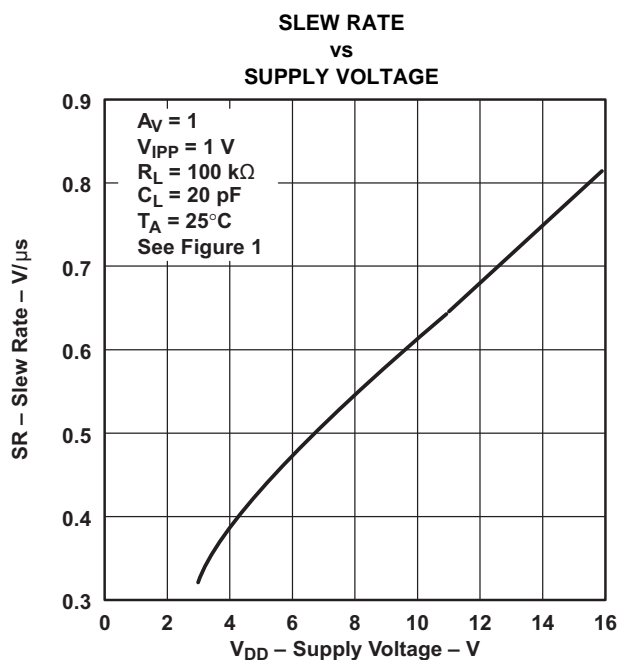
TYPICAL CHARACTERISTICS <sup>(1)</sup>

Figure 26.

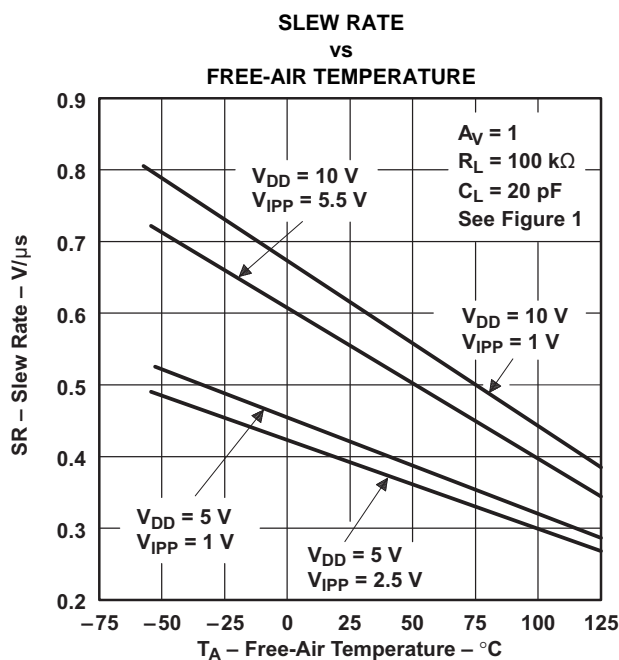


Figure 27.

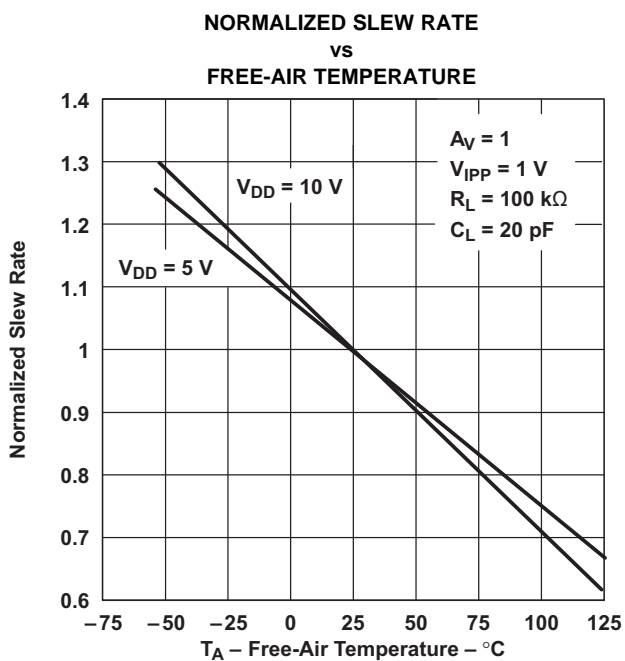


Figure 28.

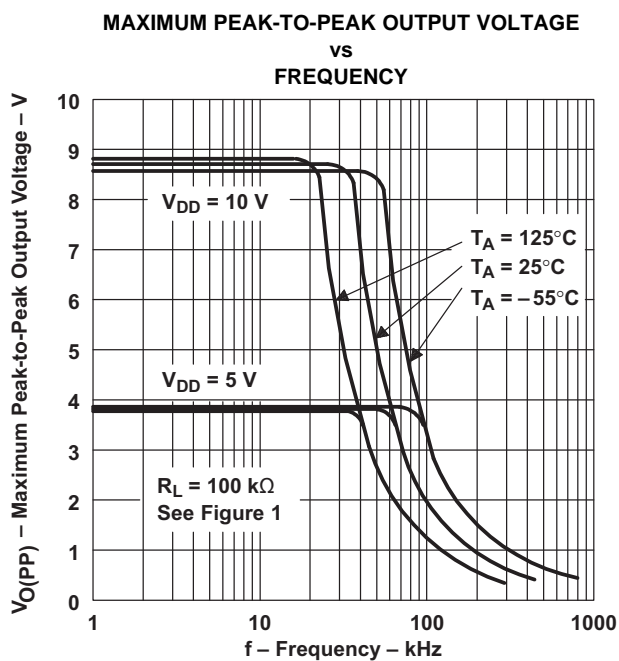


Figure 29.

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

## TYPICAL CHARACTERISTICS <sup>(1)</sup>

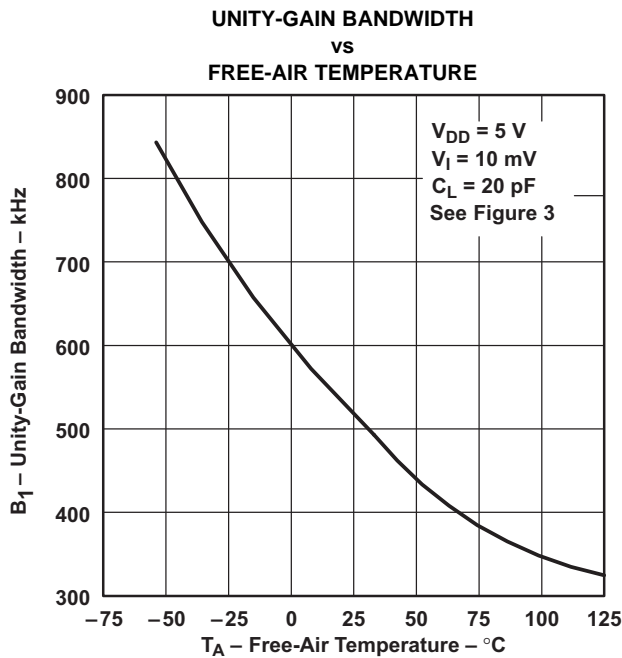


Figure 30.

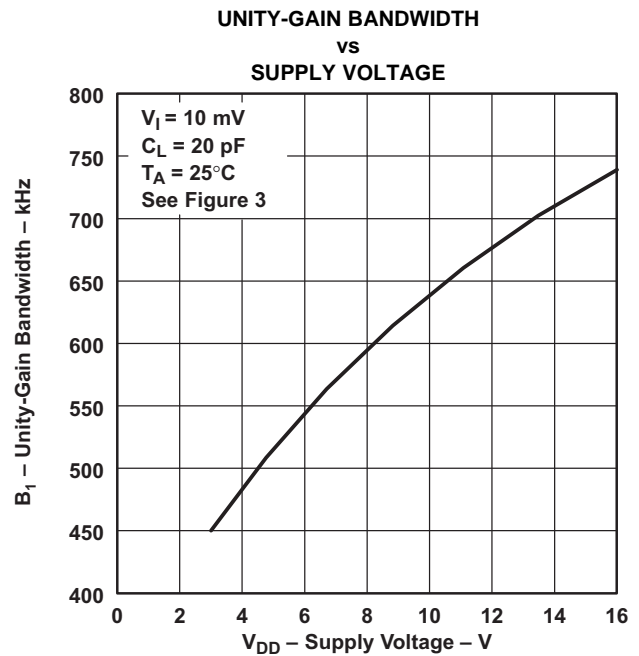


Figure 31.

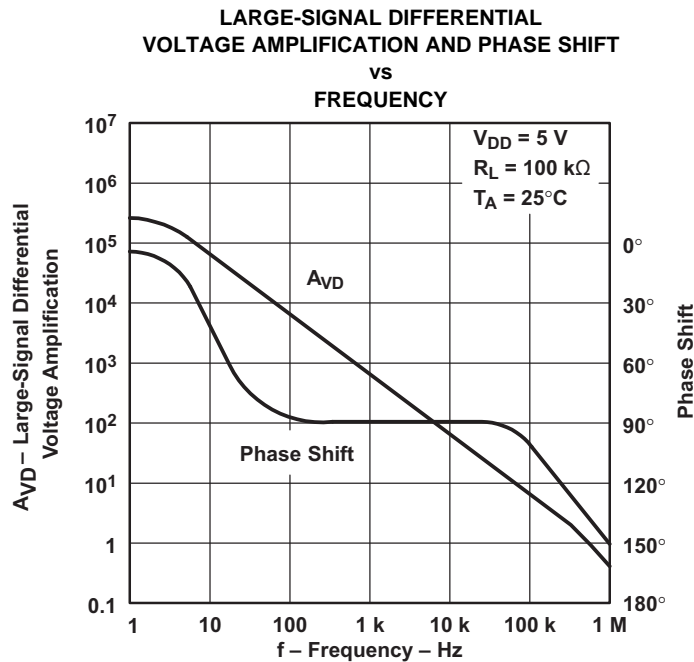


Figure 32.

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

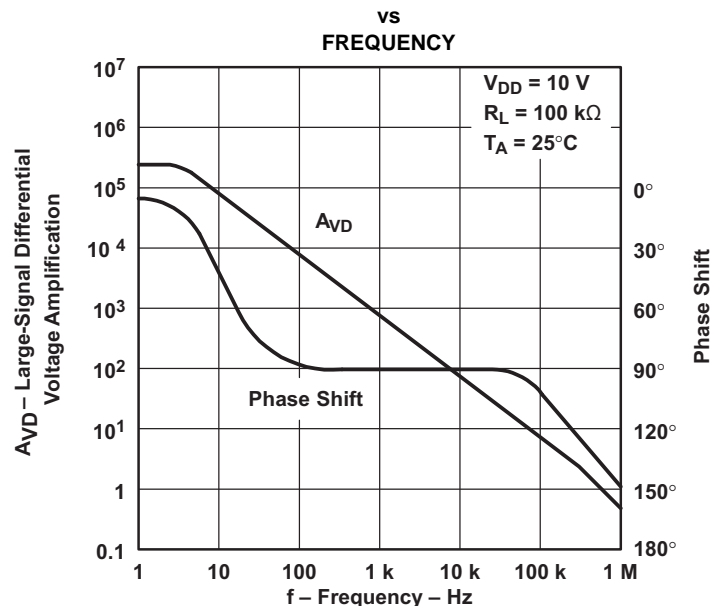
**TYPICAL CHARACTERISTICS <sup>(1)</sup>****LARGE-SIGNAL DIFFERENTIAL VOLTAGE  
AMPLIFICATION AND PHASE SHIFT**

Figure 33.

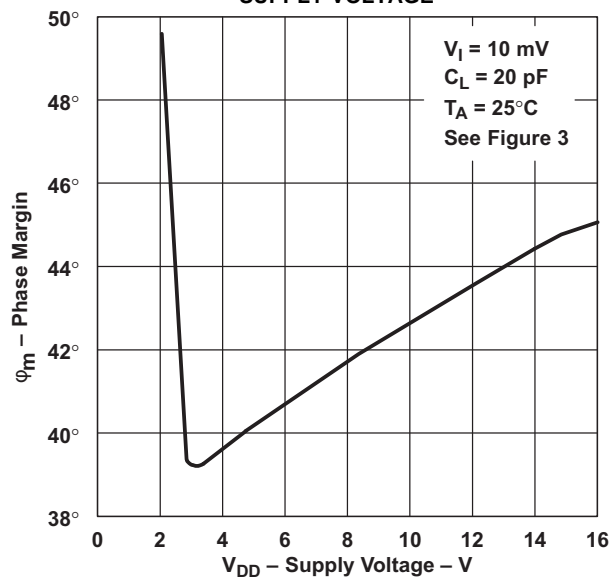
**PHASE MARGIN  
vs  
SUPPLY VOLTAGE**

Figure 34.

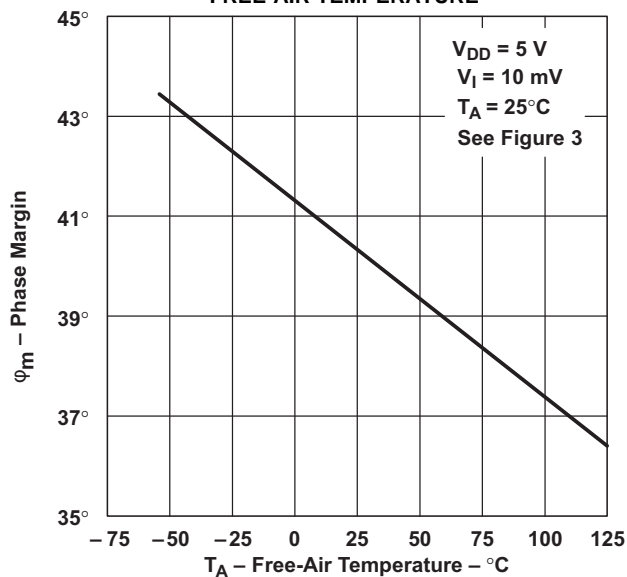
**PHASE MARGIN  
vs  
FREE-AIR TEMPERATURE**

Figure 35.

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

## TYPICAL CHARACTERISTICS

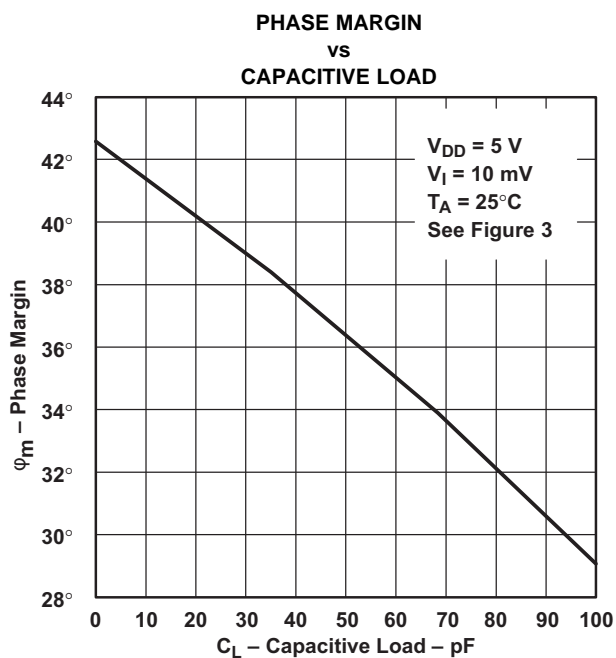


Figure 36.

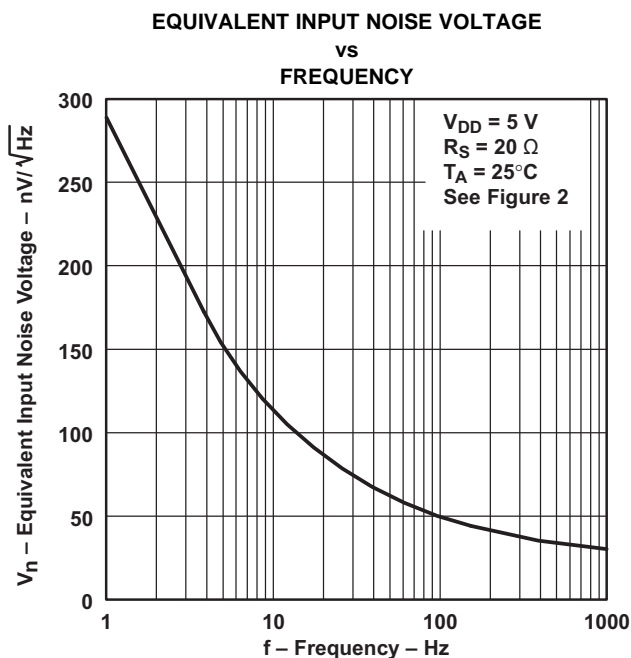


Figure 37.

## APPLICATION INFORMATION

### Single-Supply Operation

While the TLC27M4 and TLC27M9 perform well using dual power supplies (also called balanced or split supplies), the design is optimized for single-supply operation. This design includes an input common-mode voltage range that encompasses ground as well as an output voltage range that pulls down to ground. The supply voltage range extends down to 3 V (C-suffix types), thus allowing operation with supply levels commonly available for TTL and HCMOS; however, for maximum dynamic range, 16-V single-supply operation is recommended.

Many single-supply applications require that a voltage be applied to one input to establish a reference level that is above ground. A resistive voltage divider is usually sufficient to establish this reference level (see Figure 38). The low input bias current of the TLC27M4 and TLC27M9 permits the use of very large resistive values to implement the voltage divider, thus minimizing power consumption.

The TLC27M4 and TLC27M9 work well in conjunction with digital logic; however, when powering both linear devices and digital logic from the same power supply, the following precautions are recommended:

1. Power the linear devices from separate bypassed supply lines (see Figure 39); otherwise, the linear device supply rails can fluctuate due to voltage drops caused by high switching currents in the digital logic.
2. Use proper bypass techniques to reduce the probability of noise-induced errors. Single capacitive decoupling is often adequate; however, high-frequency applications may require RC decoupling.

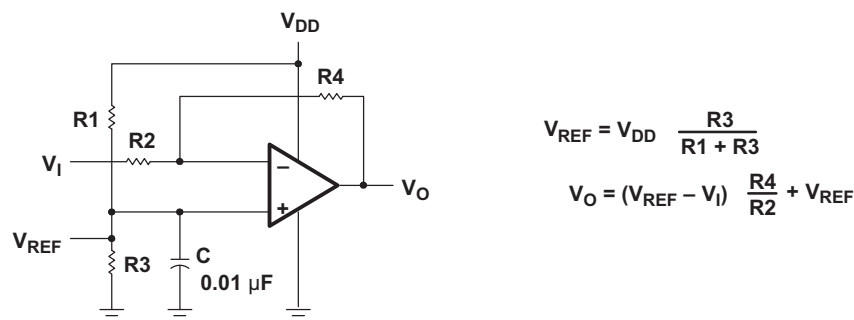


Figure 38. Inverting Amplifier With Voltage Reference

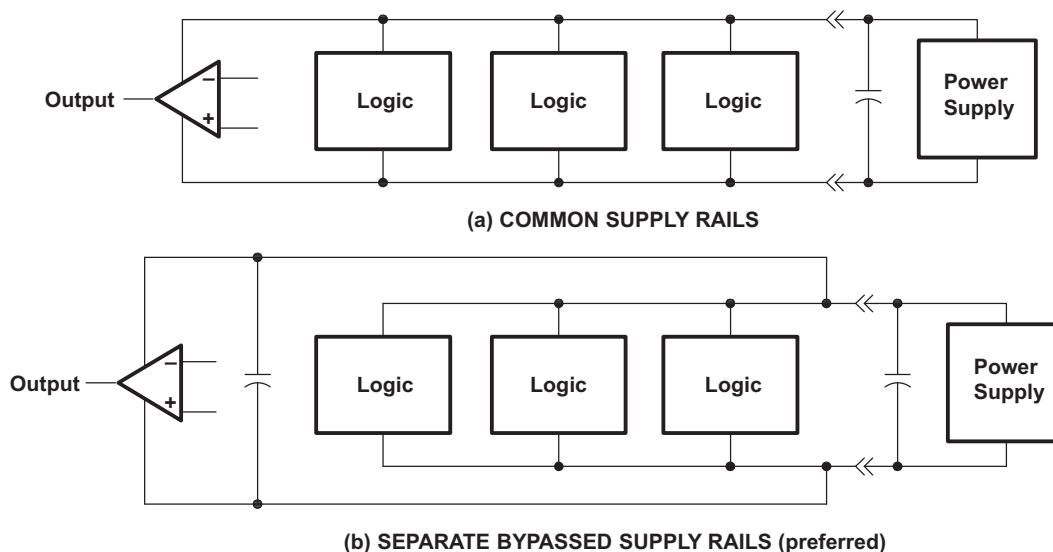


Figure 39. Common Versus Separate Supply Rails

## Input Characteristics

The TLC27M4 and TLC27M9 are specified with a minimum and a maximum input voltage that, if exceeded at either input, could cause the device to malfunction. Exceeding this specified range is a common problem, especially in single-supply operation. Note that the lower range limit includes the negative rail, while the upper range limit is specified at  $V_{DD} - 1$  V at  $T_A = 25^\circ\text{C}$  and at  $V_{DD} - 1.5$  V at all other temperatures.

The use of the polysilicon-gate process and the careful input circuit design gives the TLC27M4 and TLC27M9 very good input offset voltage drift characteristics relative to conventional metal-gate processes. Offset voltage drift in CMOS devices is highly influenced by threshold voltage shifts caused by polarization of the phosphorus dopant implanted in the oxide. Placing the phosphorus dopant in a conductor (such as a polysilicon gate) alleviates the polarization problem, thus reducing threshold voltage shifts by more than an order of magnitude. The offset voltage drift with time has been calculated to be typically 0.1  $\mu\text{V}/\text{month}$ , including the first month of operation.

Because of the extremely high input impedance and resulting low bias current requirements, the TLC27M4 and TLC27M9 are well suited for low-level signal processing; however, leakage currents on printed-circuit boards and sockets can easily exceed bias current requirements and cause a degradation in device performance. It is good practice to include guard rings around inputs (similar to those of [Figure 4](#) in the *Parameter Measurement Information* section). These guards should be driven from a low-impedance source at the same voltage level as the common-mode input (see [Figure 40](#)).

Unused amplifiers should be connected as unity-gain followers to avoid possible oscillation.

## Noise Performance

The noise specifications in operational amplifier circuits are greatly dependent on the current in the first-stage differential amplifier. The low input bias current requirements of the TLC27M4 and TLC27M9 result in a very low noise current, which is insignificant in most applications. This feature makes the devices especially favorable over bipolar devices when using values of circuit impedance greater than 50 k $\Omega$ , since bipolar devices exhibit greater noise currents.

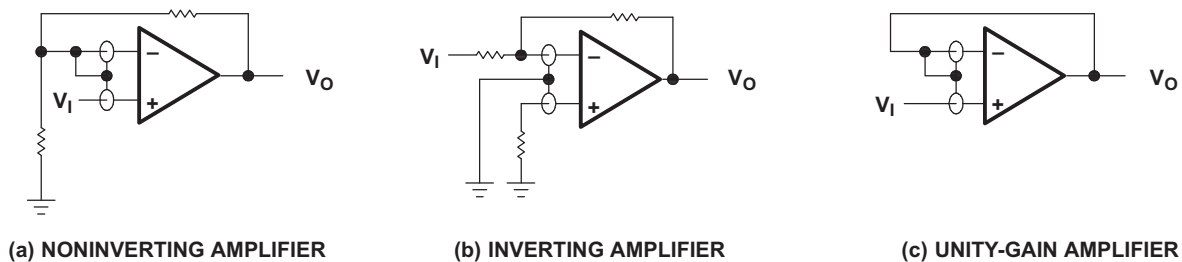
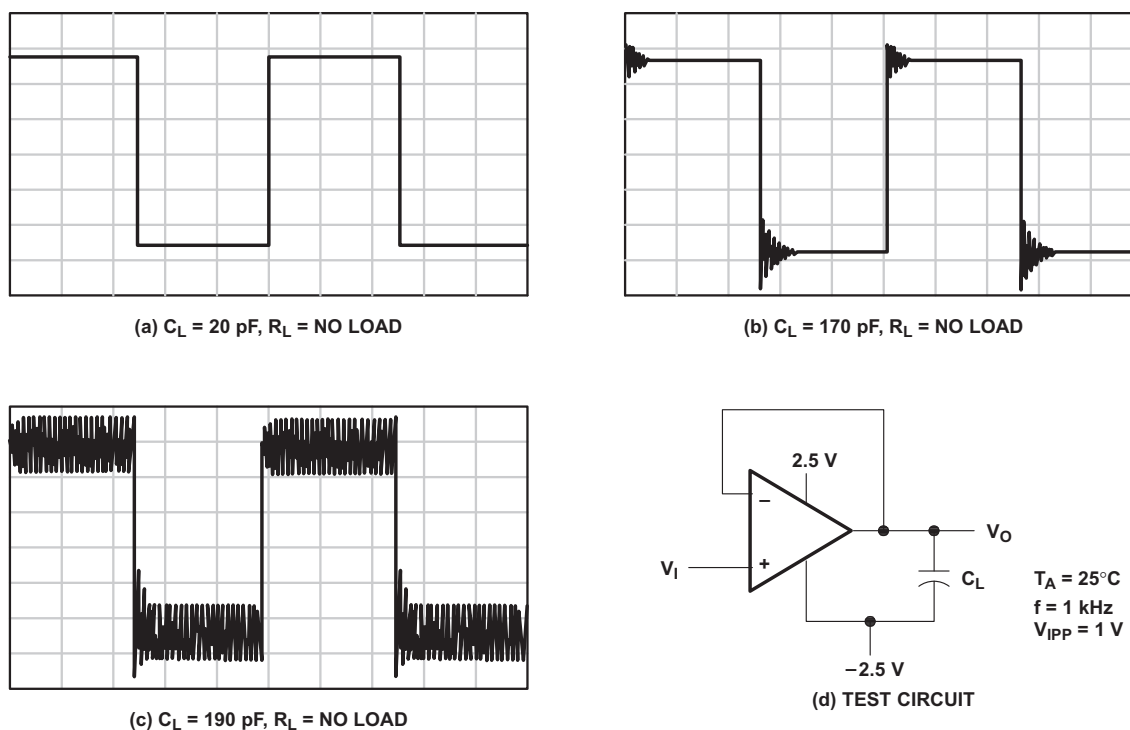


Figure 40. Guard-Ring Schemes

## Output Characteristics

The output stage of the TLC27M4 and TLC27M9 is designed to sink and source relatively high amounts of current (see *typical characteristics*). If the output is subjected to a short-circuit condition, this high current capability can cause device damage under certain conditions. Output current capability increases with supply voltage.

All operating characteristics of the TLC27M4 and TLC27M9 were measured using a 20-pF load. The devices drive higher capacitive loads; however, as output load capacitance increases, the resulting response pole occurs at lower frequencies, thereby causing ringing, peaking, or even oscillation (see [Figure 41](#)). In many cases, adding a small amount of resistance in series with the load capacitance alleviates the problem.



**Figure 41. Effect of Capacitive Loads and Test Circuit**

Although the TLC27M4 and TLC27M9 possess excellent high-level output voltage and current capability, methods for boosting this capability are available, if needed. The simplest method involves the use of a pullup resistor ( $R_P$ ) connected from the output to the positive supply rail (see [Figure 42](#)). There are two disadvantages to the use of this circuit. First, the NMOS pulldown transistor N4 (see equivalent schematic) must sink a comparatively large amount of current. In this circuit, N4 behaves like a linear resistor with an on-resistance between approximately  $60 \Omega$  and  $180 \Omega$ , depending on how hard the operational amplifier input is driven. With very low values of  $R_P$ , a voltage offset from 0 V at the output occurs. Second, pullup resistor  $R_P$  acts as a drain load to N4 and the gain of the operational amplifier is reduced at output voltage levels where N5 is not supplying the output current.



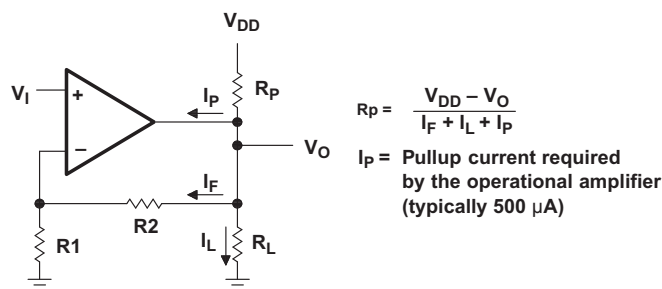


Figure 42. Resistive Pullup to Increase  $V_{OH}$

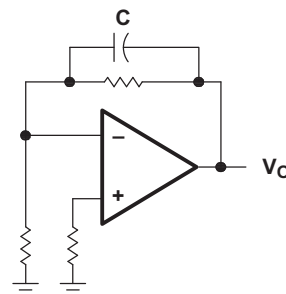


Figure 43. Compensation for Input Capacitance

## Feedback

Operational amplifier circuits nearly always employ feedback, and since feedback is the first prerequisite for oscillation, some caution is appropriate. Most oscillation problems result from driving capacitive loads (discussed previously) and ignoring stray input capacitance. A small-value capacitor connected in parallel with the feedback resistor is an effective remedy (see Figure 43). The value of this capacitor is optimized empirically.

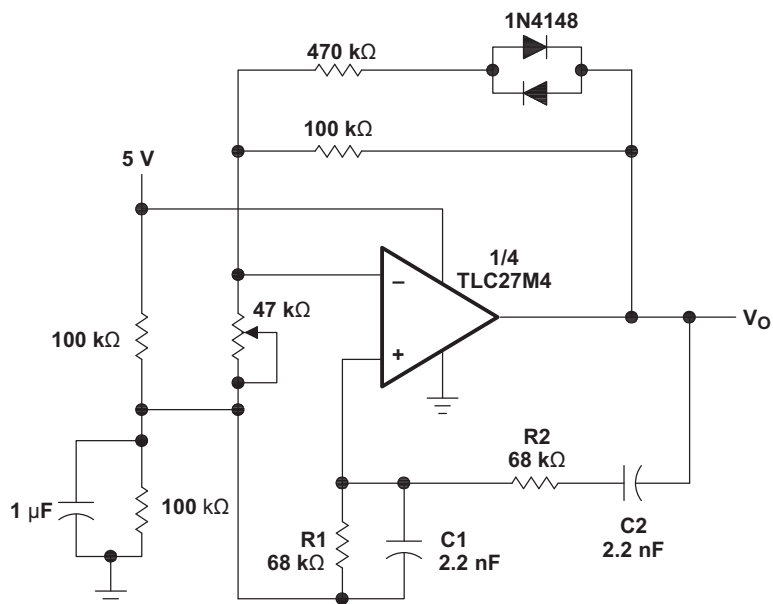
## Electrostatic Discharge Protection

The TLC27M4 and TLC27M9 incorporate an internal electrostatic discharge (ESD) protection circuit that prevents functional failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015.2. Care should be exercised, however, when handling these devices, as exposure to ESD may result in the degradation of the device parametric performance. The protection circuit also causes the input bias currents to be temperature-dependent and have the characteristics of a reverse-biased diode.

## Latch-Up

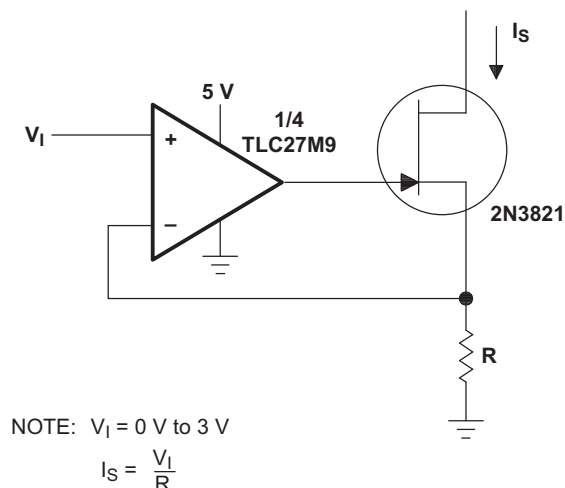
Because CMOS devices are susceptible to latch-up due to their inherent parasitic thyristors, the TLC27M4 and TLC27M9 inputs and outputs were designed to withstand —100-mA surge currents without sustaining latch-up; however, techniques should be used to reduce the chance of latch-up whenever possible. Internal protection diodes should not, by design, be forward biased. Applied input and output voltage should not exceed the supply voltage by more than 300 mV. Care should be exercised when using capacitive coupling on pulse generators. Supply transients should be shunted by the use of decoupling capacitors (0.1  $\mu$ F typical) located across the supply rails as close to the device as possible.

The current path established if latch-up occurs is usually between the positive supply rail and ground; it can be triggered by surges on the supply lines and/or voltages on either the output or inputs that exceed the supply voltage. Once latch-up occurs, the current flow is limited only by the impedance of the power supply and the forward resistance of the parasitic thyristor and usually results in the destruction of the device. The chance of latch-up occurring increases with increasing temperature and supply voltages.

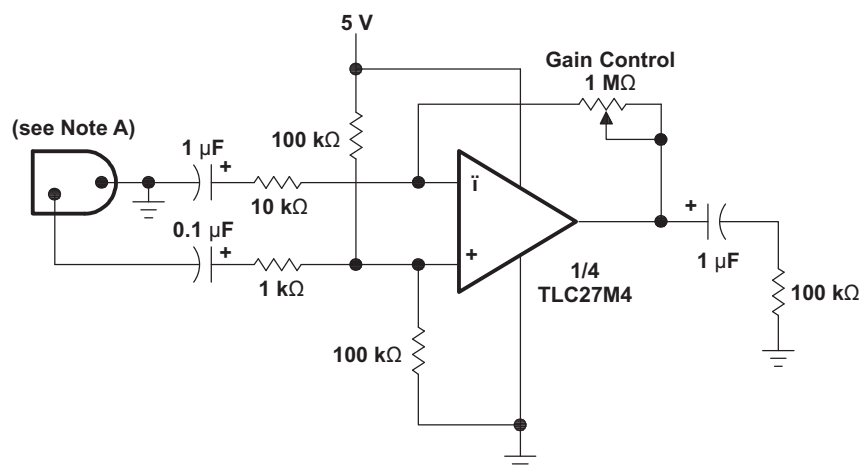
NOTE:  $V_{OPP} \approx 2\text{ V}$ 

$$f_o = \frac{1}{2\pi \sqrt{R_1 R_2 C_1 C_2}}$$

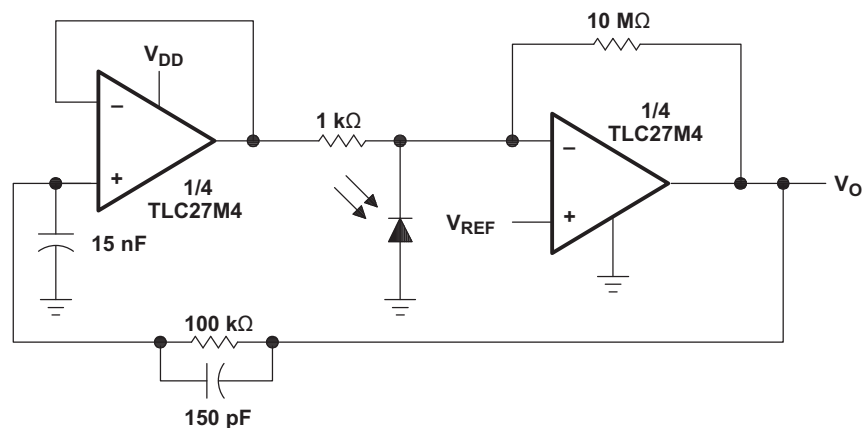
**Figure 44. Wien Oscillator**



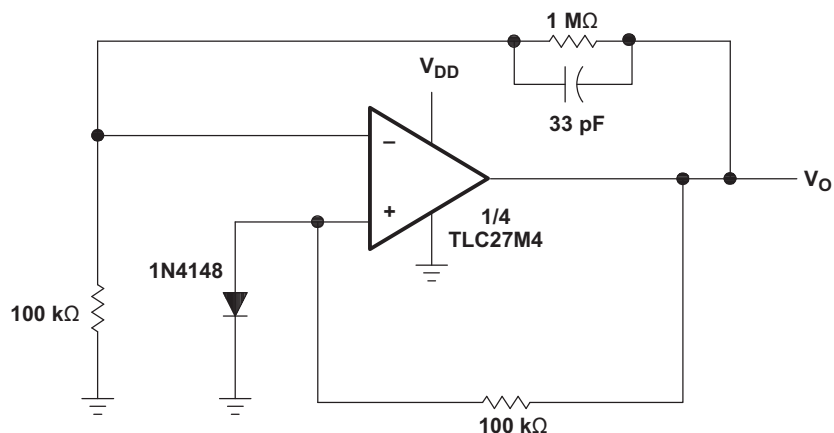
**Figure 45. Precision Low-Current Sink**



**Figure 46. Microphone Preamplifier**



**Figure 47. Photo-Diode Amplifier With Ambient Light Rejection**



NOTE:  $V_{DD} = 8\text{ V to }16\text{ V}$   
 $V_O = 5\text{ V, }10\text{ mA}$

Figure 48. Low-Power Voltage Regulator

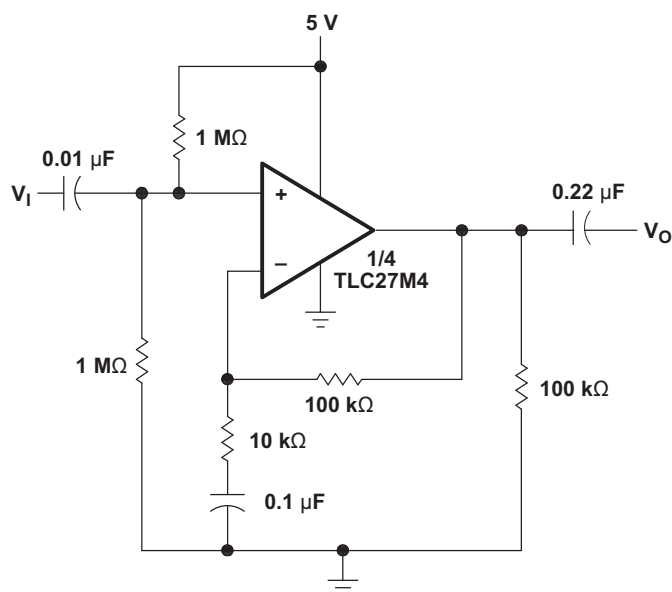


Figure 49. Single-Rail AC Amplifier

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-90604042A	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI	-55 to 125		
TLC27M4ACD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	27M4AC	<a href="#">Samples</a>
TLC27M4ACDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	27M4AC	<a href="#">Samples</a>
TLC27M4ACDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	27M4AC	<a href="#">Samples</a>
TLC27M4ACDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	27M4AC	<a href="#">Samples</a>
TLC27M4ACN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC27M4ACN	<a href="#">Samples</a>
TLC27M4ACNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC27M4ACN	<a href="#">Samples</a>
TLC27M4AID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	27M4AI	<a href="#">Samples</a>
TLC27M4AIDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	27M4AI	<a href="#">Samples</a>
TLC27M4AIDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	27M4AI	<a href="#">Samples</a>
TLC27M4AIDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	27M4AI	<a href="#">Samples</a>
TLC27M4AIN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC27M4AIN	<a href="#">Samples</a>
TLC27M4AINE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC27M4AIN	<a href="#">Samples</a>
TLC27M4BCD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	27M4BC	<a href="#">Samples</a>
TLC27M4BCDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	27M4BC	<a href="#">Samples</a>
TLC27M4BCDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	27M4BC	<a href="#">Samples</a>
TLC27M4BCDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	27M4BC	<a href="#">Samples</a>

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLC27M4BCN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC27M4BCN	<a href="#">Samples</a>
TLC27M4BID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	27M4BI	<a href="#">Samples</a>
TLC27M4BIDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	27M4BI	<a href="#">Samples</a>
TLC27M4BIDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	27M4BI	<a href="#">Samples</a>
TLC27M4BIDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	27M4BI	<a href="#">Samples</a>
TLC27M4BIN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC27M4BIN	<a href="#">Samples</a>
TLC27M4CD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC27M4C	<a href="#">Samples</a>
TLC27M4CDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC27M4C	<a href="#">Samples</a>
TLC27M4CDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC27M4C	<a href="#">Samples</a>
TLC27M4CDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC27M4C	<a href="#">Samples</a>
TLC27M4CN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC27M4CN	<a href="#">Samples</a>
TLC27M4CNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC27M4CN	<a href="#">Samples</a>
TLC27M4CNSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC27M4	<a href="#">Samples</a>
TLC27M4CPWLE	OBSOLETE	TSSOP	PW	14		TBD	Call TI	Call TI	0 to 70		
TLC27M4CPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P27M4	<a href="#">Samples</a>
TLC27M4ID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	TLC27M4I	<a href="#">Samples</a>
TLC27M4IDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	TLC27M4I	<a href="#">Samples</a>
TLC27M4IDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	TLC27M4I	<a href="#">Samples</a>

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLC27M4IDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	TLC27M4I	<a href="#">Samples</a>
TLC27M4IN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC27M4IN	<a href="#">Samples</a>
TLC27M4INE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC27M4IN	<a href="#">Samples</a>
TLC27M4IPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	P27M4I	<a href="#">Samples</a>
TLC27M4IPWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	P27M4I	<a href="#">Samples</a>
TLC27M4IPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	P27M4I	<a href="#">Samples</a>
TLC27M4MFKB	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI	-55 to 125		
TLC27M4MJ	OBSOLETE	CDIP	J	14		TBD	Call TI	Call TI	-55 to 125		
TLC27M4MJB	OBSOLETE	CDIP	J	14		TBD	Call TI	Call TI	-55 to 125		
TLC27M9CD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC27M9C	<a href="#">Samples</a>
TLC27M9CDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC27M9C	<a href="#">Samples</a>
TLC27M9CDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC27M9C	<a href="#">Samples</a>
TLC27M9CDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	TLC27M9C	<a href="#">Samples</a>
TLC27M9CN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC27M9CN	<a href="#">Samples</a>
TLC27M9CNSLE	OBSOLETE	SO	NS	14		TBD	Call TI	Call TI	0 to 70		
TLC27M9ID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	TLC27M9I	<a href="#">Samples</a>
TLC27M9IDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	TLC27M9I	<a href="#">Samples</a>
TLC27M9IDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	TLC27M9I	<a href="#">Samples</a>
TLC27M9IDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	TLC27M9I	<a href="#">Samples</a>
TLC27M9IN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC27M9IN	<a href="#">Samples</a>

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLC27M9MFKB	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI	-55 to 125		
TLC27M9MJ	OBSOLETE	CDIP	J	14		TBD	Call TI	Call TI	-55 to 125		
TLC27M9MJB	OBSOLETE	CDIP	J	14		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) 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/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish 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
TLC27M4ACDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC27M4AIDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC27M4BCDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC27M4BIDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC27M4CDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC27M4CNSR	SO	NS	14	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1
TLC27M4CPWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TLC27M4IDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC27M4IPWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TLC27M9CDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC27M9IDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLC27M4ACDR	SOIC	D	14	2500	367.0	367.0	38.0
TLC27M4AIDR	SOIC	D	14	2500	367.0	367.0	38.0
TLC27M4BCDR	SOIC	D	14	2500	367.0	367.0	38.0
TLC27M4BIDR	SOIC	D	14	2500	367.0	367.0	38.0
TLC27M4CDR	SOIC	D	14	2500	367.0	367.0	38.0
TLC27M4CNSR	SO	NS	14	2000	367.0	367.0	38.0
TLC27M4CPWR	TSSOP	PW	14	2000	367.0	367.0	35.0
TLC27M4IDR	SOIC	D	14	2500	367.0	367.0	38.0
TLC27M4IPWR	TSSOP	PW	14	2000	367.0	367.0	35.0
TLC27M9CDR	SOIC	D	14	2500	367.0	367.0	38.0
TLC27M9IDR	SOIC	D	14	2500	367.0	367.0	38.0

J (R-GDIP-T\*\*)

14 LEADS SHOWN

# CERAMIC DUAL IN-LINE PACKAGE



PINS ** DIM	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



4040083/F 03/03

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package is hermetically sealed with a ceramic lid using glass frit.
  - D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
  - E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

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

## N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE



PINS **	14	16	18	20
DIM				
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS-001 VARIATION	AA	BB	AC	AD



14/18 Pin Only  
20 Pin vendor option

4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
  - The 20 pin end lead shoulder width is a vendor option, either half or full width.

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



NOTES:

- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS-012 variation AB.

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.



PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4040064-3/G 02/11

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

# MECHANICAL DATA

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

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- 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.

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Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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