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- Trimmed Offset Voltage:
 TLC27L9 . . . 900 μV Max at 25°C,
 V_{DD} = 5 V
- Input Offset Voltage Drift . . . Typically
 0.1 μV/Month, Including the First 30 Days
- Wide Range of Supply Voltages Over Specified Temperature Range:

0°C to 70°C ... 3 V to 16 V -40°C to 85°C ... 4 V to 16 V -55°C to 125°C ... 4 V to 16 V

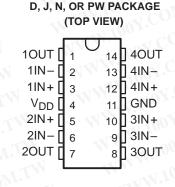
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Ultra-Low Power . . . Typically 195 μW at 25°C, V_{DD} = 5 V
- Output Voltage Range includes Negative Rail
- High Input Impedance . . . $10^{12} \Omega$ Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

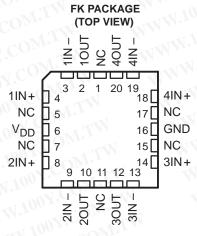
description

The TLC27L4 and TLC27L9 quad operational amplifiers combine a wide range of input offset voltage grades with low offset voltage drift, high input impedance, extremely low power, and high gain.

These devices use Texas instruments silicon-gate LinCMOS™ technology, which provides offset voltage stability far exceeding the stability available with conventional metal-gate processes.

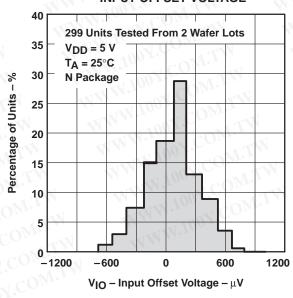
The extremely high input impedance, low bias currents, and low-power consumption make these cost-effective devices ideal for high-gain, low- frequency, low-power applications. Four offset voltage grades are available (C-suffix and l-suffix types), ranging from the low-cost TLC27L4 (10 mV) to the high-precision TLC27L9 (900 μV). 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.





NC - No internal connection

DISTRIBUTION OF TLC27L9 INPUT OFFSET VOLTAGE



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description (continued)

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 TLC27L4 and TLC27L9. The devices also exhibit low voltage single-supply operation and ultra-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 TLC27L4 and TLC27L9 incorporate internal ESD-protection circuits that prevent functional failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015.2; 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 from –55°C to 125°C.

AVAILABLE OPTIONS

	MM	1007.0	PA	CKAGED DEVI	CES	M_{-}^{TW}	CHIP
TA	V _{IO} max AT 25°C	SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	TSSOP (PW)	FORM (Y)
	900 μV	TLC27L9CD	$CO_{\overline{M}}$.	_ <u>~</u>	TLC27L9CN	CONT	- WW
0°C to 70°C	2 mV	TLC27L4BCD	CONTIN	_	TLC27L4BCN	$CO_{\overline{M}^{1,1}}$	_
0°C to 70°C	5 mV	TLC27L4ACD	Y. Om.T	N _ <	TLC27L4ACN	. COMITY	_
	10 mV	TLC27L4CD	OX.CO	- W	TLC27L4CN	TLC27L4CPW	TLC27L4Y
	900 μV	TLC27L9ID	. V.€OM.	-W-	TLC27L9IN	ON.Com	W -
-40°C to 85°C	2 mV	TLC27L4BID	ON TOM		TLC27L4BIN	TOM.	_
-40 C to 65 C	5 mV	TLC27L4AID	1007	T.T.	TLC27L4AIN	$00_J = 0M$	_
	10 mV	TLC27L4ID	· · · · · · · · · · · · · · · · · · ·	TT T	TLC27L4IN	1001-	
-55°C to 125°C	900 μV	TLC27L9MD	TLC27L9MFK	TLC27L9MJ	TLC27L9MN	CO.	TW
-55 C to 125 C	10 mV	TLC27L4MD	TLC27L4MFK	TLC27L4MJ	TLC27L4MN	N. Tuo _ CO	M

The D package is available taped and reeled. Add R suffix to the device type (e.g., TLC27L9CDR).

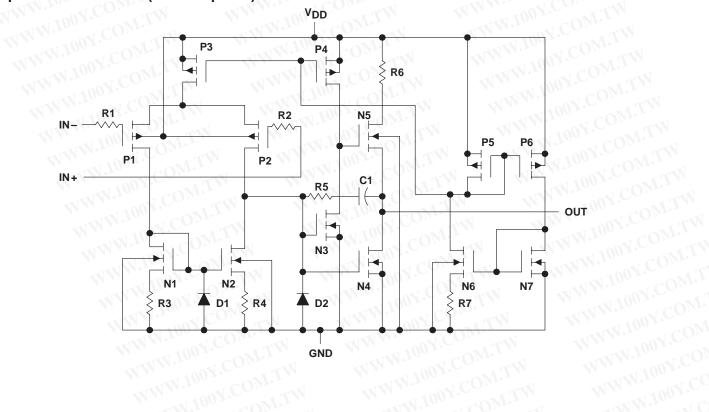
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equivalent schematic (each amplifier)

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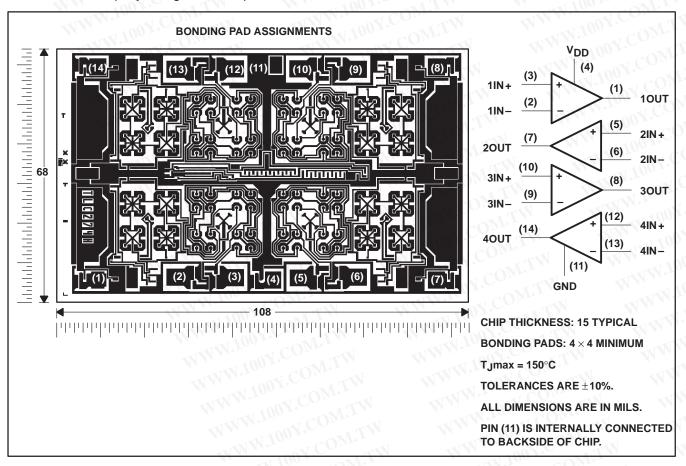
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TLC27L4Y chip information

These chips, when properly assembled, display characteristics similar to the TLC27L4C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips may be mounted with conductive epoxy or a gold-silicon preform.



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

Supply voltage, V _{DD} (see Note 1)	18 V
Differential input voltage, V _{ID} (see Note 2)	±V _{DD}
Input voltage range, V _I (any input)	
Input current, I _I	±5 mA
Output current, IO (each output)	±30 mA
Total current into V _{DD}	
Total current out of GND	45 mA
Duration of short-circuit current at (or below) 25°C (see Note	3) unlimited
Continuous total dissipation	See Dissipation Rating Table
Operating free-air temperature, T _A : C suffix	0°C to 70°C
Operating free-air temperature, T _A : C suffix	0°C to 70°C
Operating free-air temperature, T _A : C suffix	
Operating free-air temperature, T _A : C suffix	
Operating free-air temperature, T _A : C suffix	
Operating free-air temperature, T _A : C suffix	

[†] Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. All voltage values, except differential voltages, are with respect to network ground.
 - 2. Differential voltages are at IN+ with respect to IN-.
 - 3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded (see application section).

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25^{\circ}C$ 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	950 mW	7.6 mW/°C	608 mW	494 mW	_ N
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
J	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
N	1575 mW	12.6 mW/°C	1008 mW	819 mW	
PW	700 mW	5.6 mW/°C	448 mW	1007.0	$M.T^{N}$

recommended operating conditions

	ZINW.Inc. CONT.	C SU	FFIX	I SUI	FFIX	M SU	FFIX	UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	UNIT
Supply voltage, V _{DD}	MM. TIOOX.CONITY	3	16	4	16	4	16	V
Common mode insultivations Vi-	V _{DD} = 5 V	-0.2	3.5	-0.2	3.5	0	3.5	V
Common-mode input voltage, V _{IC}	V _{DD} = 10 V	-0.2	8.5	-0.2	8.5	0	8.5	V
Operating free-air temperature, TA	M. 100 COM:	0	70	-40	85	-55	125	°C

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electrical characteristics at specified free-air temperature, V_{DD} = 5 V (unless otherwise noted)

1	PARAMETER TLC27L4C		TEST CON	DITIONS	T _A †	TI TI TI	UNIT		
			-TWW.1	ONI		MIN	TYP	MAX	O_{Mr}
	W. 100x.	TI C271 4C	V _O = 1.4 V,	V _{IC} = 0,	25°C		1.1	10	OM.
		12027240	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			12	mV
		TLC27L4AC	V _O = 1.4 V,	V _{IC} = 0,	25°C	W	0.9	5	HUV
VIO	Input offset voltage	TEG27E4AC	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range		WW	6.5	V.CO
۷IO	input onset voltage	TLC27L4BC	V _O = 1.4 V,	$V_{IC} = 0$,	25°C		240	2000	×1 CC
		TEGZ7E4BC	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range		M 4.	3000	μV
		TLC27L9C	V _O = 1.4 V,	V _{IC} = 0,	25°C		200	900	μν
	Wire	12027290	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	J	wal '	1500	No.
ανιο	Average temperature confiset voltage	pefficient of input	r.I.A.	WWW.100	25°C to 70°C	N	1.1	WW	μV/°C
	land offers and the second	Nete 4) 7 CO	V 0.5 V	W OFW	25°C	CVV	0.1	WW	
lo	Input offset current (see	e Note 4)	$V_0 = 2.5 V$,	$V_{IC} = 2.5 V$	70°C	-31	7	300	pA
	Laurent Indian arrange (Austria	Maracia 100 Y.C.	V 0.5V	V 0.5V	25°C	TA	0.6	A4	33,11
IB	Input bias current (see	Note 4)	$V_0 = 2.5 \text{ V},$	$V_{IC} = 2.5 V$	70°C	WILL	40	600	pA
	Common mode input vo	oltage range	CONTAN	MMA	25°C	-0.2 to 4	-0.3 to 4.2	V	V
VICR	(see Note 5)	MMM:100	V.COM.TW		Full range	-0.2 to 3.5	TW		V
		-XV.1	o COM'I		25°C	3.2	4.1	1	-31
Vон	High-level output voltag	je .	V _{ID} = 100 mV,	$R_L = 1 M\Omega$	0°C	3	4.1		V
			LOOY.COM		70°C	3	4.2	W	V
		VVV	COM.	TV	25°C	N.C.	0	50	4
VOL	Low-level output voltage	е	$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	0°C	×1 (0 0	50	mV
			W 100 Y.C		70°C	00 .	0	50	
		WV	TOUX.CO.	WTT	25°C	50	520	TIN	
A_{VD}	Large-signal differential amplification	voltage	$V_0 = 2.5 \text{ V to 2 V},$	$R_L = 1 M\Omega$	0°C	50	680	17	√V/mV
	amplification		WW.100 2		70°C	50	380	Mr.	CN .
			1007.	OWITH	25°C	65	94	oM_{ij}	41
CMRR	Common-mode rejectio	n ratio	V _{IC} = V _{ICR} min		0°C	60	95		dB
			WWW.IO		70°C	60	95	COR	TW
			1, 100.	COM	25°C	70	97	$CO_{\overline{D}}$	TAX.
ksvr	Supply-voltage rejection	n ratio	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	0°C	60	97	- c0	dB
	$(\Delta V_{DD}/\Delta V_{IO})$		WWW	OY.CO	70°C	60	98	Y. C	
			STAM.	ON CON	25°C	WW	40	68	
I_{DD}	Supply current (four am	plifiers)	V _O = 2.5 V, No load	$V_{IC} = 2.5 V,$	0°C		48	84	μΑ
	•		140 loau		70°C		31	56	

[†] Full range is 0°C to 70°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.



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electrical characteristics at specified free-air temperature, V_{DD} = 10 V (unless otherwise noted)

WW	PARAMETER		TEST CON	DITIONS	τ _A †	N 10 TI TI VI 1TI TI	UNIT		
		1.1	W.100		N X	MIN	TYP	MAX	TW
1//	1007.0	TLC27L4C	V _O = 1.4 V,	V _{IC} = 0,	25°C	wil.	1.1	10	1.1
		TLC27L4C	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	1	1 100 3	12	mV
		TLC27L4AC	V _O = 1.4 V,	V _{IC} = 0,	25°C	MM	0.9	5	IIIV
\/.o	Input offset voltage	TLC27L4AC	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	THE WAR	M.r.	6.5	\mathcal{I}_{N_1}
VIO	input onset voltage	TLC27L4BC	V _O = 1.4 V,	V _{IC} = 0,	25°C		260	2000	OM.
		TEC27L4BC	$R_S = 50 \Omega$	$R_L = 1 M\Omega$	Full range	111 4	_ xx1.1	3000	μV
		TLC27L9C	V _O = 1.4 V,	V _{IC} = 0,	25°C	W	210	1200	μν
	W.100	TECZ/E9C	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	* 3	WW	1900	I.CO
αVIO	Average temperature of input offset voltage	coefficient of	M MI	NAN-100 X	25°C to 70°C		1	N. 100	μV/°C
	Lauret - 16 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	· Mari COM.	wal ev	W. EV. W	25°C		0.1	11.	NY.C
lio	Input offset current (se	e Note 4)	$V_0 = 5 V$,	$V_{IC} = 5 V$	70°C		7	300	γpΑ
		11007	TY-V	N 11 = 1100	25°C		0.7	-TXN	100 x.
İΙΒ	Input bias current (see	Note 4)	$V_0 = 5 V$,	$V_{IC} = 5 V$	70°C	N	50	600	pA
	Common-mode input v	roltage range	OM.TW	WWW.1	25°C	-0.2 to 9	-0.3 to 9.2	NW	N.V
VICR	(see Note 5)	MM.1007.	OM.TW		Full range	-0.2 to 8.5	Í	WV	V
		1003	OWITH	W T	25°C	8	8.9	7	Wire
Vон	High-level output voltage	ge	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	0°C	7.8	8.9		V
			A COM.		70°C	7.8	8.9		WW
			CONL	ST	25°C	OM.	0	50	wW
VOL	Low-level output voltage	je	$V_{ID} = -100 \text{ mV},$	I _{OL} = 0	0°C	COM	0	50	mV
			100Y.CO		70°C		0	50	
		WWW	CON	TW	25°C	50	870	N	V
AVD	Large-signal differentia amplification	ıl voltage	$V_0 = 1 \text{ V to 6 V},$	$R_L = 1 M\Omega$	0°C	50	1020	W	V/mV
	апринсанон		N.100 Y.		70°C	50	660	- 1	
		MM	11007.00	TIN	25°C	65	97	1.14	
CMRR	Common-mode rejection	on ratio	V _{IC} = V _{ICR} min		0°C	60	97	W	dB
			MM. Ing - CO		70°C	60	97		
			1001	OWIT	25°C	70	97	Mrr	≪ĭ
ksvr	Supply-voltage rejection (ΔVDD/ΔVIO)	n ratio	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	$V_0 = 1.4 \text{ V}$	0°C	60	97	$T.M_{C}$	dB
	(AADD)AAIO)		WWW.	CONTAIN	70°C	60	98	911	
			TWW. Inc.	COM	25°C	Mir	57	92	
I_{DD}	Supply current (four an	nplifiers)	V _O = 5 V, No load	$V_{IC} = 5 V$,	0°C		72	132	μΑ
			TWO IDAU		70°C		44	80	

† Full range is 0°C to 70°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.



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electrical characteristics at specified free-air temperature, V_{DD} = 5 V (unless otherwise noted)

TV.	PARAMETER		TEST CONI	DITIONS	T _A †	TL TL TL	UNIT		
	M. 100 1.	OM.I	TWW.1	ON COM		MIN	TYP	MAX	O_{Mr}
	W. 1001.	TLC27L4I	V _O = 1.4 V,	V _{IC} = 0,	25°C	- N	1.1	10	OM.
		11027141	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range		-31	13	mV
		TLC27L4AI	V _O = 1.4 V,	$V_{IC} = 0$,	25°C	W	0.9	5	IIIV
VIO	Input offset voltage	TEO27E4AI	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range		WW	7	V.CO
۷IO	input onset voltage	TLC27L4BI	V _O = 1.4 V,	$V_{IC} = 0$,	25°C		240	2000	×1 C
		TEGZ/E4BI	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range		M	3500	μV
		TLC27L9I	V _O = 1.4 V,	$V_{IC} = 0$,	25°C		200	900	μν
	WW	TEO27E9I	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	J		2000	W.
ανιο	Average temperature confiset voltage	oefficient of input	T.I.	WWW.100	25°C to 85°C	N	1.1	WW	μV/°C
		W. Joseph CC	V OFV	14 0.514	25°C	CVV	0.1		1
liO	Input offset current (see	e Note 4)	$V_0 = 2.5 V$,	$V_{IC} = 2.5 V$	85°C	- 1	24	1000	pA
			WILLIAM .	N - WA	25°C	1.11	0.6	Al.	-W.19
IB	Input bias current (see	Note 4)	$V_0 = 2.5 V$,	$V_{IC} = 2.5 V$	85°C	WT	200	2000	pA
	Common-mode input v	oltage range	COM.TW	WWW	25°C	-0.2 to 4	-0.3 to 4.2	V	V
VICR	(see Note 5)	WWW.10	NY.COM.TW WW		Full range	-0.2 to 3.5	TW		V
		L.W.	DO. COM'I.		25°C	3.2	4.1	ĺ	-11
Vон	High-level output voltage	ge	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	-40°C	3	4.1		V
			LOUX.COM		85°C	3	4.2	N	V
		VWV	COM.	TW	25°C	N.C.	0	50	4
VOL	Low-level output voltag	e	$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	-40°C	×1 (0 0	50	mV
			100 Y.		85°C	00 .	0	50	
		W	A. TOON CO.	WTI	25°C	50	480	TW	
A_{VD}	Large-signal differentia amplification	l voltage	$V_0 = 0.25 \text{ V to 2 V},$	$R_L = 1 M\Omega$	-40°C	50	900	. 17	√V/mV
	amplification		W.100 1		85°C	50	330	Mr.	(X)
			1001	-OM:TW	25°C	65	94	W.	-
CMRR	Common-mode rejection	on ratio	V _{IC} = V _{ICR} min		-40°C	60	95	110	dB
			WW.Io		85°C	60	95	COR	TW
	-		A. 100,	COM	25°C	70	97	$CO_{\overline{N}}$	
ksvr	Supply-voltage rejection	n ratio	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	-40°C	60	97	. 601	dB
	$(\Delta V_{DD}/\Delta V_{IO})$		WWW	OY.CO	85°C	60	98	A.C.	
			M.M.M.	CON	25°C	WW	39	68	
I_{DD}	Supply current (four am	nplifiers)	V _O = 2.5 V,	$V_{IC} = 2.5 V,$	-40°C		62	108	μΑ
20		. ,	No load		85°C		29	52	

[†]Full range is -40°C to 85°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.



^{5.} This range also applies to each input individually.

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electrical characteristics at specified free-air temperature, V_{DD} = 10 V (unless otherwise noted)

NN	PARAMETER	LM A	TEST CON	DITIONS	TAT	TI ATI	LC27L4I LC27L4 <i>I</i> LC27L4I LC27L9I	AI BI	UNIT
		. I V	WW.100		XI XX	MIN	TYP	MAX	W
	1007.	TLC27L4I	V _O = 1.4 V,	V _{IC} = 0,	25°C	WIXE	1.1	10	1.1
		1LC2/L41	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	1	1 1007	13	- N
		TI C271 4A1	V _O = 1.4 V,	V _{IC} = 0,	25°C	MMA	0.9	5	mV
\/. -	lanut offset voltage	TLC27L4AI	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	WW	W.ra.	7	D_{Mr}
VIO	Input offset voltage	TI COZI ADI	V _O = 1.4 V,	V _{IC} = 0,	25°C		260	2000	OM
		TLC27L4BI	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range		311	3500	Mas
		TI C271 01	V _O = 1.4 V,	V _{IC} = 0,	25°C	W	210	1200	μV
	W.100	TLC27L9I	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	<	WW	2900	$^{\Lambda}$.C $_{O_L}$
αVIO	Average temperature co offset voltage	efficient of input	W WW	1.100 X.C	25°C to 85°C		1	N.100	μV/°C
		u st CONI.	wal su	WW. Two	25°C		0.1	Missi	V.C
liO	Input offset current (see	Note 4)	$V_0 = 5 V$,	$V_{IC} = 5 V$	85°C		26	1000	pΑ
		1007.	TW V	100	25°C		0.7	- XXI	100
ΙΒ	Input bias current (see N	Note 4)	$V_O = 5 V$	V _{IC} =.5 V	85°C	N	220	2000	pA
	Common-mode input vo	oltage range	DM.TW	WWW.I	25°C	-0.2 to 9	-0.3 to 9.2	WW	N.VOO
VICR	(see Note 5)	N. 100 X .	OM.TW		Full range	-0.2 to 8.5		WY	V
	N.	100	OWITH	71	25°C	8	8.9	44	WIN
Vон	High-level output voltage	e VV	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	-40°C	7.8	8.9		V
			Y.COM.		85°C	7.8	8.9		WWN
		77W.10	COM	1 - 1	25°C	COMP.	0	50	WIN
VOL	Low-level output voltage	, WW.	$V_{ID} = -100 \text{ mV},$	I _{OL} = 0	-40°C	COM	0	50	mV
			OOY.COTT		85°C		0	50	11/1
		WWW.	CON	W	25°C	50	800	N	V
AVD	Large-signal differential amplification	voltage	$V_0 = 1 \text{ V to 6 V},$	$R_L = 1 M\Omega$	-40°C	50	1550	XX	V/mV
	amplification		N 100 Y.	In	85°C	50	585	-1	
		MM	1100 Y.C.	LIV	25°C	65	97	1.44	
CMRR	Common-mode rejection	n ratio	V _{IC} = V _{ICR} min		-40°C	60	97	TI	dB
			MAIN CC		85°C	60	98		Ī
		44	1001.	OMITW	25°C	70	97	Mir	T
ksvr	Supply-voltage rejection	ratio	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	-40°C	60	97	$T_{\cdot Mc}$	dB
	$(\Delta V_{DD}/\Delta V_{IO})$		WWW.I	COM	85°C	60	98		
			111W.100	COM	25°C	1111.77	57	92	
I_{DD}	Supply current (four amp	plifiers)	$V_0 = 5 V$,	$V_{IC} = 5 V$	-40°C		98	172	μΑ
		•	No load		85°C		40	72	

†Full range is -40°C to 85°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.



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electrical characteristics at specified free-air temperature, V_{DD} = 5 V (unless otherwise noted)

	PARAMETER		TEST CONI	DITIONS	T _A †	- T 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	.C27L4I .C27L9I		UNI
			W.10			MIN	TYP	MAX	Mr.
	WW. 1007.0	TLC27L4M	V _O = 1.4 V,	V _{IC} = 0,	25°C	N. T	1.1	10) m)/
V	lanut effect voltage	TLC27L4W	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	11/11	-311	12	mV
VIO	Input offset voltage	TLC27L9M	V _O = 1.4 V,	V _{IC} = 0,	25°C	W	200	900	V
	W .100 1.	TLC27L9W	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	- 1	WW.	3750	μV
αVIO	Average temperature co offset voltage	efficient of input	N WW	W.100 1.	25°C to 125°C		1.4	700	μV/°(
	Input offset current (see	Note 4)	V = 2.5 V	V10 - 2 E V	25°C		0.1	N.r.	pA
lo lo	input onset current (see	Note 4)	V _O = 2.5 V,	V _{IC} = 2.5 V	125°C		1.4	15	nA
1	lanut hisa aymaat (aaa h	(20 1)	V- 05V	V 10.5.V	25°C		0.6	-xx1 1	рА
lВ	Input bias current (see N	iote 4)	$V_0 = 2.5 \text{ V},$	$V_{IC} = 2.5 V$	125°C	V	9	35	nA
.,	Common-mode input vo	Itage range	M.TW	WWW.100	25°C	-0.2 to 4	-0.3 to 4.2		1.1V
VICR	(see Note 5)	W.100Y.C	OM.TW		Full range	-0.2 to 3.5		WW	V
	W	1007.	TITT	MA	25°C	3.2	4.1	- 14	
Vон	High-level output voltage	eWW.	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	−55°C	3	4.1	1	V
			COM		125°C	3	4.2	4	VV
		V 100	COMP		25°C	$O_{M^{*}}$	0	50	
VOL	Low-level output voltage		$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	−55°C	M.	0	50	m√
			MY.COM TV	I W	125°C		0	50	W
		TWW.	COM	N v	25°C	50	480		V
AVD	Large-signal differential amplification	voltage	$V_0 = 0.25 \text{ V to 2 V},$	$R_L = 1 M\Omega$	−55°C	25	950	*1	V/m
	amplification		100 Y. COM.		125°C	25	200	**	1
		MMA	TOON.CO.	TW	25°C	65	94	M	
CMRR	Common-mode rejection	n ratio	V _{IC} = V _{ICR} min		−55°C	60	95	TW	dB
			W.100 . CO		125°C	60	85	-31	1
		N.	1001.	Milly	25°C	70	97	1.1	-
ksvr	Supply-voltage rejection	ratio	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	−55°C	60	97	TIM	dB
	(ΔΛDD/7ΛΙΟ)		WW. TO C		125°C	60	98		W
			111W.100	OM	25°C	Wira.	39	68	-TX
I_{DD}	Supply current (four amp	olifiers)	V _O = 2.5 V, No load	$V_{IC} = 2.5 V,$	−55°C	VIVI.II	69	120	μΑ
			No load		125°C	1	27	48	IN



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electrical characteristics at specified free-air temperature, V_{DD} = 10 V (unless otherwise noted)

WW	PARAMETER		TEST COI	NDITIONS	TAT		C27L4I		UNIT
			W 100 r			MIN	TYP	MAX	
M	1100Y.	TLC27L4M	V _O = 1.4 V,	V _{IC} = 0,	25°C	-TXV.1	1.1	10	\/-
v W	Vanue of a college	TLC27L4M	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	N. T.	1007	12	mV
VIO	Input offset voltage	TI 0071 0M	V _O = 1.4 V,	V _{IC} = 0,	25°C	MIN.	210	1200	
		TLC27L9M	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range	TINI	Too	4300	μV
αγιο	Average temperature co	pefficient of	WWW.	TOON.COM	25°C to 125°C	WW	1.4	N.C	μV/°C
	1 N 1	40M	V EV	100 EVO	25°C	-311	0.1	×1 (pA
ΙΟ	Input offset current (see	Note 4)	V _O = 5 V,	V _{IC} = 5 V	125°C		1.8	15	nA
	1		V 5V	V 105X	25°C	W	0.7	1007	рА
lΒ	Input bias current (see I	Note 4)	$V_0 = 5 V$,	$V_{IC} = 5 V$	125°C		10	35	nA
V	Common-mode input vo	oltage range	W W	M.100X.	25°C	0 to 9	-0.3 to 9.2	W.10	N V
VICR	(see Note 5)	100X.COM	T.TW V		Full range	0 to 8.5	W	NW.	V.
	MM	11007	MIN	10	25°C	8	8.9		100
Vон	High-level output voltag	e .CC	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	−55°C	7.8	8.8	MAA.	VO
			0_{M}		125°C	7.8	9	WW	N.2
		111.100	OM_{*}	War	25°C	. 1	0	50	M're
VOL	Low-level output voltage	e 1007.	$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	-55°C	TILL	0	50	mV
			CONTANT		125°C	TI	0	50	M
		M.IO	COM	WW	25°C	50	800	1	MA
A_{VD}	Large-signal differential amplification	voltage	$V_0 = 1 \ V \ to \ 6 \ V$	$R_L = 1 M\Omega$	−55°C	25	1750		V/mV
	атриновант	WW. 10	DY. OM.TV	1111	125°C	25	380		NN '
		MAN	MY.CO	N N	25°C	65	97		4/1/4
CMRR	Common-mode rejectio	n ratio	V _{IC} = V _{ICR} min		−55°C	60	97		dB
			Too r. COM.		125°C	60	91	X.	***
		MAL	100Y.	IM	25°C	70	97		4
ksvr	Supply-voltage rejection (ΔV _{DD} /ΔV _{IO})	n ratio	$V_{DD} = 5 \text{ V to } 10 \text{ V}$	$V_0 = 1.4 \text{ V}$	−55°C	60	97		dB
	(¬, \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	WX	M. To CO		125°C	60	98	TW	
			W.100	W.	25°C	o √ 1 (57	92	
I_{DD}	Supply current (four am	plifiers)	$V_O = 5 V$, No load	$V_{IC} = 5 V$	−55°C	700	111	192	μΑ
			140 1000		125°C	1003	35	60	

†Full range is -55°C to 125°C.

NOTES: 4. The typical values of input bias current and Input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually. WWW.100Y

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electrical characteristics at specified free-air temperature, V_{DD} = 5 V, T_A = 25°C (unless otherwise noted)

	STANDAMETER N STANDAMETER N	TEST COM	DITIONS	TI	LC27L4	CO_{i}	100
	PARAMETER	TEST CONI	MIN	TYP	MAX	UNIT	
VIO	Input offset voltage	$V_{O} = 1.4 \text{ V},$ $R_{S} = 50 \Omega,$	$V_{IC} = 0,$ $R_L = 1 M\Omega$	WW	1.1	10	mV
ανιο	Average temperature coefficient of input offset voltage	T _A = 25°C to 70°C	NI.		1.1	. V.	μV/°C
lιο	Input offset current (see Note 4)	V _O = 2.5 V,	V _{IC} = 2.5 V		0.1	100	рА
I _{IB}	Input bias current (see Note 4)	$V_0 = 2.5 V$,	V _{IC} = 2.5 V		0.6	700,	pА
V _{ICR}	Common-mode input voltage range (see Note 5)	MMM.100X.C	COM.TW	-0.2 to 4	-0.3 to 4.2	N.100	V
Vон	High-level output voltage	V _{ID} = 100 mV,	$R_L = 1 M\Omega$	3.2	4.1	1	V
VOL	Low-level output voltage	$V_{ID} = -100 \text{ mV},$	IOL = 0	J.	0	50	mV
AVD	Large-signal differential voltage amplification	$V_0 = 0.25 \text{ V to 2 V},$	$R_L = 1 M\Omega$	50	520	WW	V/mV
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}min$	OY.	65	94	1	dB
ksvr	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	70	97	MAIN	dB
I _{DD}	Supply current (four amplifiers)	V _O = 2.5 V, No load	$V_{IC} = 2.5 V,$	TW	40	68	μА

electrical characteristics at specified free-air temperature, V_{DD} = 10 V, T_A = 25 °C (unless otherwise noted)

	DADAMETER ST. 100 x. CON.	TEST SOM	DITIONS	T-MO	LC27L4	′	
	PARAMETER	TEST CON	DITIONS	MIN	TYP	MAX	UNIT
VIO	Input offset voltage	$V_{O} = 1.4 \text{ V},$ $R_{S} = 50 \Omega,$	$V_{IC} = 0,$ $R_L = 1 M\Omega$	CON	1.1	10	mV
ανιο	Average temperature coefficient of input offset voltage	T _A = 25°C to 70°C	W 100	- 00	1		μV/°C
IIO	Input offset current (see Note 4)	V _O = 5 V,	V _{IC} = 5 V	ON.	0.1		pA
I _{IB}	Input bias current (see Note 4)	V _O = 5 V,	V _{IC} = 5 V	ant.C	0.7	W	pА
VICR	Common-mode input voltage range (see Note 5)	COM.TW	WWW.	-0.2 to 9	-0.3 to 9.2	TW	V
Vон	High-level output voltage	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	8	8.9	1.	V
VOL	Low-level output voltage	$V_{ID} = -100 \text{ mV},$	I _{OL} = 0	W 100	0	50	mV
A _{VD}	Large-signal differential voltage amplification	$V_{O} = 1 \text{ V to 6 V},$	$R_L = 1 M\Omega$	50	870	Time	V/mV
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICR} min	W	65	97	$\Omega_{N_{\alpha}}$	dB
ksvr	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	70	97	OM	dB
I _{DD}	Supply current (four amplifiers)	V _O = 5 V, No load	V _{IC} = 5 V,	WW.	57	92	μΑ

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.

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

WW	PARAMETER	TEST CO	ONDITIONS	TA	TI	LC27L4 LC27L4 LC27L4 LC27L9	AC BC	UNIT
		W.100	COM		MIN	TYP	MAX	WW
	1001. ONITH	1001	COM.	25°C	WIN.	0.03	COL	1.1
		N W 1005	V _{IPP} = 1 V	0°C	N. A.	0.04		M.I.M
CD	CINN, IV COM	$R_L = 1 M\Omega$,	V.CON.	70°C	MM	0.03	N.C	N/L
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1	COM	25°C		0.03	N.C	V/µs
		Nov. igaio	V _{IPP} = 2.5 V	0°C		0.03	10	OM.
		WW	001.	70°C	1/1/4	0.02	00x.	Mon
٧n	Equivalent input noise voltage	f = 1 kHZ, See Figure 2	$R_S = 20 \Omega$,	25°C	W	70	.100Y	nV/√Hz
	WW. 100Y. CONTRA	W.	x 100 x.	25°C		5	N.100	CO
Вом	Maximum output-swing bandwidth	$V_O = V_{OH}$, $R_I = 1 M\Omega$,	C _L = 20 pF, See Figure 1	0°C		6	-110	kHz
		KL = 1 Wisz,	See Figure 1	70°C		4.5	M	NY.C
	M. TOO TO COM. T.		MW.Too	25°C	s I	85	VW.	~ ×1 (
В1	Unity-gain bandwidth	$V_I = 10 \text{ mV},$	$C_L = 20 pF$,	0°C		100	-100	kHz
		See Figure 3	M. 100X.	70°C		65	A.	100Y
	M. In. COM.	- N	WWW.	25°C	W	34°	MWA	1007
φm	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	0°C	- 1	36°	- TW	W.Inc
		Σ <u>- 2</u> 0 μι,	Cool Iguio o	70°C	1.7.4	30°	11	W.101

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

	PARAMETER WWW.100Y.CO	TEST CO	ONDITIONS	TAY.C	TLC27L4 TLC27L4 TLC27L4 TLC27L9	AC BC	UNIT
	WW. 100X.	WILMO		100 Y	MIN TYP	MAX	
	MMM	COLLIN	MIN	25°C	0.05		4/1/
		COM	V _{IPP} = 1 V	0°C	0.05	N	W
SR	Class rate at units agin	$R_L = 1 M\Omega$,		70°C	0.04	-31) \////
SK	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C	0.04	1.4	V/μs 🤇
		7.0	V _{IPP} = 5.5 V	0°C	0.05	TW	1
		A COM	XXI	70°C	0.04	W	1
٧n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C	.C70	M.T.	nV/√ Hz
	WWW	CO	W. T.W.	25°C	V.C.	T	N
ВОМ	Maximum output-swing bandwidth	$V_O = V_{OH},$ $R_I = 1 M\Omega,$	C _L = 20 pF, See Figure 1	0°C	1.3	O_{Mr} .	kHz
			See rigule r	70°C	0.9		1
	MA	1007.6	TILL	25°C	110		
B ₁	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 pF$,	0°C	125		kHz
		See Figure 3	COM.	70°C	90		1
	V	1,100	(5	25°C	38°		
φm	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	0°C	40°		1
		CL = 20 pi ,	cccguio c	70°C	34°		1

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

	PARAMETER	TEST CO	ONDITIONS	TA	J	LC27L4 LC27L4 LC27L4 LC27L9	AI BI	UNIT
	W.100 r COM.1	LINW.10	COM	«N	MIN	TYP	MAX	O_{Mr}
	WW. TOOX.	W TW.1	$g_{0,r}$	25°C		0.03	JU -	OM.
		MM	V _{IPP} = 1 V	-40°C	111	0.04	100x	Mos
0.0	O TINNING CONT.	$R_L = 1 M\Omega$	LOV.COM	85°C	W	0.03	4003	CO
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1	Jos COD	25°C		0.03	.10	V/μs
		0001.194.01	V _{IPP} = 2.5 V	-40°C		0.04	N.100	- c0
		M MM	100Y.C	85°C		0.02	-xx 10	07.0
٧n	Equivalent input noise voltage	f = 1 HZ, See Figure 2	$R_S = 20 \Omega$,	25°C	1	70	WW.	nV/√Hz
	MALTIONICA	IN	1007.	25°C		5	TVN	700 .
Вом	Maximum output-swing bandwidth	$V_O = V_{OH},$ $R_L = 1 M\Omega,$	C _L = 20 pF, See Figure 1	-40°C	N	7	MA.	kHz
		$R_{\perp} = 1 \text{ IVIS2},$	See Figure 1	85°C		4	WW	N.10
	W 100 x	M_{\odot}	A. TOO	25°C		85	-111	W.In.
B ₁	Unity-gain bandwidth	$V_{\parallel} = 10 \text{ mV},$	$C_L = 20 pF,$	-40°C	1.1.	130	11	kHz
		See Figure 3		85°C	WTI	55	W	1
	TWW.Isa	COM	· ENWW.	25°C	TV	34°	T)	M.M.
φm	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	-40°C	DMr.	38°		WW.
		OL = 20 pr,	Coc riguio 3	85°C	T.Mo.	28°		N

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

	PARAMETER WWW.100	TEST CO	ONDITIONS	TA	V.COT	LC27L4 LC27L4 LC27L4 LC27L9	AI BI	UNIT
	WWW	MY.Com	LM A	1	MIN	TYP	MAX	
	MMM	V. Com	W	25°C	OOY.C	0.05	TW	
		A COM	V _{IPP} = 1 V	-40°C		0.06	TV	
SR	Clausesta at units anim	$R_L = 1 M\Omega$,	1.7	85°C	100	0.03	1	J. Who
SK	Slew rate at unity gain	C _L = 20 pF, See Figure 1	TILL	25°C	N 1003	0.04	M.T.	V/μs
		J. Soot igans	V _{IPP} = 2.5 V	-40°C	100	0.05	-17	N
		W.Joo	O_{M}	85°C	Mir	0.03	Obs	rW
٧n	Equivalent input noise voltage	f = 1 HZ, See Figure 2	$R_S = 20 \Omega$,	25°C	WW.I	70	COM	nV/√ Hz
		INW.	COM	25°C	MAN		Coz	WT
Вом	Maximum output-swing bandwidth	$V_O = V_{OH},$ $R_L = 1 M\Omega,$	C _L = 20 pF, See Figure 1	-40°C	TINVI	1.4	of CO	kHz
		INC = 1 IVISZ,	See Figure 1	85°C	V - 41X	0.8	> -	
		MW.	OY.CO	25°C	11/1/	110		
B ₁	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 pF$,	-40°C		155		kHz
		See Figure 3		85°C		80		
		V 40 - 11 V	1007.	25°C		38°		
φm	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	-40°C		42°		
		C = 20 pi,	ccc . iguic o	85°C		32°		

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TLC27L4, TLC27L4A, TLC27L4B, TLC27L4Y, TLC27L9 LinCMOS™ PRECISION QUAD OPERATIONAL AMPLIFIERS

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

WW.	PARAMETER	TEST CO	ONDITIONS	TA		LC27L4 LC27L9		UNIT
111.		W.100 F C		- 1	MIN	TYP	MAX	-XX
1	WI 100Y.	100 Y	PM:IN	25°C	W.1	0.03	COM	. 1.
V		100X.	V _{IPP} = 1 V	−55°C	-1	0.04	-01	LTW
CD.	Clays rate at units gain	$R_L = 1 M\Omega$,	CONTRA	125°C	M. M.	0.02	r.Co.	Visio
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1	COM	25°C	OT WY	0.03	$\sim CO$	V/µs
		W 1100	V _{IPP} = 2.5 V	−55°C	- 1	0.04		DM_{TT}
	WWW. any.Com	WW 1100	N.C.	125°C	1/1/1/	0.02	01.0	.ov.T
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C	WV	70	00Y.	nV/√ Hz
	MM. 100X.Co TITW	N. VI	100 Y. O.M.	25°C	14	5	100,	
ВОМ	Maximum output-swing bandwidth	$V_O = V_{OH},$ $R_L = 1 M\Omega,$	C _L = 20 pF, See Figure 1	−55°C		8	100	kHz
			See Figure 1	125°C		3	N.º	V.CO
	M. 100 F. O.W. I.A.		N.100	25°C		85	M.In	*1 C
В1	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 pF,$	−55°C		140	-1XV.1	kHz
		See rigure 5		125°C		45	W	100 X.
	COM.	N v 40	WW. Poor	25°C	N	34°	MAN	You
φm	Phase margin	$V_{l} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	-55°C	· ~SI	39°		1.700
		7 20 p.,	333gulo 0	125°C	LAN	25°	NA .	N.100

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

	PARAMETER	TEST CO	ONDITIONS	TA CO		LC27L4 LC27L9		UNIT
		TW		100 J.C.	MIN	TYP	MAX	1111
	MW. Io	ON.	MW.	25°C	Oh.	0.05		WW
		COM.I	V _{IPP} = 1 V	−55°C	$-O_{MT}$.	0.06		-111
CD	Slaw rate at waits ratio	$R_L = 1 M\Omega$,	N.	125°C	MOD	0.03		\ //a
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1	MAN	25°C	.0	0.04		V/µs
		CONSTANT	V _{IPP} = 5.5 V	−55°C	A'CO	0.06	N	V
	V .10	COWIT	*I	125°C	ST CC	0.03	TA I	
۷n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C	ONY.C	70	TW	nV/√Hz
	WW.	in, "<1 COM.	-3XI _	25°C		COH	TW	
Вом	Maximum output-swing bandwidth	$V_O = V_{OH},$ $R_L = 1 M\Omega,$	C _L = 20 pF, See Figure 1	−55°C	100	1.5	1.1	kHz
		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Occ rigure r	125°C	1 1007	0.7	M.T.V	N
	WW	M. CO.	_ Wrs	25°C	100	110	TIL	N
B ₁	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 pF$,	−55°C	Mir	165) Mr.	kHz
		See rigule 3		125°C	UW.10	70		
	W.	100	ON TW	25°C		38°		
фm	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	−55°C		43°		
		10L - 20 PI,	230 1 19410 0	125°C		29°		

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operating characteristics, V_{DD} = 5 V, T_A = 25°C

1	TANK TOO YOU TO THE TOO THE TOO TO THE TOO TO THE TOO TO THE TOO TO THE TOO THE TOO TO THE TOO TO THE TOO TO THE TOO THE T	TEST OF	MOITIONS	ΤL	_C27L4\	((1)	TUALIT
	PARAMETER	CIEST CO	ONDITIONS	MIN	TYP	MAX	UNIT
SR	Slow rate of unity gain	$R_L = 1 M\Omega$, $C_L = 20 pF$,	V _{IPP} = 1 V	MMA	0.03	Y.CC	V/uo
SK	Slew rate at unity gain	See Figure 1	V _{IPP} = 2.5 V	MM	0.03	107.C	V/μs
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	W	70	100 Y	nV/√ Hz
ВОМ	Maximum output-swing bandwidth	$V_O = V_{OH},$ $R_L = 1 M\Omega,$	C _L = 20 pF, See Figure 1	N	5	1002	kHz
В ₁	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	C _L = 20 pF,		85	1100 N.TOO	kHz
φm	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	1	34°	NW.	00Y.C

operating characteristics, V_{DD} = 10 V, T_A = 25°C

Region Slew rate at unity gain $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		PARAMETER	TEST CO	NDITIONS	TL	.C27L4Y	MM.	UNIT	
Slew rate at unity gain $C_L = 20 \text{ pF},$ See Figure 1 $V_{IPP} = 5.5 \text{ V}$ 0.04 $V_{IPP} = 5.5 $		COM.	120100	COM	MIN	TYP	MAX	10.01	
See Figure 1 $V_{IPP} = 5.5 \text{ V}$ 0.04 In Equivalent input noise voltage $ f = 1 \text{ kHz}, \\ See Figure 2 $ $ FOM Maximum output-swing bandwidth $ $ V_{O} = V_{OH}, \\ R_{L} = 1 \text{ M}\Omega, \\ See Figure 1 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $ $ V_{I} = 10 \text{ mV}, \\ See Figure 3 $	2D	Slow rate at unity gain				0.05		V/us	
See Figure 2 YO = VOH, $C_L = 20 \text{ pF}$, $C_L = 20 \text{ pF}$, $C_L = 1 \text{ M}\Omega$, See Figure 1 Unity-gain bandwidth VI = 10 mV, $C_L = 20 \text{ pF}$, $C_L = 20 \text{ pF}$	SIN	Siew rate at utility gairi		V _{IPP} = 5.5 V	V.	0.04	1	V/μs	
Maximum output-swing bandwidth $R_L = 1 \text{ M}\Omega$, See Figure 1 $V_I = 10 \text{ mV}$, $C_L = 20 \text{ pF}$, $V_I = 10 \text{ mV}$, $C_L = 20 \text{ pF}$, $V_I = 10 \text{ mV}$, $V_I = $	′n	Equivalent input noise voltage		$R_S = 20 \Omega$,	MIT	70		nV/√Hz	
See Figure 3 $V_1 = 10 \text{ mV}$, $f = B_1$, 38°	ВОМ	Maximum output-swing bandwidth			COM.	TW1		kHz	
	1	Unity-gain bandwidth		C _L = 20 pF,	COM	110		kHz	
0_ = 20 p1,	m	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	Y.CO	38°		V	

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PARAMETER MEASUREMENT INFORMATION

single-supply versus split-supply test circuits

Because the TLC27L4 and TLC27L9 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.

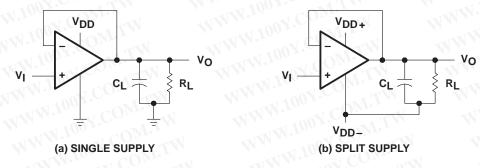


Figure 1. Unity-Gain Amplifier

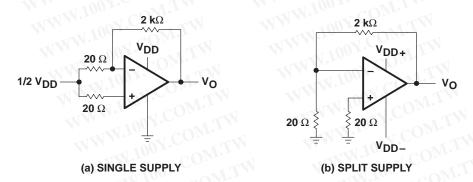


Figure 2. Noise-Test Circuit

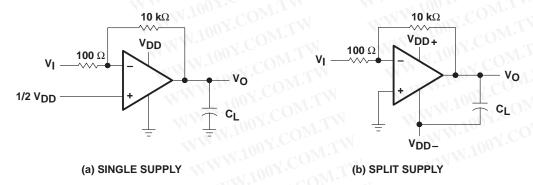


Figure 3. Gain-of-100 Inverting Amplifier

TLC27L4, TLC27L4A, TLC27L4B, TLC27L4Y, TLC27L9 Lincmos™ Precision quad operational amplifiers

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PARAMETER MEASUREMENT INFORMATION

input bias current

Because of the high input impedance of the TLC27L4 and TLC27L9 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.

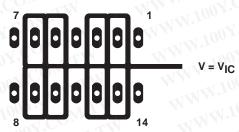


Figure 4. Isolation Metal Around Device Inputs (J and N packages)

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 Figures 14 through 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.



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PARAMETER MEASUREMENT INFORMATION

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.

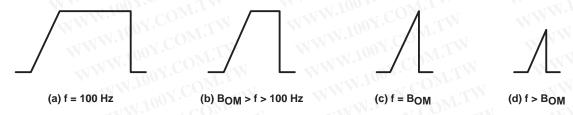


Figure 5. Full-Power-Response Output Signal

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.

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TYPICAL CHARACTERISTICS

Table of Graphs

		TOON.	FIGURE
VIO	Input offset voltage	Distribution	6, 7
α VIO	Temperature coefficient	Distribution	8, 9
Vон	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
AVD	Differential voltage amplification	vs Supply voltage vs Free-air temperature vs Frequency	20 21 32, 33
I _{IB} /I _{IO}	Input bias and input offset current	vs Free-air temperature	22
VIC	Common-mode input voltage	vs Supply voltage	23
IDD	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
VO(PP)	Maximum peak-to-peak output voltage	vs Frequency	29
В ₁	Unity-gain bandwidth	vs Free-air temperature vs Supply voltage	30 31
фm	Phase margin	vs Supply voltage vs Free-air temperature vs Capacitive loads	34 35 36
٧n	Equivalent input noise voltage	vs Frequency	37
ф	Phase shift	vs Frequency	32, 33



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TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLC27L4 INPUT OFFSET VOLTAGE

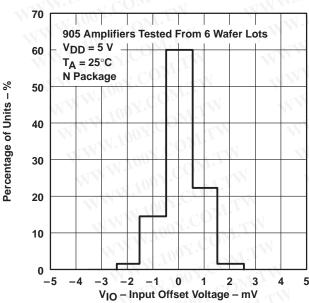


Figure 6

DISTRIBUTION OF TLC27L4 AND TLC27L9 INPUT OFFSET VOLTAGE

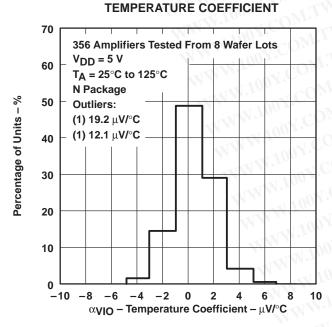


Figure 8

DISTRIBUTION OF TLC27L4 INPUT OFFSET VOLTAGE

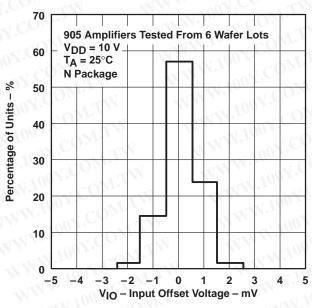


Figure 7

DISTRIBUTION OF TLC27L4 AND TLC27L9 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

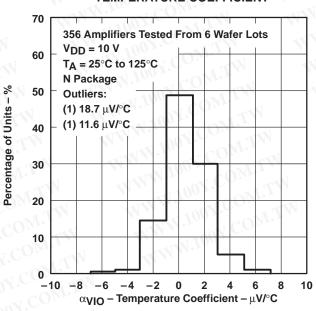


Figure 9

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TYPICAL CHARACTERISTICS†

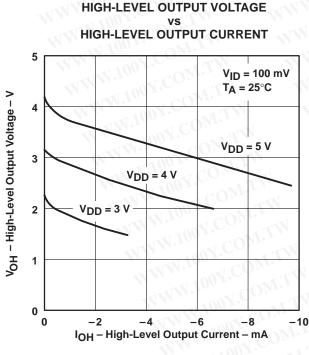
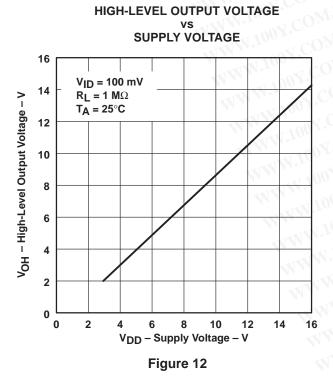


Figure 10



HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

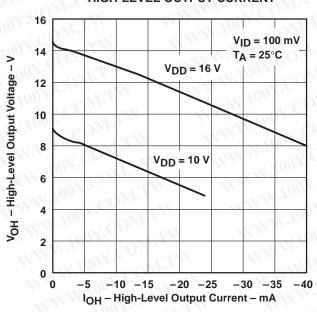
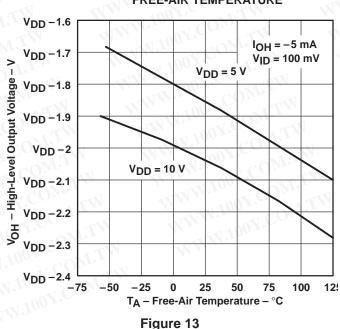


Figure 11

HIGH-LEVEL OUTPUT VOLTAGE VS FREE-AIR TEMPERATURE



 $\ ^{\dagger} \, {\hbox{\scriptsize Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices}.$



TYPICAL CHARACTERISTICS†

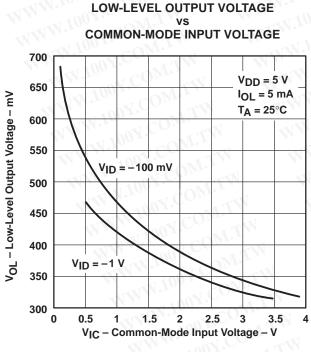
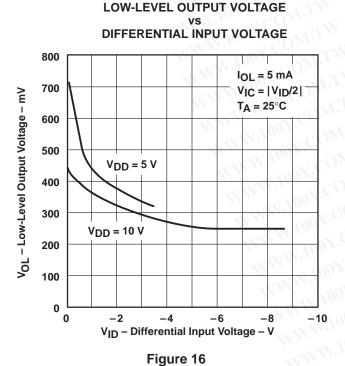


Figure 14



LOW-LEVEL OUTPUT VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

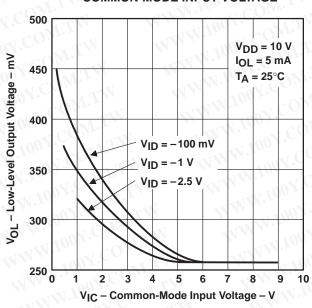


Figure 15

LOW-LEVEL OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

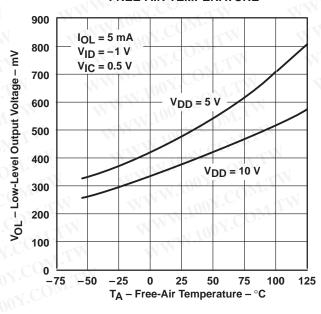


Figure 17

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

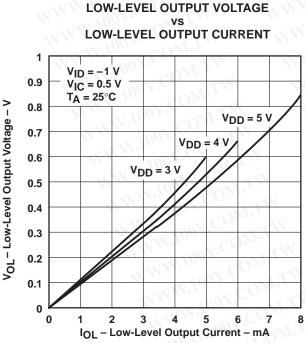


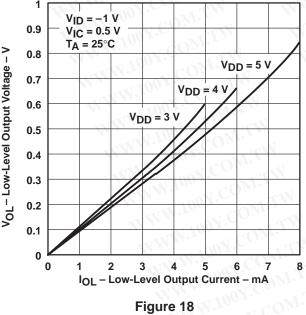
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TYPICAL CHARACTERISTICS[†]





LARGE-SIGNAL **DIFFERENTIAL VOLTAGE AMPLIFICATION** SUPPLY VOLTAGE

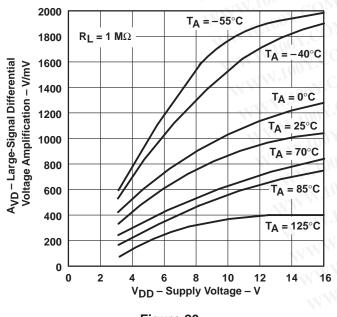


Figure 20

LOW-LEVEL OUTPUT VOLTAGE LOW-LEVEL OUTPUT CURRENT

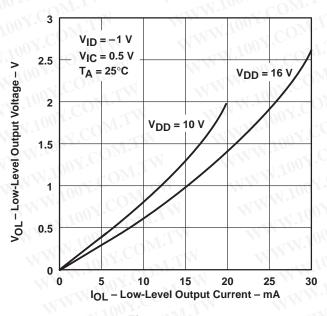


Figure 19

LARGE-SIGNAL **DIFFERENTIAL VOLTAGE AMPLIFICATION** FREE-AIR TEMPERATURE

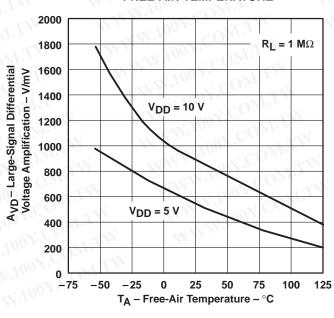


Figure 21

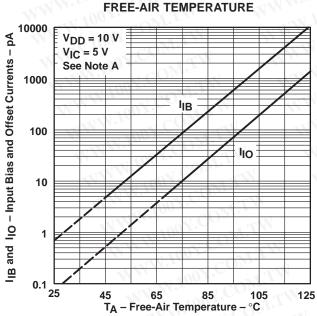
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.



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TYPICAL CHARACTERISTICS[†]

INPUT BIAS CURRENT AND INPUT OFFSET CURRENT VS



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

COMMON-MODE INPUT VOLTAGE POSITIVE LIMIT SUPPLY VOLTAGE

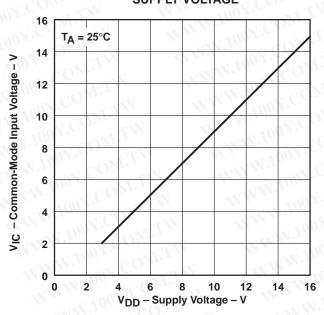
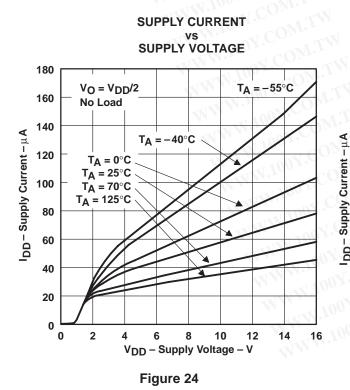
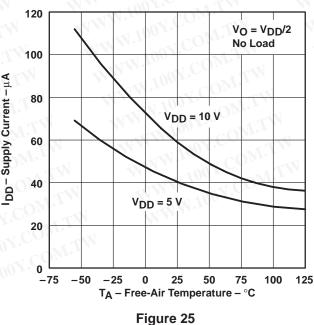


Figure 23

Figure 22



SUPPLY CURRENT VS FREE-AIR TEMPERATURE 120

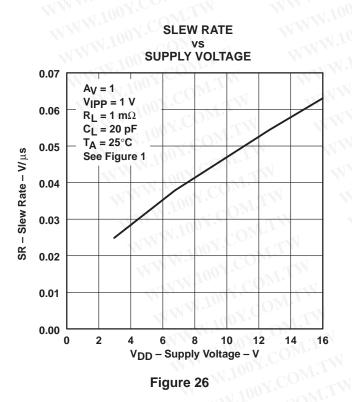


† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

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TYPICAL CHARACTERISTICS†



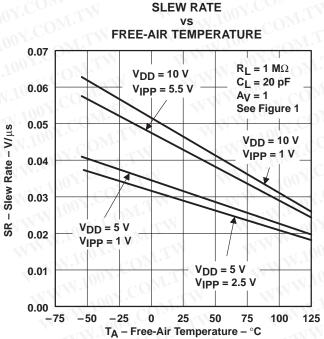
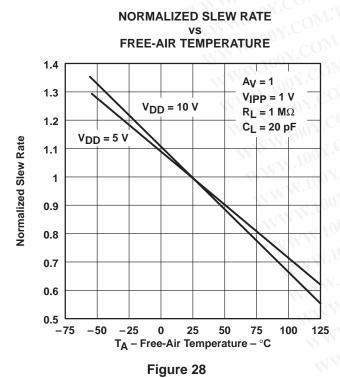


Figure 27



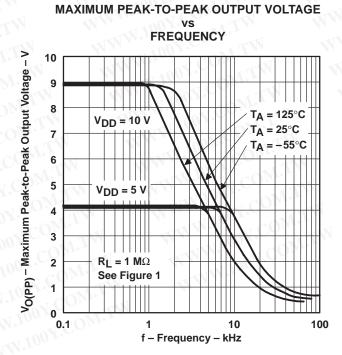


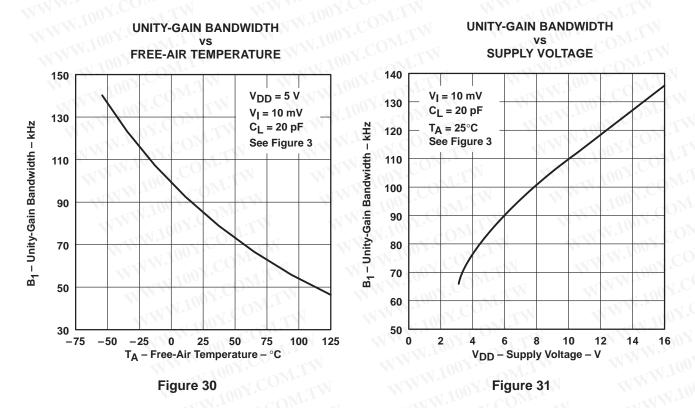
Figure 29

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

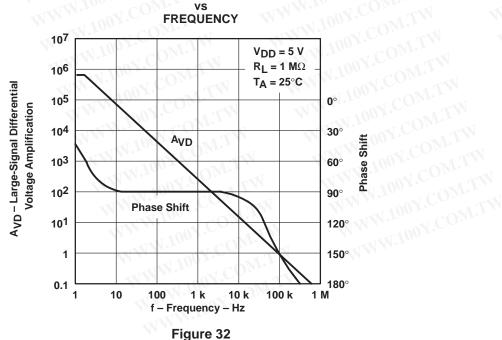


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TYPICAL CHARACTERISTICS[†]



LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT



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

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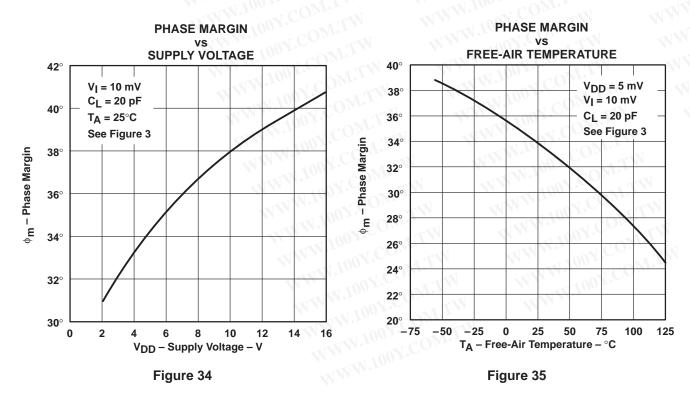
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TYPICAL CHARACTERISTICS†

LARGE-SIGNAL DIFFERENTIAL VOLTAGE **AMPLIFICATION AND PHASE SHIFT** VS **FREQUENCY** $V_{DD} = 10 V$ $R_L = 1 M\Omega$ 106 T_A = 25°C A_{VD} - Large-Signal Differential 105 0° Voltage Amplification 104 30° AVD Phase Shift 103 60° 102 90° **Phase Shift** 101 120° 150° 180° 0.1 100 1 k 10 k 100 k 1 M

Figure 33

f - Frequency - Hz



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



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TLC27L4, TLC27L4A, TLC27L4B, TLC27L4Y, TLC27L9 LinCMOS™ PRECISION QUAD OPERATIONAL AMPLIFIERS

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TYPICAL CHARACTERISTICS

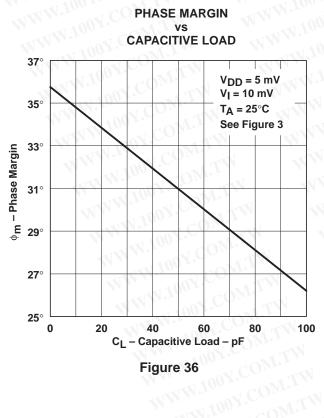


Figure 36 WWW.100Y.COM.TW

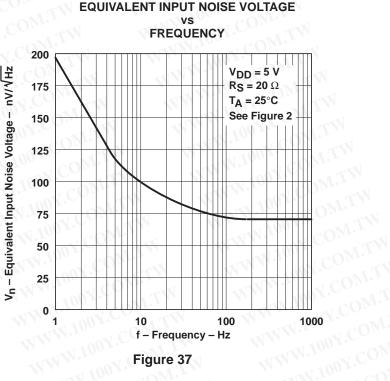


Figure 37 WWW.100Y.COM

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APPLICATION INFORMATION

single-supply operation

While the TLC27L4 and TLC27L9 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 TLC27L4 and TLC27L9 permits the use of very large resistive values to implement the voltage divider, thus minimizing power consumption.

The TLC27L4 and TLC27L9 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:

- 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.

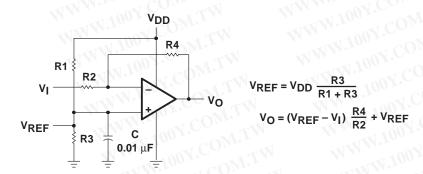


Figure 38. Inverting Amplifier With Voltage Reference

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APPLICATION INFORMATION

single-supply operation (continued)

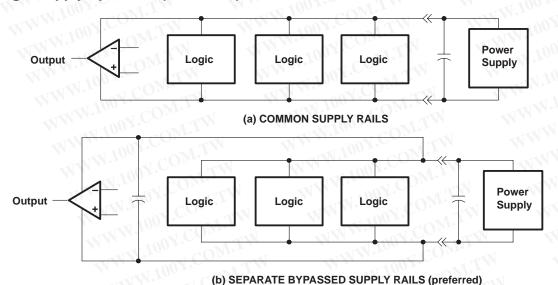


Figure 39. Common Versus Separate Supply Rails

input characteristics

The TLC27L4 and TLC27L9 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 $T_A = 25$ °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 TLC27L4 and TLC27L9 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 μ V/month, including the first month of operation.

Because of the extremely high input impedance and resulting low bias current requirements, the TLC27L4 and TLC27L9 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).

The inputs of any unused amplifiers should be tied to ground 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 TLC27L4 and TLC27L9 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 $50~\mathrm{k}\Omega$, since bipolar devices exhibit greater noise currents.



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noise performance (continued)

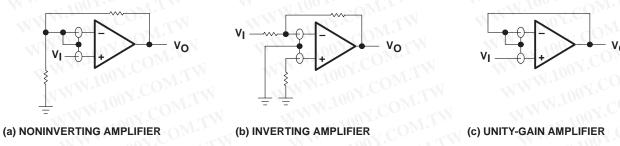
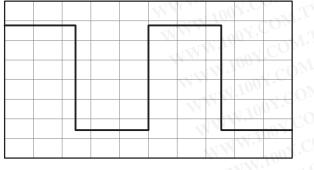


Figure 40. Guard-Ring Schemes

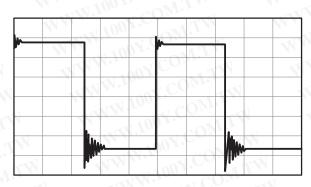
output characteristics

The output stage of the TLC27L4 and TLC27L9 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.

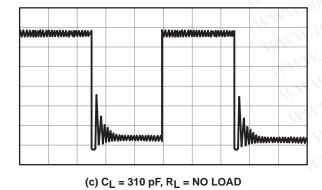
All operating characteristics of the TLC27L4 and TLC27L9 were measured using a 20-pF load. The devices drive higher capacitive loads; however, as output load capacitance increases, the resulting response pole occurs at lower frequencies, thereby causing ringing, peaking, or even oscillation (see Figure 41). In many cases, adding a small amount of resistance in series with the load capacitance alleviates the problem.

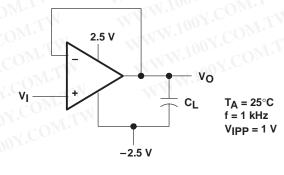






(b) $C_L = 260 \text{ pF}, R_L = NO \text{ LOAD}$





(d) TEST CIRCUIT

Figure 41. Effect of Capacitive Loads and Test Circuit



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output characteristics (continued)

Although the TLC27L4 and TLC27L9 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 (Rb) 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 Rp, a voltage offset from 0 V at the output occurs. Second, pullup resistor Rp 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.

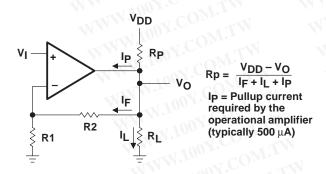


Figure 42. Resistive Pullup to Increase VOH

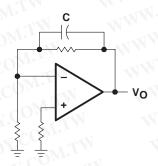


Figure 43. Compensation for Input Capacitance

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 TLC27L4 and TLC27L9 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 TLC27L4 and TLC27L9 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 μF typical) located across the supply rails as close to the device as possible.



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latch-up (continued)

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

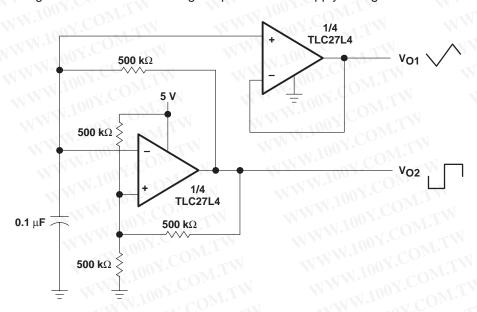
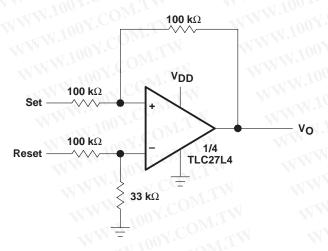


Figure 44. Multivibrator



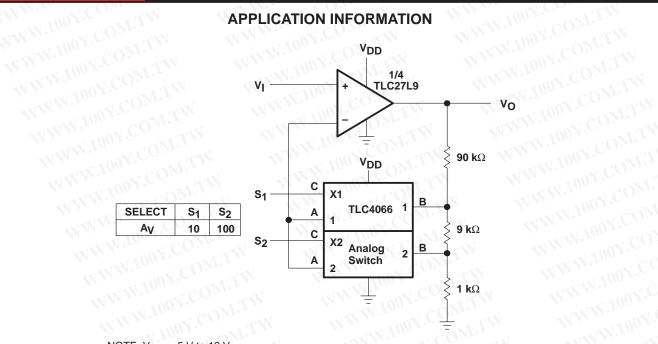
NOTE: $V_{DD} = 5 \text{ V to } 16 \text{ V}$

Figure 45. Set/Reset Flip-Flop



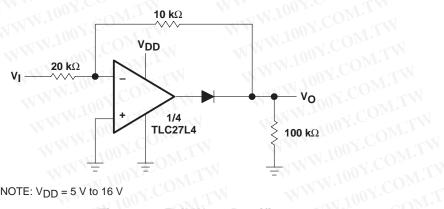
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NOTE: $V_{DD} = 5 V \text{ to } 12 V$

Figure 46. Amplifier With Digital Gain Selection



NOTE: $V_{DD} = 5 \text{ V to } 16 \text{ V}$

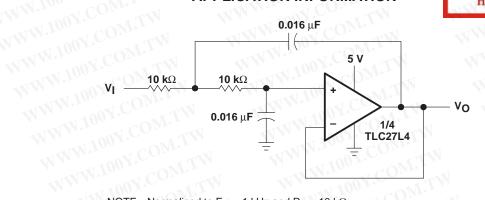
Figure 47. Full-Wave Rectifier WWW.100Y.COM

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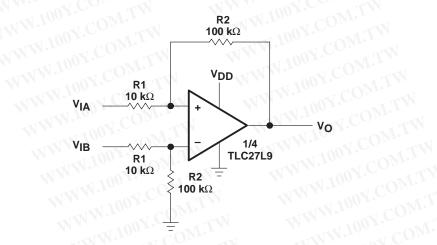
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NOTE: Normalized to FC = 1 kHz and RL = 10 k Ω

Figure 48. Two-Pole Low-Pass Butterworth Filter



NOTE: $V_{DD} = 5 \text{ V to } 16 \text{ V}$ $V_{O} = \frac{R2}{R1} (V_{IB} - V_{IA})$

Figure 49. Difference Amplifier

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