TLC27Mxx LinCMOS™ Precision Quad Operational Amplifiers

1 Features

- Trimmed offset voltage: ±300μV max at 25°C, V_{DD} = 5V
- Low offset voltage drift: ±0.6μV/°C
- Low noise: typically 32nV/$\sqrt{Hz}$ at f = 1kHz
- Wide range of supply voltages over specified temperature ranges:
  - 0°C to 70°C: 3V to 16V
  - −40°C to 85°C: 4V to 16V
  - −55°C to 125°C: 4V to 16V
- Low quiescent current: typically 120uA at 25°C, V_{DD} = 5V
- Output voltage range includes negative rail
- High input impedance: 6TΩ typ
- ESD−protection circuitry
- Designed-in latch-up immunity

2 Applications

- Multiplexed data-acquisition systems
- Test and measurement equipment
- Motor drive: power stage and control modules
- Power delivery: UPS, server, and merchant network power
- Programmable logic controllers
- Analog input and output modules

3 Description

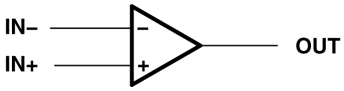
The TLC27M4 and TLC27M9 quad operational amplifiers combine a wide range of input offset voltage grades with low offset voltage drift, high input impedance, low noise, and speeds comparable to that of general-purpose bipolar devices.

The high input impedance and low bias currents make these devices an excellent choice for applications that are typically reserved for general-purpose bipolar products, but with only a fraction of the power consumption.

Table 3-1. Device Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
TLC27M4	NS (SOP, 14)	10.3mm × 5.3mm
	D (SOIC, 14)	8.65mm × 3.9mm
	N (PDIP, 14)	19.3mm × 6.35mm
	PW (TSSOP, 14)	5mm × 4.4mm
TLC27M4A	D (SOIC, 14)	8.65mm × 3.9mm
	N (PDIP, 14)	19.3mm × 6.35mm
TLC27M4B	D (SOIC, 14)	8.65mm × 3.9mm
	N (PDIP, 14)	19.3mm × 6.35mm
TLC27M9	D (SOIC, 14)	8.65mm × 3.9mm
	N (PDIP, 14)	19.3mm × 6.35mm

(1) For more information, see Section 11.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Symbol (Each Amplifier)

Table of Contents

4 Device Comparison Table

Table 4-1. Device Comparison Table

T_A	V_{IO}max AT 25°C	PACKAGE[1]			
		SMALL OUTLINE (D)	Plastic DIP (N)	Plastic Small Outline (NS)	TSSOP (PW)
0°C to 70°C	900µV	TLC27M9CD	TLC27M9CN	TLC27M4CNS	—
	2mV	TLC27M4BCD	TLC27M4BCN	—	—
	5mV	TLC27M4ACD	TLC27M4ACN	—	—
	10mV	TLC27M4CD	TLC27M4CN	—	TLC27M4CPW
–40°C to 85°C	900µV	TLC27M9ID	TLC27M9IN	—	—
	2mV	TLC27M4BID	TLC27M4BIN	—	—
	5mV	TLC27M4AID	TLC27M4AIN	—	—
	10mV	TLC27M4ID	TLC27M4IN	—	TLC27M4IPW

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

5 Pin Configuration and Functions

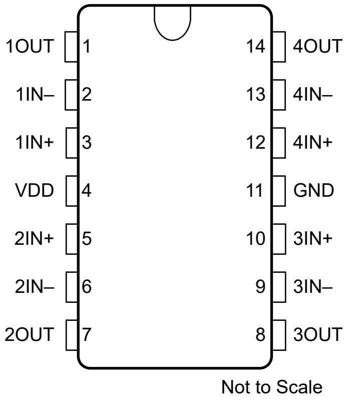


Figure 5-1. TLC27Mx D or PW Package (Top View)

Table 5-1. Pin Functions: TLC27Mxx

PIN		TYPE	DESCRIPTION
NAME	D, P or PW		
1OUT	1	Output	Output channel 1
1IN–	2	Input	Inverting input channel 1
1IN+	3	Input	Non Inverting input channel 1
V_{DD}	4	—	Positive power supply
2IN+	5	Input	Non Inverting input channel 2
2IN–	6	Input	Inverting input channel 2
2OUT	7	Output	Output channel 2
3OUT	8	Output	Output channel 3
3IN–	9	Input	Inverting input channel 3
3IN+	10	Input	Non Inverting input channel 3
GND	11	—	Ground or negative power supply
4IN+	12	Input	Non Inverting input channel 4
4IN–	13	Input	Inverting input channel 4
4OUT	14	Output	Output channel 4

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

			MIN	MAX	UNIT
V_{DD}	Supply voltage(2)			18	V
V_{ID}	Differential input voltage(3)			$\pm V_{DD}$	
V_I	Input voltage range		-0.3	V_{DD}	V
I_I	Input current			±5	mA
I_O	Output short circuit			Continuous	
	Duration of short-circuit current at (or below) 25°C(4)		Unlimited		
T_A	Operating free-air temperature	C suffix	0	70	°C
		I suffix	-40	85	
		M suffix	-55	125	
	Storage temperature range		-65	150	
	Lead temperature 1.6mm (1/16 inch) from case for 10 seconds	D or P package		260	°C
	Lead temperature 1.6mm (1/16 inch) from case for 60 seconds	JG package		300	°C

(1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime

(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 can be shorted to either supply. Temperature and/or supply voltages must be limited to make sure that the maximum dissipation rating is not exceeded (see Section 8.1).

6.2 Dissipation Ratings

PACKAGE	$T_A \leq 25°C$ POWER RATING	DERATING FACTOR ABOVE T_A = 25°C	T_A = 70°C POWER RATING	T_A = 85°C POWER RATING	T_A = 125°C POWER RATING
D	950mW	7.6mW/°C	608mW	494mW	—
PW	700mW	5.6mW/°C	448mW	—	—
N	1575mW	12.6mW/°C	1008mW	819mW	—

6.3 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} = 5V	–0.2	3.5	–0.2	3.5	0	3.5	V
	V_{DD} = 10V	–0.2	8.5	–0.2	8.5	0	8.5	
Operating free-air temperature, T_A		0	70	–40	85	–55	125	°C

6.4 Electrical Characteristics - TLC27M4C 5V

at specified free-air temperature, V_{DD} = 5V, V_{CM} = 2.5V, R_L = 10kΩ (unless otherwise noted)

PARAMETER			TEST CONDITIONS		T_A	TLC27M4C TLC27M4AC TLC27M4BC TLC27M9C			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC27M4C			25°C		±0.3	10	mV
					Full range			12	
		TLC27M4AC			25°C		±0.3	5	
					Full range			6.5	
		TLC27M4BC			25°C		±300	2000	µV
					Full range			3000	
		TLC27M9C			25°C		±300	1500	
					Full range			1750	
α_{VIO}	Average temperature coefficient of input offset voltage				25°C to 70°C		±0.6		µV/°C
I_{IO}	Input offset current				25°C		±5	60	pA
					70°C		7	300	
I_{IB}	Input bias current				25°C		±10	60	pA
					70°C		40	600	
V_{CM}	Common-mode input voltage range				25°C		−0.2 to 5.2		V
					Full range		−0.2 to 3.5		V
V_{OH}	High-level output voltage		V_{ID} = 100mV		25°C	3.2	4.95		V
					0°C	3	4.95		
					70°C	3	4.95		
V_{OL}	Low-level output voltage		V_{ID} = −100mV	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 = 0.25V to 2V		25°C	25	1000		V/mV
					0°C	15			
					70°C	15			
CMRR	Common-mode rejection ratio		V_{CM} = -0.1V < V_{CM} < 2V		25°C	65	80		dB
					0°C	60			
					70°C	60			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5V to 10V	V_O = 1.4V	25°C	70	140		dB
					0°C	60	120		
					70°C	60	120		
I_Q	Supply current (two amplifiers)		I_O = 0A		25°C		120	150	µA
					0°C			160	
					70°C			160	

6.5 Electrical Characteristics - TLC27M4C 10V

at specified free-air temperature, V_{DD} = 10V, V_{CM} = 5V, R_L = 10kΩ (unless otherwise noted)

PARAMETER			TEST CONDITIONS		T_A	TLC27M4C, TLC27M4AC, TLC27M4BC, TLC27M9C			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC27M4C			25°C		±0.3	10	mV
					Full range			12	
		TLC27M4AC			25°C		±0.3	5	
					Full range			6.5	
		TLC27M4BC			25°C		±300	2000	µV
					Full range			3000	
		TLC27M9C			25°C		±300	1500	
					Full range			1900	
α_{VIO}	Average temperature coefficient of input offset voltage				25°C to 70°C		±0.75		µV/°C
I_{IO}	Input offset current				25°C		±5	60	pA
					70°C		7	300	
I_{IB}	Input bias current				25°C		±10	60	pA
					70°C		50	600	
V_{CM}	Common-mode input voltage range				25°C	−0.2 to 9	−0.2 to 9.2		V
					Full range	−0.2 to 8.5			V
V_{OH}	High-level output voltage		V_{ID} = 100mV		25°C	8	9.95		V
					0°C	7.8			
					70°C	7.8			
V_{OL}	Low-level output voltage		V_{ID} = −100mV	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 = 1V to 6V		25°C	25	1000		V/mV
					0°C	15			
					70°C	15			
CMRR	Common-mode rejection ratio		$V_{CM} = V_{CM_{min}}$		25°C	65	80		dB
					0°C	60			
					70°C	60			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5V to 10V	V_O = 1.4V	25°C	70	140		dB
					0°C	60	120		
					70°C	60	120		
I_Q	Supply current (two amplifiers)		V_O = 5V, No load	V_{IC} = 5V	25°C		120	150	µA
					0°C			160	
					70°C			160	

6.6 Electrical Characteristics - TLC27M4I 5V

at specified free-air temperature, V_{DD} = 5V, V_{CM} = 2.5V, R_L = 10kΩ (unless otherwise noted)

PARAMETER			TEST CONDITIONS		T_A	TLC27M4I, TLC27M4AI, TLC27M4BI, TLC27M9I			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC27M4I			25°C		±0.3	10	mV
					Full range			13	
		TLC27M4AI			25°C		±0.3	5	
					Full range			7	
		TLC27M4BI			25°C		±300	2000	µV
					Full range			3500	
		TLC27M9I			25°C		±300	1500	
					Full range			1750	
α_{VIO}	Average temperature coefficient of input offset voltage				25°C to 70°C		±0.6		µV/°C
I_{IO}	Input offset current				25°C		±5	60	pA
					70°C		200	1000	
I_{IB}	Input bias current				25°C		±10	60	pA
					70°C		40	2000	
V_{CM}	Common-mode input voltage range				25°C	−0.2 to 4	−0.2 to 5.2		V
					Full range		−0.2 to 3.5		V
V_{OH}	High-level output voltage		V_{ID} = 100mV		25°C	3.2	4.95		V
					0°C	3	4.95		
					70°C	3	4.95		
V_{OL}	Low-level output voltage		V_{ID} = −100mV	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 = 0.25V to 2V		25°C	25	1000		V/mV
					0°C	15			
					70°C	15			
CMRR	Common-mode rejection ratio		V_{CM} = -0.1V < V_{CM} < 2V		25°C	65	80		dB
					0°C	60			
					70°C	60			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5V to 10V	V_O = 1.4V	25°C	70	140		dB
					0°C	60	120		
					70°C	60	120		
I_Q	Supply current (two amplifiers)		I_O = 0A		25°C		120	150	µA
					0°C			160	
					70°C			160	

6.7 Electrical Characteristics - TLC27M4I 10V

at specified free-air temperature, V_{DD} = 10V, V_{CM} = 5V, R_L = 10kΩ (unless otherwise noted)

PARAMETER			TEST CONDITIONS		T_A	TLC27M4I, TLC27M4AI, TLC27M4BI, TLC27M9I			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC27M4I			25°C		±0.3	10	mV
					Full range			12	
		TLC27M4AI			25°C		±0.3	5	
					Full range			6.5	
		TLC27M4BI			25°C		±300	2000	µV
					Full range			3000	
		TLC27M9I			25°C		±300	1500	
					Full range			1900	
α_{VIO}	Average temperature coefficient of input offset voltage				25°C to 70°C		±0.75		µV/°C
I_{IO}	Input offset current				25°C		±5	60	pA
					70°C		7	300	
I_{IB}	Input bias current				25°C		±10	60	pA
					70°C		50	600	
V_{CM}	Common-mode input voltage range				25°C	−0.2 to 9	−0.2 to 9.2		V
					Full range	−0.2 to 8.5			V
V_{OH}	High-level output voltage		V_{ID} = 100mV		25°C	8	9.95		V
					0°C	7.8			
					70°C	7.8			
V_{OL}	Low-level output voltage		V_{ID} = −100mV	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 = 1V to 6V		25°C	25	1000		V/mV
					0°C	15			
					70°C	15			
CMRR	Common-mode rejection ratio		$V_{CM} = V_{CM_{min}}$		25°C	65	80		dB
					0°C	60			
					70°C	60			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5V to 10V	V_O = 1.4V	25°C	70	140		dB
					0°C	60	120		
					70°C	60	120		
I_Q	Supply current (two amplifiers)		I_O = 0A		25°C		120	150	µA
					0°C			160	
					70°C			160	

6.8 Electrical Characteristics - TLC27M4M 5V

at specified free-air temperature, V_{DD} = 5V, VCM = 2.5V, RL = 10kΩ (unless otherwise noted)

PARAMETER			TEST CONDITIONS		T_A (1)	TLC27M4M TLC27M9M			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC27M4M	V_O = 1.4V, R_S = 50Ω,	V_{IC} = 0, R_L = 100kΩ	25°C		1.1	10	mV
					Full range			12	
		TLC27M9M	V_O = 1.4V, R_S = 50Ω,	V_{IC} = 0, R_L = 100kΩ	25°C		210	900	µV
					Full range			3750	
α_{VIO}	Average temperature coefficient of input offset voltage				25°C to 125°C		1.7		µV/°C
I_{IO}	Input offset current(2)		V_O = 2.5V,	V_{IC} = 2.5V	25°C		0.1		pA
					125°C		1.4	15	nA
I_{IB}	Input bias current(2)		V_O = 2.5V,	V_{IC} = 2.5V	25°C		0.6		pA
					85°C		9	35	nA
V_{ICR}	Common-mode input voltage range(3)				25°C	0 to 4	–0.3 to 4.2		V
					Full range	0 to 3.5			V
V_{OH}	High-level output voltage		V_{ID} = 100mV,	R_L = 100kΩ	25°C	3.2	3.9		V
					–55°C	3	3.9		
					125°C	3	4		
V_{OL}	Low-level output voltage		V_{ID} = –100mV,	I_{OL} = 0	25°C		0	50	mV
					–55°C		0	50	
					125°C		0	50	
A_{VD}	Large-signal differential voltage amplification		V_O = 0.25V to 2V,	R_L = 100kΩ	25°C	25	170		V/mV
					–55°C	15	270		
					125°C	15	120		
CMRR	Common-mode rejection ratio		V_{IC} = V_{ICR}min		25°C	65	91		dB
					–55°C	60	89		
					125°C	60	91		
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5V to 10V,	V_O = 1.4V	25°C	70	93		dB
					–55°C	60	91		
					125°C	60	94		
I_{DD}	Supply current (four amplifiers)		V_O = 2.5V, No load	V_{IC} = 2.5V,	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 5pA were determined mathematically.
(3) This range also applies to each input individually.

6.9 Electrical Characteristics - TLC27M4M 10V

at specified free-air temperature, V_{DD} = 10V, V_{CM} = 5V, R_L = 10kΩ (unless otherwise noted)

PARAMETER			TEST CONDITIONS		T_A (1)	TLC27M4M TLC27M9M			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC27M4M	V_O = 1.4V, R_S = 50Ω,	V_{IC} = 0, R_L = 100kΩ	25°C		1.1	10	mV
					Full range			12	
		TLC27M9M	V_O = 1.4V, R_S = 50Ω,	V_{IC} = 0, R_L = 100kΩ	25°C		220	1200	μV
					Full range			4300	
α_{VIO}	Average temperature coefficient of input offset voltage				25°C to 125°C		2.1		μV/°C
I_{IO}	Input offset current(2)		V_O = 5V,	V_{IC} = 5V	25°C		0.1		pA
					125°C		1.8	15	nA
I_{IB}	Input bias current(2)		V_O = 5V,	V_{IC} = 5V	25°C		0.7		pA
					125°C		10	35	nA
V_{ICR}	Common-mode input voltage range(3)				25°C	0 to 9	–0.3 to 9.2		V
					Full range	–0.2 to 8.5			V
V_{OH}	High-level output voltage		V_{ID} = 100mV,	R_L = 100kΩ	25°C	8	8.7		V
					–55°C	7.8	8.6		
					125°C	7.8	8.8		
V_{OL}	Low-level output voltage		V_{ID} = –100mV,	I_{OL} = 0	25°C		0	50	mV
					–55°C		0	50	
					125°C		0	50	
A_{VD}	Large-signal differential voltage amplification		V_O = 1V to 6V,	R_L = 100kΩ	25°C	25	275		V/mV
					–55°C	15	420		
					125°C	15	190		
CMRR	Common-mode rejection ratio		V_{IC} = V_{ICR}min		25°C	65	94		dB
					–55°C	60	93		
					125°C	60	93		
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5V to 10V,	V_O = 1.4V	25°C	70	93		dB
					–55°C	60	91		
					125°C	60	94		
I_{DD}	Supply current (four amplifiers)		V_O = 5V, No load	V_{IC} = 5V,	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 5pA were determined mathematically.
(3) This range also applies to each input individually.

6.10 Operating Characteristics - TLC27M4

at specified free-air temperature, V_{DD} = 5V to 10V, V_{CM} = V_{DD} / 2, R_L = 10kΩ

PARAMETER		TEST CONDITIONS		T_A	TLC27M4C, TLC27M4AC, TLC27M4BC, TLC27M9C,TLC27M4I, TLC27M4AI, TLC27M4BI, TLC27M9I			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	R_L = 10kΩ C_L = 20pF	$V_{I(PP)}$ = 100mV	25°C		0.5		V/µs
			$V_{I(PP)}$ = 1V	25°C		4.5		
V_n	Equivalent input noise voltage	f = 1kHz	R_S = 20Ω	25°C		32		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	V_O = V_{OH}, R_L = 10kΩ	C_L = 20pF	25°C		40		kHz
B_1	Unity-gain bandwidth	V_I = 10mV	C_L = 20pF	25°C		1.1		MHz
$Φ_m$	Phase margin	V_I = 10mV, C_L = 20pF	f = B_1	25°C		60°		

6.11 Operating Characteristics - TLC27M4M 5V

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

PARAMETER		TEST CONDITIONS		T_A	TLC27M4M TLC27M9M			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	R_L = 100kΩ, C_L = 20pF, See Figure 7-1	V_{IPP} = 1V	25°C		0.43		V/µs
				–55°C		0.54		
				125°C		0.29		
			V_{IPP} = 2.5V	25°C		0.40		
				–55°C		0.50		
				125°C		0.28		
V_n	Equivalent input noise voltage	f = 1kHz, See Figure 7-2	R_S = 20Ω	25°C		32		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	V_O = V_{OH}, R_L = 100kΩ,	C_L = 20pF, See Figure 7-1	25°C		56		kHz
				–55°C		80		
				125°C		40		
B_1	Unity-gain bandwidth	V_I = 10mV, See Figure 7-3	C_L = 20pF	25°C		525		kHz
				–55°C		850		
				125°C		330		
$φ_m$	Phase margin	V_I = 10mV, C_L = 20pF,	f = B_1, See Figure 7-3	25°C		40°		
				–55°C		44°		
				125°C		36°		

6.12 Operating Characteristics - TLC27M4M 10V

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

PARAMETER		TEST CONDITIONS		T_A	TLC27M4M TLC27M9M			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	R_L = 100kΩ, C_L = 20pF, See Figure 7-1	V_{IPP} = 1V	25°C		0.62		V/µs
				–55°C		0.81		
				125°C		0.38		
			V_{IPP} = 5.5V	25°C		0.56		
				–55°C		0.73		
				125°C		0.35		
V_n	Equivalent input noise voltage	f = 1kHz, See Figure 7-2	R_S = 20Ω	25°C		32		nV/√ Hz
B_{OM}	Maximum output-swing bandwidth	V_O = V_{OH}, R_L = 100kΩ,	C_L = 20pF, See Figure 7-1	25°C		35		kHz
				–55°C		50		
				125°C		20		
B_1	Unity-gain bandwidth	V_I = 10mV, See Figure 7-3	C_L = 20pF	25°C		635		kHz
				–55°C		960		
				125°C		440		
φ_m	Phase margin	V_I = 10mV, C_L = 20pF,	f = B_1, See Figure 7-3	25°C		43°		
				–55°C		47°		
				125°C		39°		

6.13 Typical Characteristics

at T_A = 25°C, V_{DD} = ±20V, V_{CM} = V_{DD} / 2, R_{LOAD} = 10kΩ connected to V_{DD} / 2, and C_L = 10pF (unless otherwise noted)

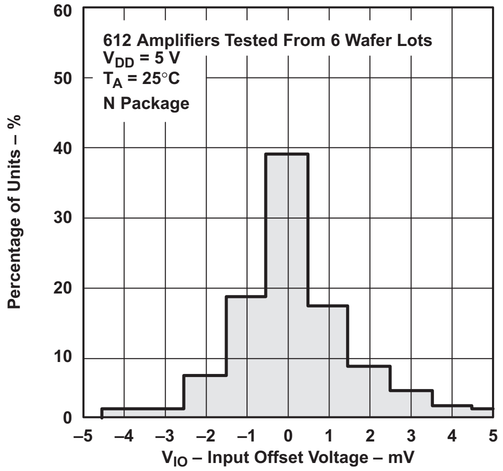


Figure 6-1. Distribution of TLC27M4 Input Offset Voltage, Old Die

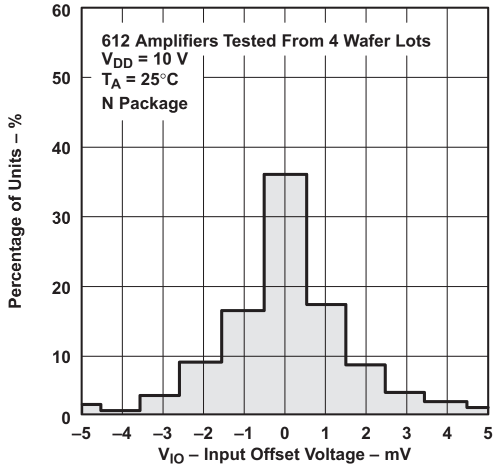


Figure 6-2. Distribution of TLC27M4 Input Offset Voltage, Old Die

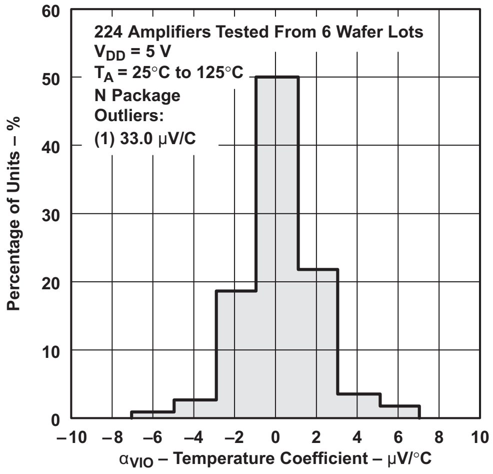


Figure 6-3. Distribution of TLC27M4 and TLC27M9 Input Offset Voltage Temperature Coefficient, Old Die

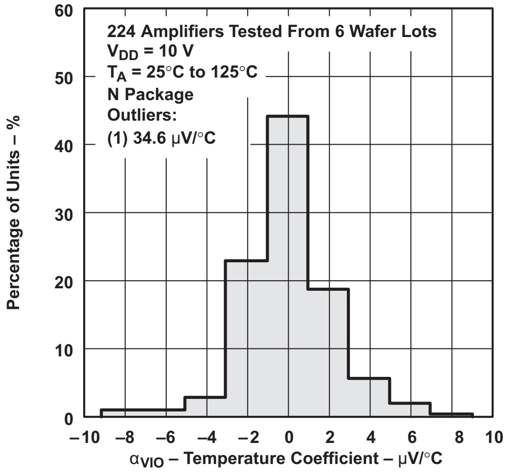


Figure 6-4. Distribution of TLC27M4 and TLC27M9 Input Offset Voltage Temperature Coefficient, Old Die

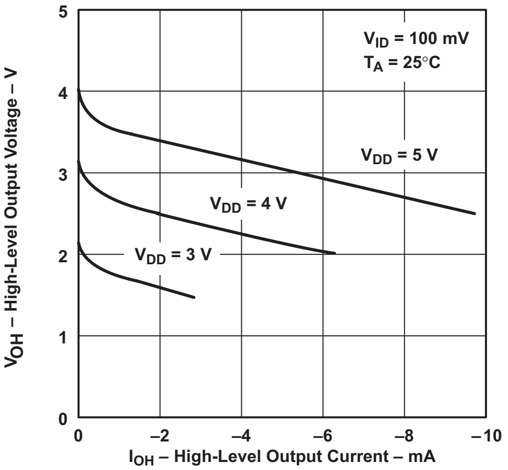


Figure 6-5. High-Level Output Voltage vs High-Level Output Current, Old Die

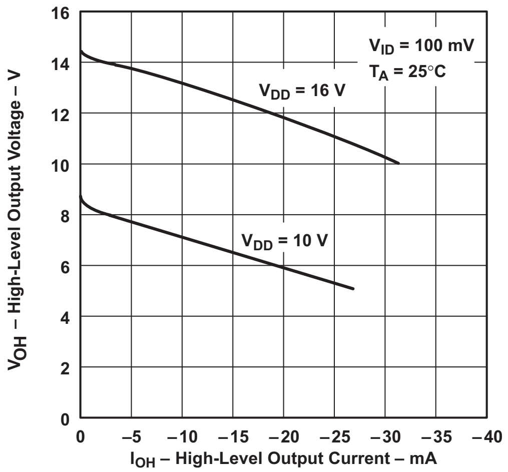


Figure 6-6. High-Level Output Voltage vs High-Level Output Current, Old Die

6.13 Typical Characteristics (continued)

at T_A = 25°C, V_{DD} = ±20V, V_{CM} = V_{DD} / 2, R_{LOAD} = 10kΩ connected to V_{DD} / 2, and C_L = 10pF (unless otherwise noted)

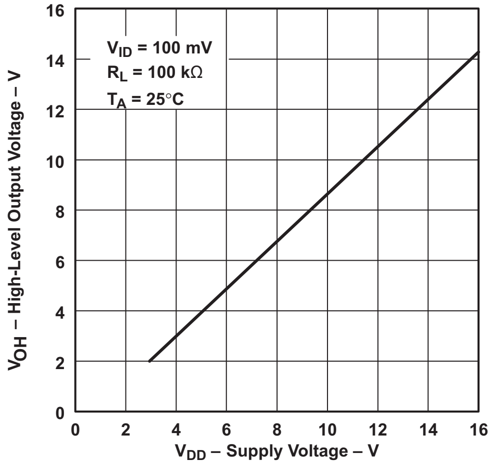


Figure 6-7. High-Level Output Voltage vs Supply Voltage, Old Die

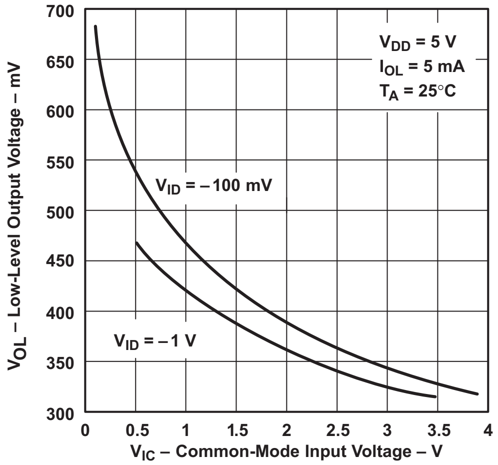


Figure 6-8. Low-Level Output Voltage vs Common-Mode Input Voltage, Old Die

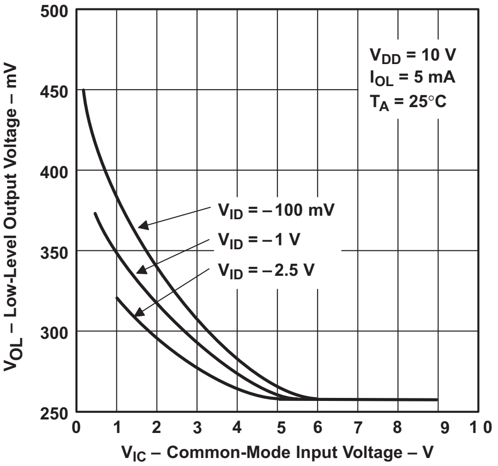


Figure 6-9. Low-Level Output Voltage vs Common-Mode Input Voltage, Old Die

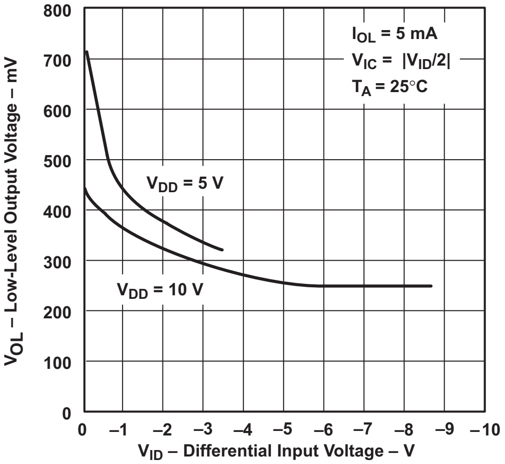


Figure 6-10. Low-Level Output Voltage vs Differential Input Voltage, Old Die

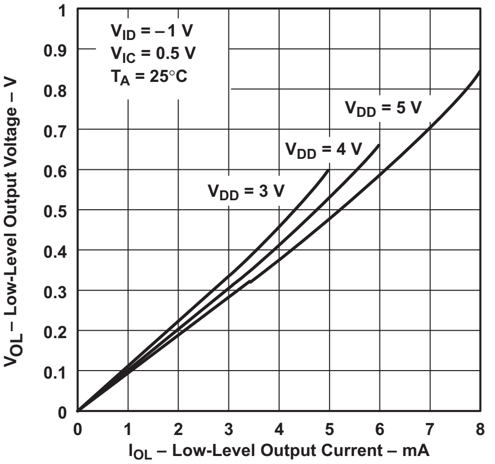


Figure 6-11. Low-Level Output Voltage vs Low-Level Output Current, Old Die

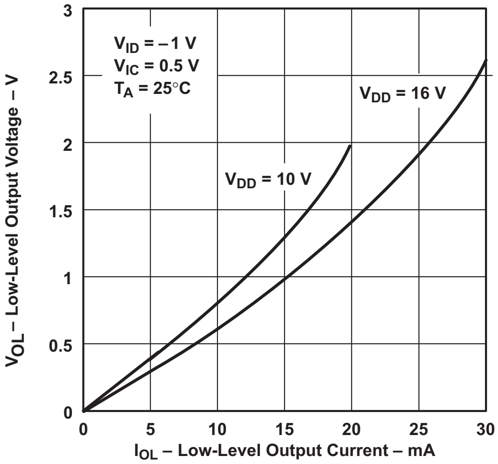


Figure 6-12. Low-Level Output Voltage vs Low-Level Output Current, Old Die

6.13 Typical Characteristics (continued)

at T_A = 25°C, V_{DD} = ±20V, V_{CM} = V_{DD} / 2, R_{LOAD} = 10kΩ connected to V_{DD} / 2, and C_L = 10pF (unless otherwise noted)

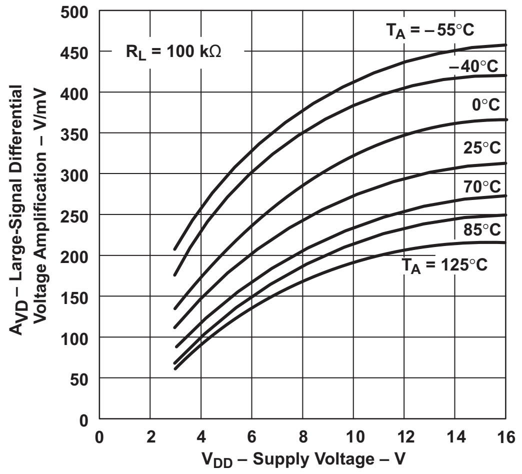


Figure 6-13. Large-Signal Differential Voltage Amplification vs Supply Voltage, Old Die

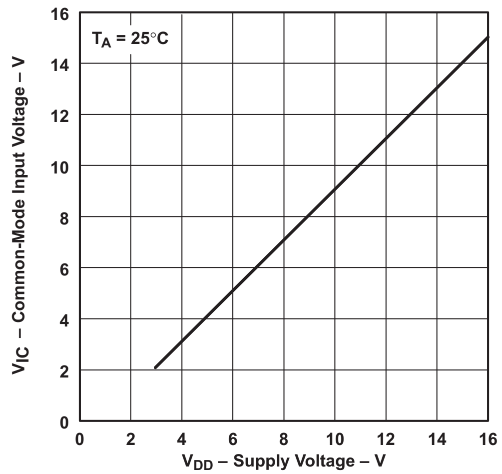


Figure 6-14. Common-Mode Input Voltage Positive Limit vs Supply Voltage, Old Die

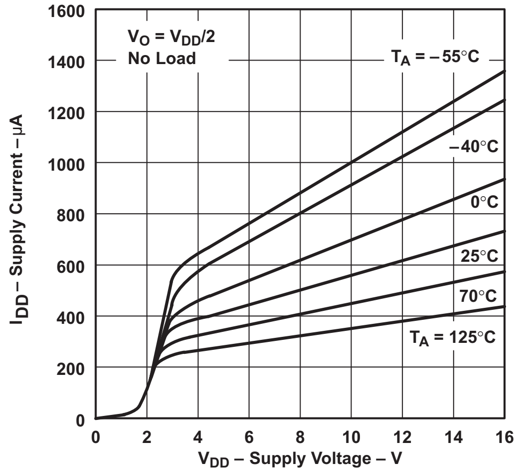


Figure 6-15. Supply Current vs Supply Voltage, Old Die

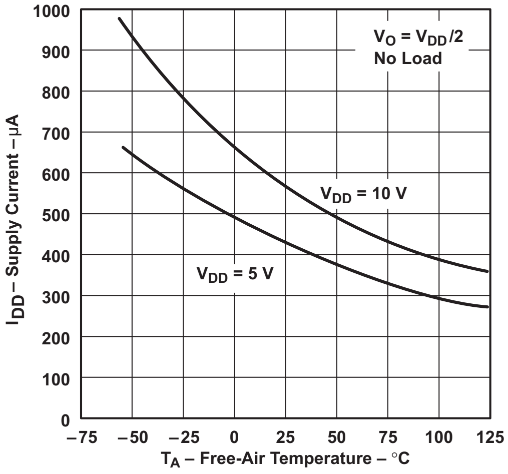


Figure 6-16. Supply Current vs Free-Air Temperature, Old Die

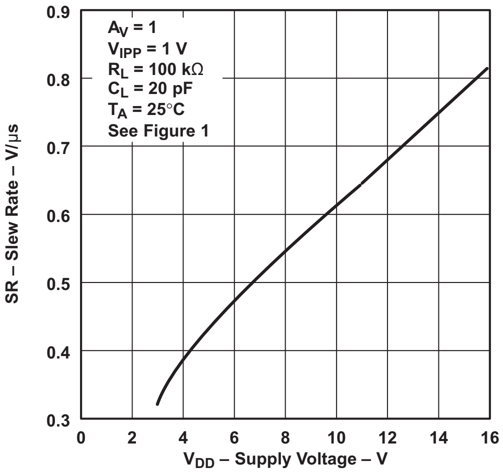


Figure 6-17. Slew Rate vs Supply Voltage, Old Die

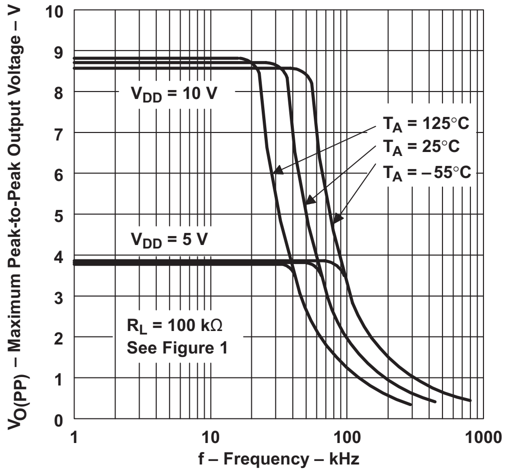


Figure 6-18. Maximum Peak-to-Peak Output Voltage vs Frequency, Old Die

6.13 Typical Characteristics (continued)

at T_A = 25°C, V_{DD} = ±20V, V_{CM} = V_{DD} / 2, R_{LOAD} = 10kΩ connected to V_{DD} / 2, and C_L = 10pF (unless otherwise noted)

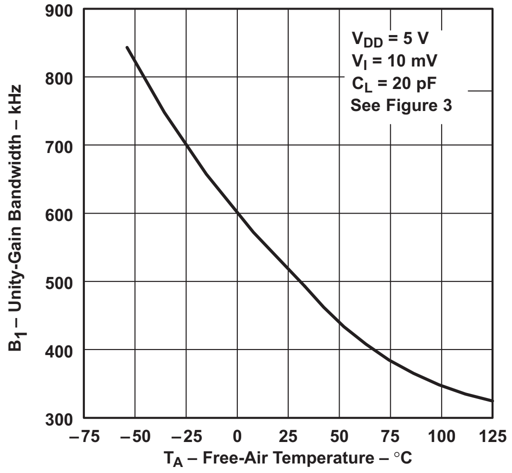


Figure 6-19. Unity-Gain Bandwidth vs Free-Air Temperature, Old Die

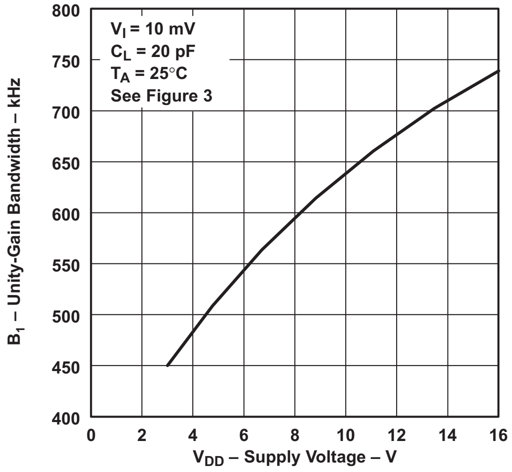


Figure 6-20. Unity-Gain Bandwidth vs Supply Voltage, Old Die

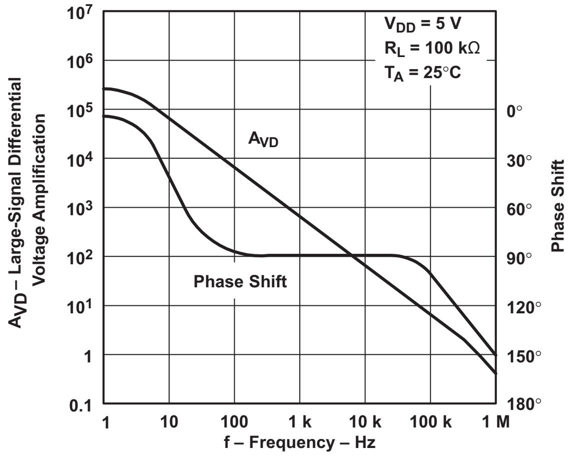


Figure 6-21. Large-Signal Differential Voltage Amplification and Phase Shift vs Frequency, Old Die

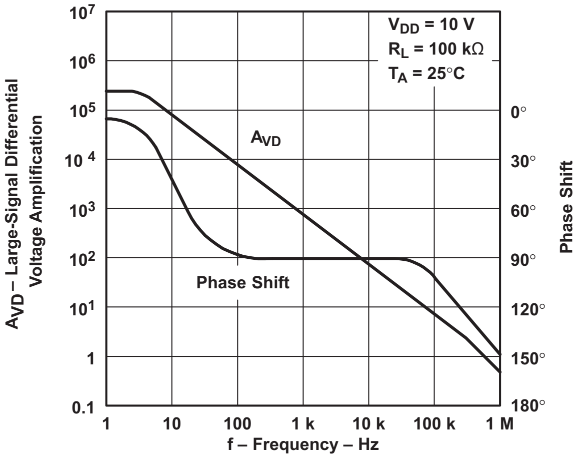


Figure 6-22. Large-Signal Differential Voltage Amplification and Phase Shift vs Frequency, Old Die

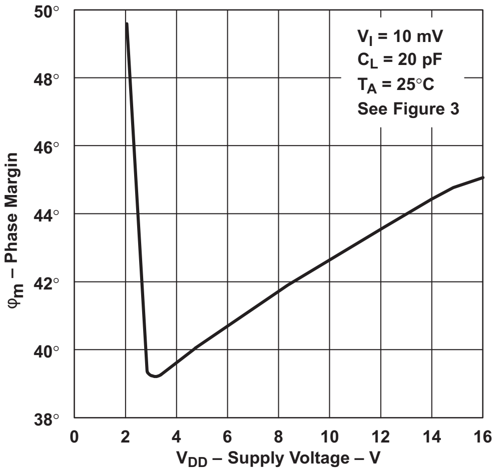
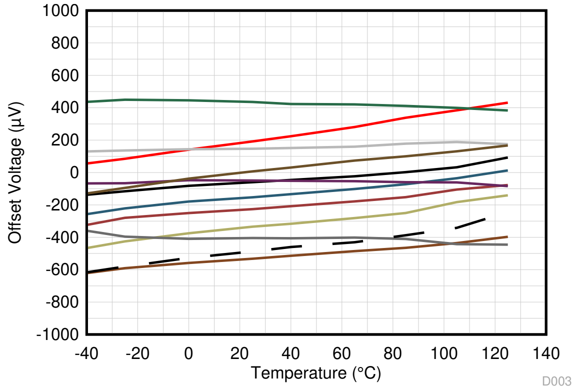


Figure 6-23. Phase Margin vs Supply Voltage, Old Die



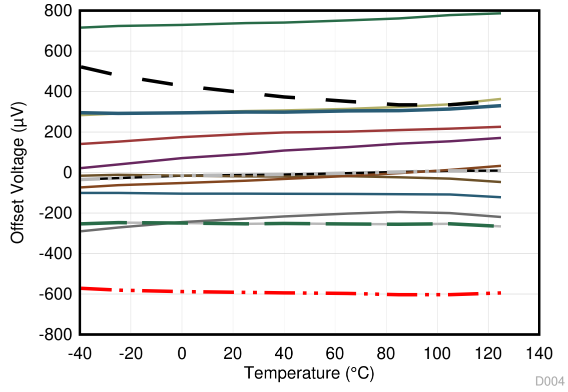
V_{CM} = V+

Each color represents one sample device.

Figure 6-24. Offset Voltage vs Temperature, New Die

6.13 Typical Characteristics (continued)

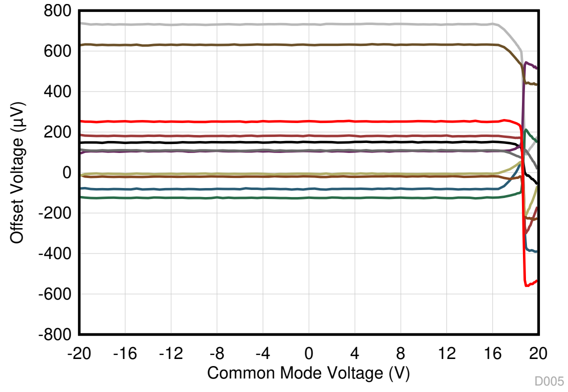
at T_A = 25°C, V_{DD} = ±20V, V_{CM} = V_{DD} / 2, R_{LOAD} = 10kΩ connected to V_{DD} / 2, and C_L = 10pF (unless otherwise noted)



V_{CM} = V–

Each color represents one sample device.

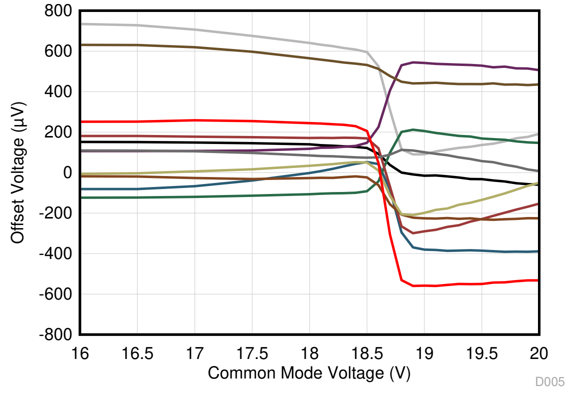
Figure 6-25. Offset Voltage vs Temperature, New Die



T_A = 25°C

Each color represents one sample device.

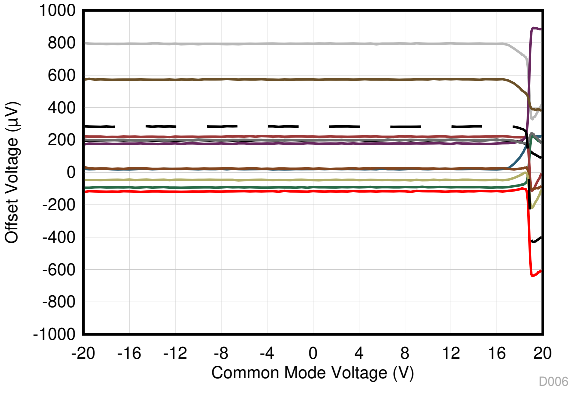
Figure 6-26. Offset Voltage vs Common-Mode Voltage, New Die



T_A = 25°C

Each color represents one sample device.

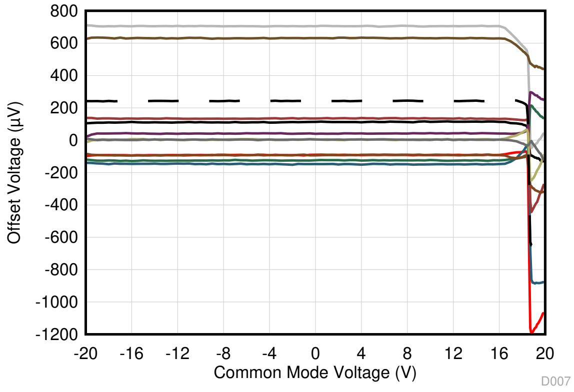
Figure 6-27. Offset Voltage vs Common-Mode Voltage (Transition Region), New Die



T_A = 125°C

Each color represents one sample device.

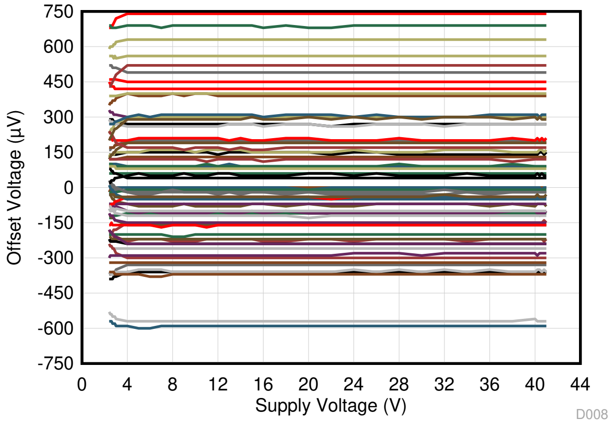
Figure 6-28. Offset Voltage vs Common-Mode Voltage, New Die



T_A = –40°C

Each color represents one sample device.

Figure 6-29. Offset Voltage vs Common-Mode Voltage, New Die



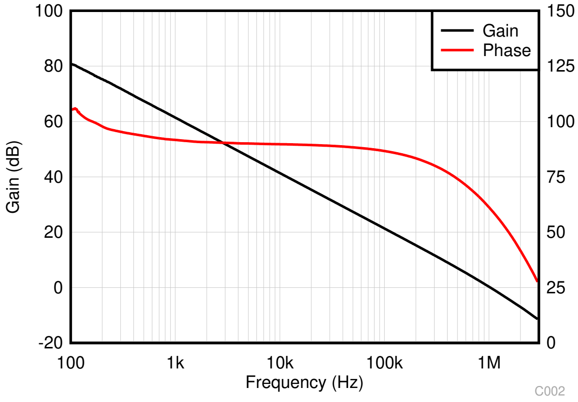
V_{CM} = V–

Each color represents one sample device.

Figure 6-30. Offset Voltage vs Power Supply, New Die

6.13 Typical Characteristics (continued)

at T_A = 25°C, V_{DD} = ±20V, V_{CM} = V_{DD} / 2, R_{LOAD} = 10kΩ connected to V_{DD} / 2, and C_L = 10pF (unless otherwise noted)



C_L = 20pF

Figure 6-31. Open-Loop Gain and Phase vs Frequency, New Die

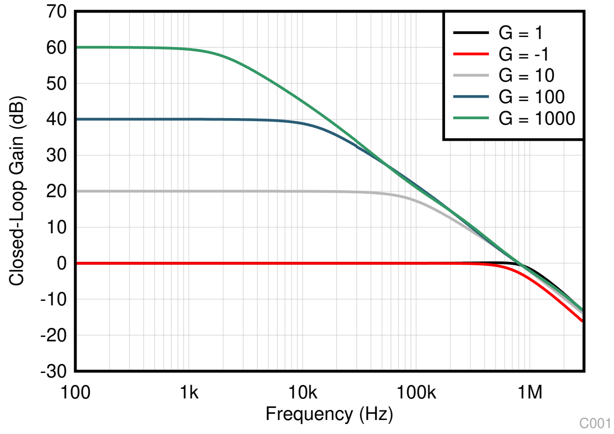


Figure 6-32. Closed-Loop Gain vs Frequency, New Die

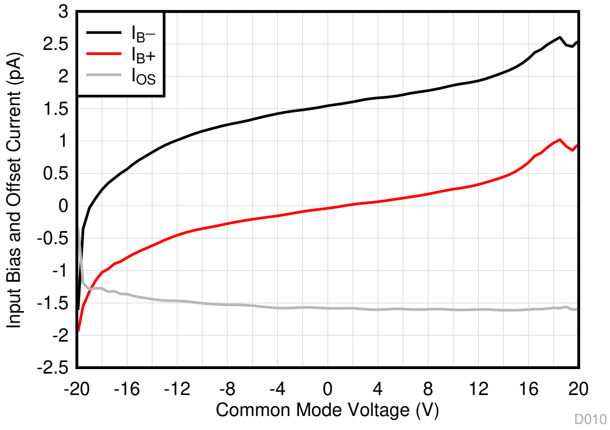


Figure 6-33. Input Bias Current vs Common-Mode Voltage, New Die

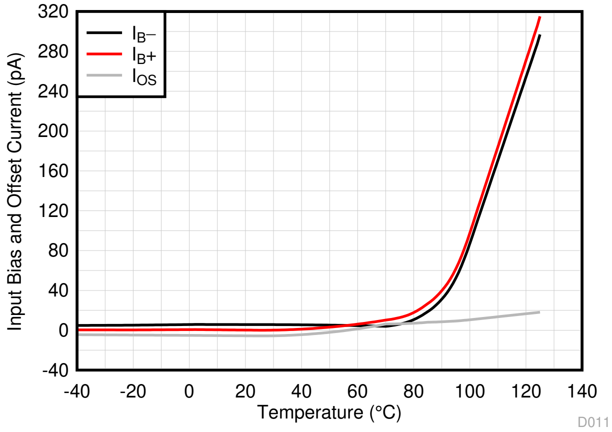


Figure 6-34. Input Bias Current vs Temperature, New Die

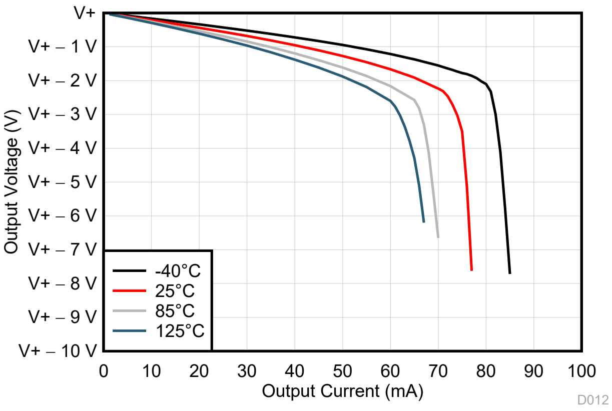


Figure 6-35. Output Voltage Swing vs Output Current (Sourcing), New Die

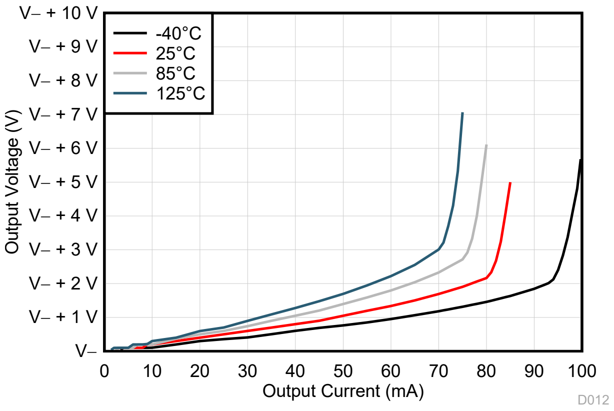
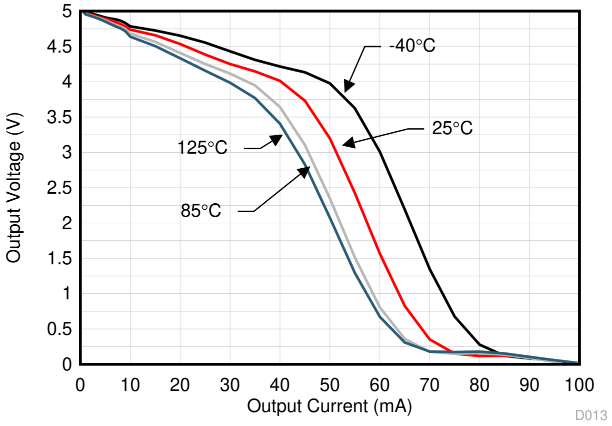


Figure 6-36. Output Voltage Swing vs Output Current (Sinking), New Die

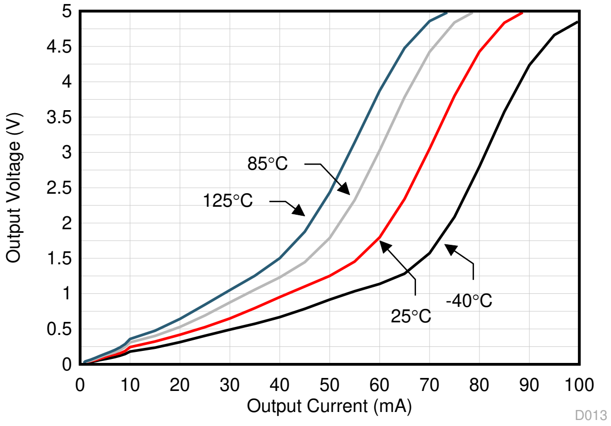
6.13 Typical Characteristics (continued)

at T_A = 25°C, V_{DD} = ±20V, V_{CM} = V_{DD} / 2, R_{LOAD} = 10kΩ connected to V_{DD} / 2, and C_L = 10pF (unless otherwise noted)



V_S = 5V

Figure 6-37. Output Voltage Swing vs Output Current (Sourcing), New Die



V_S = 5V

Figure 6-38. Output Voltage Swing vs Output Current (Sinking), New Die

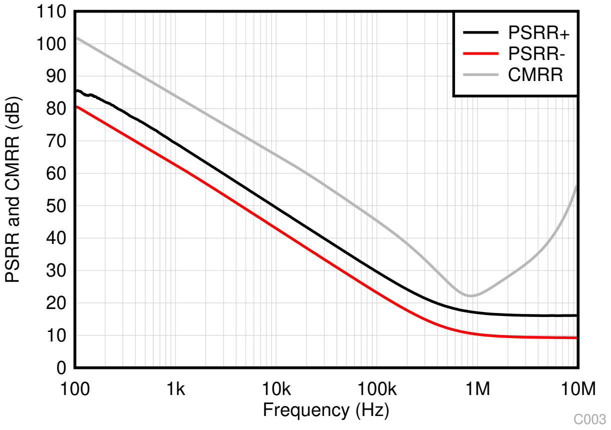


Figure 6-39. CMRR and PSRR vs Frequency, New Die

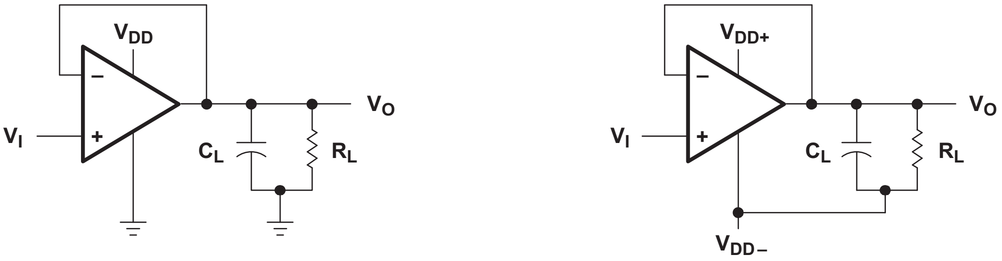
6.14 Old Versus New Die Comparison

As of the publication of revision E of this datasheet, Texas Instruments has moved manufacturing of the die for TLC27M4/9 to a modern fabrication site. The two different die are referred to in this document as “old” (previous fabrication site) and “new” die. The die origin can be separated from the “Chip Source Origin” (CSO) parameter in the shipping information. The old die CSO is “DM4”, for the new die the CSO is “RFB”. The old die information is in the shipping information. The old die CSO is “DM4”, for the new die the CSO is “RFB”. The old die information is maintained in this datasheet for comparison purposes, but all new manufacturing has moved to the new die.

7 Parameter Measurement Information

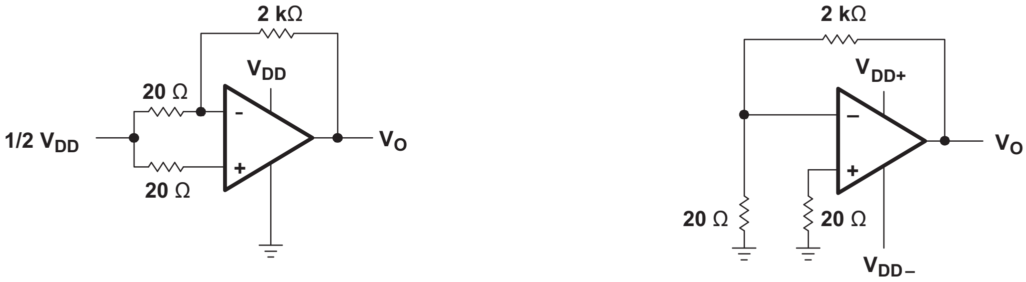
7.1 Single-Supply Versus Split-Supply Test Circuits

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.



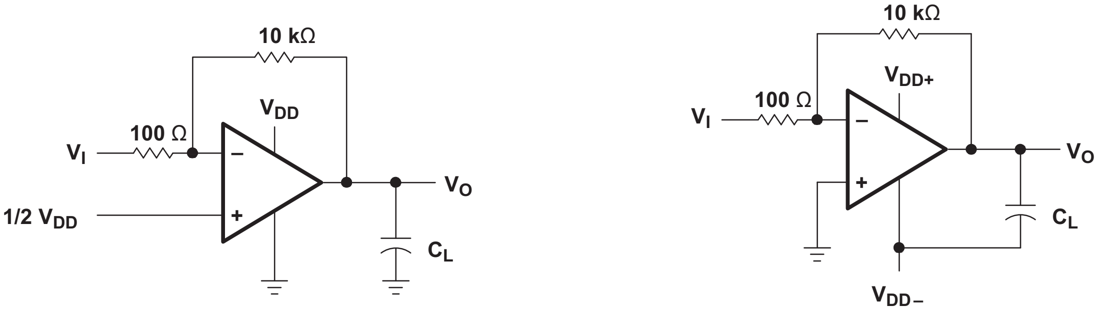
(a) SINGLE SUPPLY (b) SPLIT SUPPLY

Figure 7-1. Unity-Gain Amplifier



(a) SINGLE SUPPLY (b) SPLIT SUPPLY

Figure 7-2. Noise-Test Circuit



(a) SINGLE SUPPLY (b) SPLIT SUPPLY

Figure 7-3. Gain-of-100 Inverting Amplifier

7.2 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 1pA, 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 7-4). Leakages that can 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.

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.

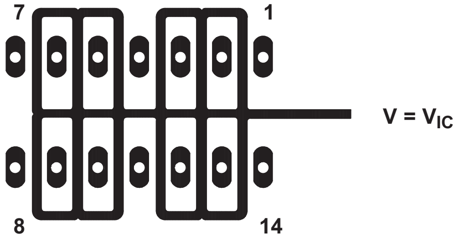


Figure 7-4. Isolation Metal Around Device Inputs (J and N packages)

7.3 Low-Level Output Voltage

To obtain low-supply-voltage operation, some compromise is necessary in the input stage. This compromise results in the device low-level output being dependent on both the common-mode input voltage level and the differential input voltage level. When attempting to correlate low-level output readings with those quoted in the electrical specifications, these two conditions must be observed.

7.4 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, because the moisture also covers the isolation metal, thereby rendering the method useless. TI suggests that these measurements be performed at temperatures above freezing to minimize error.

8 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

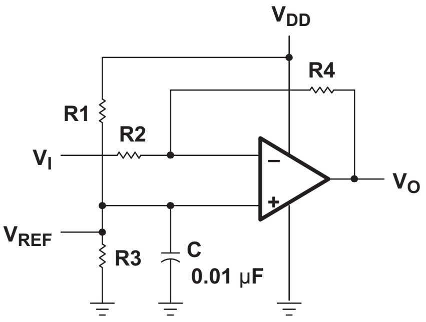
8.1.1 Single-Supply Operation

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 3V (C-suffix types), thus allowing operation with supply levels commonly available for TTL and HCMOS. However, for maximum dynamic range, 16V 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 typically sufficient to establish this reference level (see Figure 8-1). 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 8-2); 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 can require RC decoupling.



$$V_{REF} = V_{DD} \frac{R3}{R1 + R3}$$

$$V_O = (V_{REF} - V_I) \frac{R4}{R2} + V_{REF}$$

Figure 8-1. Inverting Amplifier With Voltage Reference

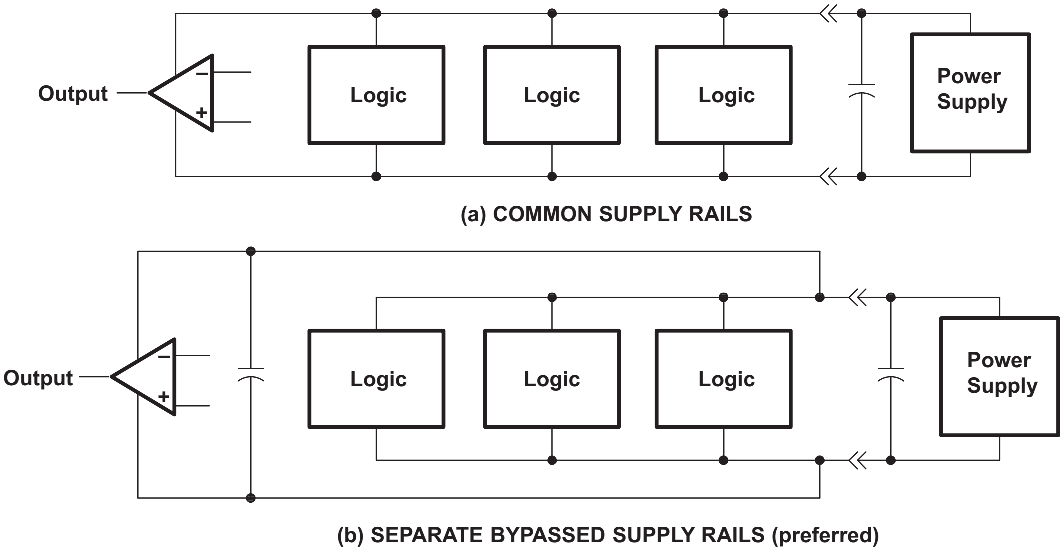


Figure 8-2. Common Versus Separate Supply Rails

8.1.2 Input Characteristics

The TLC27M4 and TLC27M9 are specified with a minimum and a maximum input voltage that, if exceeded at either input, can 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} – 1V at T_A = 25°C and at V_{DD} – 1.5V at all other temperatures.

Because of the extremely high input impedance and resulting low bias current requirements, the TLC27M4 and TLC27M9 are practical 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. Include guard rings around inputs (similar to those of Figure 7-4 in the *Parameter Measurement Information* section). These guards must be driven from a low-impedance source at the same voltage level as the common-mode input (see Figure 8-3).

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

8.1.3 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 50kΩ, since bipolar devices exhibit greater noise currents.

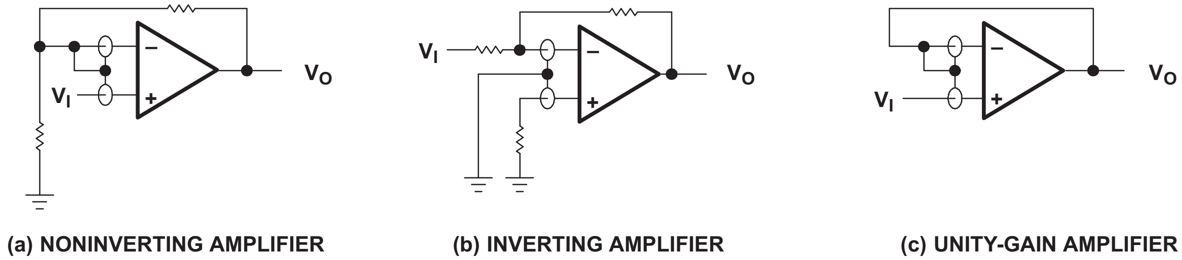


Figure 8-3. Guard-Ring Schemes

8.1.4 Output Characteristics

The output stage of the TLC27M4 and TLC27M9 is designed to sink and source relatively high amounts of current. 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.

The TLC2M4 and TLC27M9 devices can 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. In many cases, adding a small amount of resistance in series with the load capacitance alleviates the problem.

8.1.5 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 and ignoring stray input capacitance. A small-value capacitor connected in parallel with the feedback resistor is an effective remedy (see Figure 8-4). The value of this capacitor is optimized empirically.

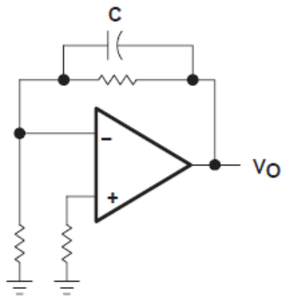


Figure 8-4. Compensation for Input Capacitance

8.1.6 Electrostatic Discharge Protection

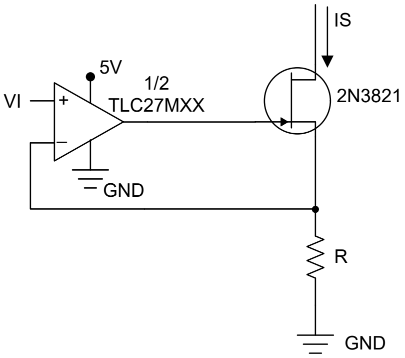
The TLC27M4 and TLC27M9 incorporate an internal electrostatic-discharge (ESD) protection circuit that prevents functional failures at voltages up to 2000V as tested under MIL-STD-883C, Method 3015.2. Care must be exercised, however, when handling these devices because exposure to ESD can result in the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

8.1.7 Latch-Up

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

The current path established if latch-up occurs is typically between the positive supply rail and ground and 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 typically results in the destruction of the device. The chance of latch-up occurring increases with increasing temperature and supply voltages.

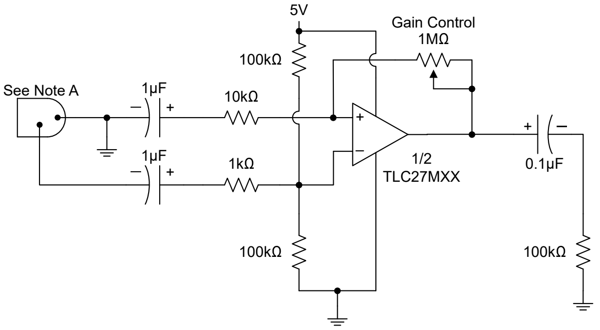
8.2 Typical Application



A. V_I = 0V to 3V

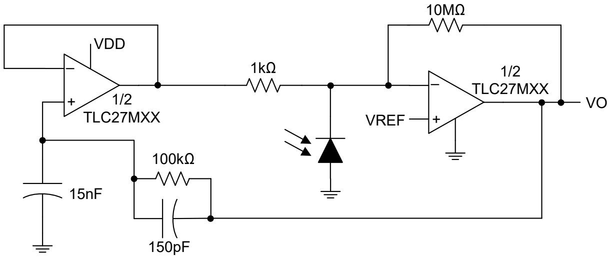
B. $I_S = \frac{V_I}{R}$

Figure 8-5. Precision Low-Current Sink



A. Low to medium impedance dynamic mike.

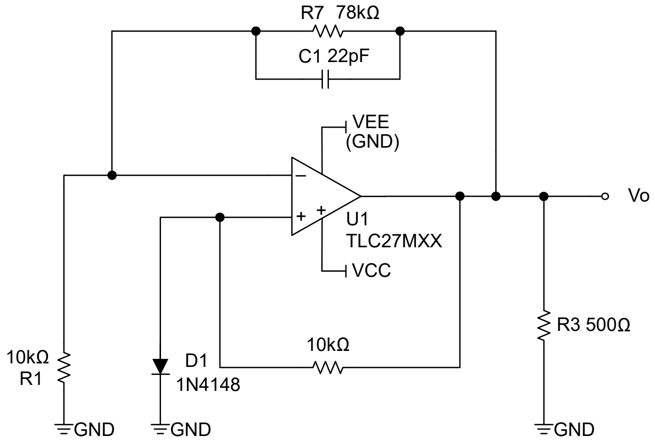
Figure 8-6. Microphone Preamplifier



A. V_{DD} = 4V to 15V

B. V_{ref} = 0V to V_{DD}– 2V

Figure 8-7. Photo-Diode Amplifier With Ambient Light Rejection



A. V_{DD} = 8V to 16V

B. V_O = 5V, 10mA

Figure 8-8. 5V Low-Power Voltage Regulator

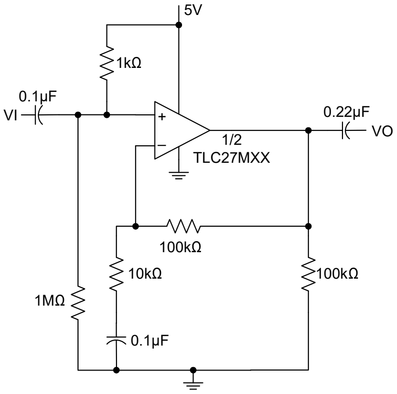


Figure 8-9. Single-Rail AC Amplifiers

9 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

9.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

9.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

9.4 Trademarks

LinCMOS™ is a trademark of Texas Instruments.
TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

9.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

9.6 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision D (October 2012) to Revision E (July 2026)	Page
• Added device name to document title	0
• Changed Trimmed offset voltage from ±900μV to ±300μV	1
• Changed Low power from 2.1mW to Quiescent Current 120μA	1
• Changed High Input impedance from $10^{12}\Omega$ to $6T\Omega$	1
• Deleted Common mode input voltage range	1
• Deleted Output voltage range includes negative rail	1
• Deleted small outline package option	1
• Added Applications section	1
• Added Device Information table	1
• Deleted *TLC27M4Y chip information* section	5
• Deleted Total current into V_{DD}	5

- Deleted Total current out of GND ... 5
- Deleted Continuous total dissipation ... 5
- Deleted Case temperature for 60 seconds ... 5
- Changed Output current from ±30mA to output short circuit continuous ... 5
- Changed Input offset voltage for TLC27M4C from 1.1mV to ±0.3mV ... 6
- Changed Input offset voltage for TLC27M4AC from 0.9mV to ±0.3mV ... 6
- Changed Input offset voltage for TLC274BC from 250µV to ±300µV ... 6
- Changed Input offset voltage for TLC279C typ from 210µV to ±300µV ... 6
- Changed Input offset voltage for TLC279C max from 900µV to 1500µV ... 6
- Deleted Test conditions for V_{IO}, I_{IO}, I_{IB} ... 6
- Changed Common-mode rejection ratio from 91dB to 80dB, Supply-voltage rejection ratio ... 6
- Changed Supply-voltage rejection ratio from 93dB to 140dB at 25°C and 120dB at 0° and 70°C ... 6
- Changed Average temperature coefficient of input voltage from 2.1µV/°C to ±0.75µV/°C ... 7
- Changed Input offset current from 0.1pA to ±5pA ... 7
- Changed Input bias current from 0.7pA to ±10pA ... 7
- Changed Common-mode input voltage range from −0.3V to −0.2V ... 7
- Changed High-level output voltage from 8.7V to 9.95V ... 7
- Changed Large-signal differential voltage amplification from 275V/mV to 1000V/mV ... 7
- Deleted T_A = 0°C and 70°C values ... 12
- Changed Slew rate from 0.43V/ s to 0.5V/ s at 100mV ... 12
- Changed Slew rate from 0.40V/ s to 4.5V/ s at 1V ... 12
- Changed RL in Slew rate from 100KΩ to 10KΩ ... 12
- Changed Maximum output-swing bandwidth from 55kHz to 40kHz ... 12
- Changed Phase margin from 40° to 60° ... 12
- Merged 5V and 10V operating characteristics tables ... 12
- Updated plots with New Die characteristics ... 14
- Added *Old Versus New Die Comparison* section ... 20
- Deleted *Full Power Response* and *Test Time* sections ... 22
- Deleted Effect of Capacitive Loads and Test Circuit, Resistive Pullup to Increase V_{OH}, and Compensation for Input Capacitance figures ... 25
- Deleted text regarding boosting current capacity ... 25
- Added Compensation for Input Capacitance figure ... 25
- Deleted Wien Oscillator, Precision Low-Current Sink, Microphone Preamplifier, Photo-Diode Amplifier With Ambient Light Rejection, Low-Power Voltage Regulator and Single-Rail AC Amplifier figures ... 25
- Added *Typical Application* section ... 25
- Added Precision Low-Current Sink, Microphone Preamplifier, Photo-Diode Amplifier With Ambient Light Rejection, 5V Low-Power Voltage Regulator and Single-Rail AC Amplifier figures in *Typical Application* section ... 26

11 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale, TI’s General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025