- Trimmed Offset Voltage: TLC27L7 . . . 500 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 95 μW at 25°C, V_{DD} = 5 V
- Output Voltage Range includes Negative Rail
- High Input Impedance . . . 10¹² Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up immunity

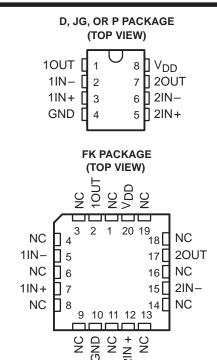
description

The TLC27L2 and TLC27L7 dual 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.

AVAILABLE OPTIONS

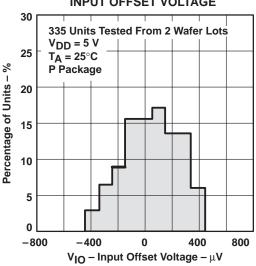
			PACK	AGE	
TA	V _{IO} max AT 25°C	SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)
0°C to 70°C	500 μV 2 mV 5 mV 10 mV	TLC27L7CD TLC27L2BCD TLC27L2ACD TLC27L2CD	I	ı	TLC27L7CP TLC27L2BCP TLC27L2ACP TLC27L2CP
-40°C to 85°C	500 μV 2 mV 5 mV 10 mV	TLC27L7ID TLC27L2BID TLC27L2AID TLC27L2ID	- 1	_	TLC27L7IP TLC27L2BIP TLC27L2AIP TLC27L2IP
−55°C to 125°C	500 μV 10 mV	TLC27L7MD TLC27L2MD	TLC27L7MFK TLC27L2MFK	TLC27L7MJG TLC27L2MJG	TLC27L7MP TLC27L2MP

The D package is available taped and reeled. Add R suffix to the device type (e.g., TLC27L7CDR).



NC - No internal connection

DISTRIBUTION OF TLC27L7 INPUT OFFSET VOLTAGE



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description (continued)

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 I-suffix types), ranging from the low-cost TLC27L2 (10 mV) to the high-precision TLC27L7 (500 μ V). These advantages, in combination with good common-mode rejection and supply voltage rejection, make these devices a good choice for new state-of-the-art designs as well as for upgrading existing designs.

In general, many features associated with bipolar technology are available in 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 TLC27L2 and TLC27L7. 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.

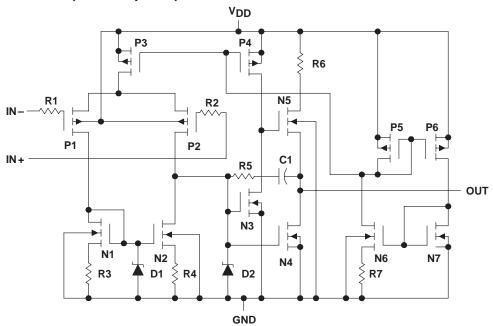
A wide range of packaging options is available, including small-outline and chip-carrier versions for high-density system applications.

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

The TLC27L2 and TLC27L7 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 over the full military temperature range of -55° C to 125° C.

equivalent schematic (each amplifier)





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

Supply voltage, V _{DD} (see Note 1)	
Input voltage range, V _I (any input)	
Input current, I _I	±5 mA
Output current, I _O (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	Soo Discipation Pating Table
Continuous total alcolpation in the first transfer to the first transfer transfer to the first transfer	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 –40°C to 85°C
Operating free-air temperature, T _A : C suffix	0°C to 70°C 40°C to 85°C 55°C to 125°C
Operating free-air temperature, T _A : C suffix	0°C to 70°C 40°C to 85°C 55°C to 125°C 65°C to 150°C
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	$T_{\mbox{A}} \le 25^{\circ}\mbox{C}$ 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	725 mW	5.8 mW/°C	464 mW	377 mW	_
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
Р	1000 mW	8.0 mW/°C	640 mW	520 mW	_

recommended operating conditions

		C SU	FFIX	I SUF	FIX	M SU	FFIX	UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	UNIT
Supply voltage, V _{DD}		3	16	4	16	4	16	V
Common mode input voltage Vie	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		0	70	-40	85	-55	125	°C



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

	PARAMETER		TEST CONE	DITIONS	T _A †	TL(TL(C27L2C C27L2A C27L2B C27L7C	C C	UNIT
						MIN	TYP	MAX	
		TLC27L2C	$V_0 = 1.4 \text{ V},$	$V_{IC} = 0$,	25°C		1.1	10	
			$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			12	mV
		TLC27L2AC	V _O = 1.4 V,	$V_{IC} = 0$,	25°C		0.9	5	
VIO	Input offset voltage		$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			6.5	
	, ,	TLC27L2BC	$V_0 = 1.4 \text{ V},$	$V_{IC} = 0$,	25°C		204	2000	
			$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			3000	μV
		TLC27L7C	$V_0 = 1.4 \text{ V},$	$V_{IC} = 0$,	25°C		170	500	,
		1	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			1500	
αΝΙΟ	Average temperature coef offset voltage	ficient of input			25°C to 70°C		1.1		μV/°C
1	lament offerst surmant (see a bi	ata 4)	V- 05V	V:- 0.5.V	25°C		0.1		A
lio	Input offset current (see N	ote 4)	$V_0 = 2.5 \text{ V},$	$V_{IC} = 2.5 V$	70°C		7	300	pА
	lanut bing gumant (and No	to 4)	V 05V	V 0.5.V	25°C		0.6		A
lΙΒ	Input bias current (see No	te 4)	$V_0 = 2.5 \text{ V},$	$V_{IC} = 2.5 V$	70°C		50	600	pΑ
.,	Common-mode input volta	ige range			25°C	-0.2 to 4	-0.3 to 4.2		V
VICR	(see Note 5)	3 3.			Full range	-0.2 to 3.5			V
					25°C	3.2	4.1		
Vон	High-level output voltage		$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	0°C	3	4.1		V
					70°C	3	4.2		
					25°C		0	50	
VOL	Low-level output voltage		$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	0°C		0	50	mV
					70°C		0	50	
		_			25°C	50	700		
AVD	Large-signal differential vo amplification	ltage	$V_0 = 0.25 \text{ V to 2 V},$	$R_L = 1 M\Omega$	0°C	50	700		V/mV
	ampilication				70°C	50	380		
					25°C	65	94		
CMRR	Common-mode rejection r	atio	$V_{IC} = V_{ICR}min$		0°C	60	95		dB
					70°C	60	95		
					25°C	70	97		
ksvr	Supply-voltage rejection ra (ΔVDD/ΔVIO)	atio	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	$V_0 = 1.4 \text{ V}$	0°C	60	97		dB
	(7) DD(7)				70°C	60	98		
			V 0511	.,	25°C		20	34	
I_{DD}	Supply current (two amplif	iers)	V _O = 2.5 V, No load	$V_{IC} = 2.5 V,$	0°C		24	42	μΑ
					70°C		16	28	

[†] Full range is 0°C to 70°C.

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

5. This range also applies to each input individually.



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

	PARAMETER		TEST CONI	DITIONS	τ _A †	TL TL	C27L2C C27L2A C27L2B C27L7C	C C	UNIT
						MIN	TYP	MAX	
		TLC27L2C	$V_0 = 1.4 V,$	$V_{IC} = 0$,	25°C		1.1	10	
		12027220	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			12	mV
		TLC27L2AC	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		0.9	5	1111
VIO	Input offset voltage	1202722710	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			6.5	
10	input onset voltage	TLC27L2BC	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		235	2000	
		120272230	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			3000	μV
		TLC27L7C	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		190	800	
		1.2027.27.0	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			1900	
αVIO	Average temperature confiset voltage	oefficient of input			25°C to 70°C		1		μV/°C
lio.	Input offset current (see	a Note 4)	V _O = 5 V,	V _{IC} = 5 V	25°C		0.1		pА
lio	input onset current (set	5 NOIE 4)	V() = 3 V,	VIC = 9 V	70°C		8	300	PΛ
lin.	Input bias current (see	Note 4)	V _O = 5 V,	V _{IC} = 5 V	25°C		0.7		pА
ΙΒ	input bias current (see	Note 4)	V() = 3 V,	AIC = 2 A	70°C		50	600	PΛ
) / ·	Common-mode input v	oltage range			25°C	-0.2 to 9	-0.3 to 9.2		V
VICR	(see Note 5)				Full range	-0.2 to 8.5			V
				2	25°C	8	8.9		
Vон	High-level output voltag	ge	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	0°C	7.8	8.9		V
					70°C	7.8	8.9		
					25°C		0	50	
VOL	Low-level output voltag	е	$V_{ID} = -100 \text{ mV},$	IOL = 0	0°C		0	50	mV
					70°C		0	50	
	Lorgo signal differentia	Lyoltogo			25°C	50	860		
A_{VD}	Large-signal differentia amplification	rvoitage	$V_0 = 1 \text{ V to 6 V},$	$R_L = 1 M\Omega$	0°C	50	1025		V/mV
	·				70°C	50	660		
					25°C	65	97		
CMRR	Common-mode rejection	on ratio	V _{IC} = V _{ICR} min		0°C	60	97		dB
					70°C	60	97		
	Supply-voltage rejectio	n ratio			25°C	70	97		
ksvr	(ΔV _{DD} /ΔV _{IO})	ii iallo	$V_{DD} = 5 V \text{ to } 10 V,$	$V_0 = 1.4 \text{ V}$	0°C	60	97		dB
					70°C	60	98		
			V _O = 5 V,	V _{IC} = 5 V,	25°C		29	46	
IDD	Supply current (two am	plifiers)	No load	-10 0 1,	0°C		36	66	μΑ
					70°C		22	40	

[†]Full range is 0°C to 70°C.

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



⁵ This range also applies to each input individually.

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

	PARAMETER		TEST CONI	DITIONS	τ _A †	TL:	C27L2I C27L2A C27L2B C27L7I		UNIT
						MIN	TYP	MAX	
		TLC27L2I	V _O = 1.4 V,	V _{IC} = 0,	25°C		1.1	10	
		TLOZILZI	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			13	mV
		TLC27L2AI	V _O = 1.4 V,	V _{IC} = 0,	25°C		0.9	5	1117
VIO	Input offset voltage	TLOZILZAI	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			7	
VIO	input onset voltage	TLC27L2BI	V _O = 1.4 V,	V _{IC} = 0,	25°C		240	2000	
		TECZTEZBI	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			3500	μV
		TLC27L7I	V _O = 1.4 V,	V _{IC} = 0,	25°C		170	500	μν
		TEOZILII	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			2000	
αVIO	Average temperature co input offset voltage	pefficient of			25°C to 85°C		1.1		μV/°C
	land offers and the same	Nata 4)	V 05V	V 05V	25°C		0.1		A
10	Input offset current (see	Note 4)	$V_0 = 2.5 V$,	$V_{IC} = 2.5 V$	85°C		24	1000	pА
	lament him a summent (a.e. I	Mata 4)	V 05V)/ 0.5.\/	25°C		0.6		A
IВ	Input bias current (see I	Note 4)	$V_0 = 2.5 V$,	$V_{IC} = 2.5 V$	85°C		200	2000	pΑ
	Common-mode input vo	oltage range			25°C	-0.2 to 4	-0.3 to 4.2		V
VICR	(see Note 5)	mage range			Full range	-0.2 to 3.5			V
					25°C	3.2	4.1		
VOH	High-level output voltag	е	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	-40°C	3	4.1		V
					85°C	3	4.2		
					25°C		0	50	
VOL	Low-level output voltage	е	$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	-40°C		0	50	mV
					85°C		0	50	
					25°C	50	480		
AVD	Large-signal differential voltage amplification		$V_0 = 0.25 \text{ V to 2 V},$	$R_L = 1 M\Omega$	-40°C	50	900		V/mV
	voltage amplification				85°C	50	330		
					25°C	65	94		
CMRR	Common-mode rejectio	n ratio	$V_{IC} = V_{ICR}min$		-40°C	60	95		dB
					85°C	60	95		
					25°C	70	97		
ksvr	Supply-voltage rejection (ΔV _{DD} /ΔV _{IO})	n ratio	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	$V_0 = 1.4 \text{ V}$	-40°C	60	97		dB
	(A) (D) (A) (D)				85°C	60	98		
			V 0511	.,	25°C		20	34	
I_{DD}	Supply current (two amp	olifiers)	V _O = 2.5 V, No load	$V_{IC} = 2.5 V$,	-40°C		31	54	μΑ
					85°C		15	26	

[†] 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, $V_{\mbox{\scriptsize DD}}$ = 10 V (unless otherwise noted)

	PARAMETER		TEST CONI	DITIONS	Τ _Α †	TL TL	C27L2I C27L2A C27L2B C27L7I		UNIT
						MIN	TYP	MAX	
		TLC27L2I	$V_0 = 1.4 V$	$V_{IC} = 0$,	25°C		1.1	10	
		12027221	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			13	mV
		TLC27L2AI	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		0.9	5	
VIO	Input offset voltage	1202722711	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			7	
1,10	input onoot voltage	TLC27L2BI	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		235	2000	
		120272231	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			3500	μV
		TLC27L7I	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		190	800	μν
		1	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			2900	
αVIO	Average temperature coeff offset voltage	icient of input			25°C to 85°C		1		μV/°C
	Innut offset surrent (see No	oto 4)	V- 5 V	V:- EV	25°C		0.1		- A
li0	Input offset current (see No	ote 4)	V _O = 5 V,	$V_{IC} = 5 V$	85°C		26	1000	pА
1	Innut him august (ass Not	- 4)	V- 5 V	V:- EV	25°C		0.7		- A
IB	Input bias current (see Not	e 4)	$V_O = 5 V$	$V_{IC} = 5 V$	85°C		220	2000	pΑ
	Common-mode input volta	ge range			25°C	-0.2 to 9	-0.3 to 9.2		V
VICR	(see Note 5)	3 3 .			Full range	-0.2 to 8.5			V
					25°C	8	8.9		
Vон	High-level output voltage		$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	-40°C	7.8	8.9		V
					85°C	7.8	8.9		
					25°C		0	50	
VOL	Low-level output voltage		$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	-40°C		0	50	mV
					85°C		0	50	
					25°C	50	860		
AVD	Large-signal differential vol amplification	tage	$V_0 = 1 V to 6 V$,	$R_L = 1 M\Omega$	-40°C	50	1550		V/mV
					85°C	50	585		
		<u> </u>			25°C	65	97		
CMRR	Common-mode rejection ra	atio	$V_{IC} = V_{ICR}min$		-40°C	60	97		dB
					85°C	60	98		
	Cumply voltage ====================================	#ia			25°C	70	97		
ksvr	Supply-voltage rejection ra (ΔV _{DD} /ΔV _{IO})	liO	$V_{DD} = 5 V \text{ to } 10 V,$	$V_0 = 1.4 \text{ V}$	−40°C	60	97		dB
					85°C	60	98		
			V _O = 5 V,	V _{IC} = 5 V,	25°C		29	46	
IDD	Supply current (two amplifi	ers)	No load	ν ₁ Ο = 5 ν,	−40°C		49	86	μΑ
					85°C		20	36	

[†] 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, $V_{DD} = 5 \text{ V}$ (unless otherwise noted)

			TEST COND	DITIONS	T _A †	TL	C27L7N	1	UNIT
						MIN	TYP	MAX	
		TLC27L2M	V _O = 1.4 V,	V _{IC} = 0,	25°C		1.1	10	mV
\ \/ \	Innut offeet velters	1 LC27 LZIVI	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			12	mv
VIO I	Input offset voltage	TLC27L7M	V _O = 1.4 V,	V _{IC} = 0,	25°C		170	500	\/
		TLC27L7W	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			3750	μV
	Average temperature coinput offset voltage	oefficient of			25°C to 125°C		1.4		μV/°C
		- NI-1- 4\	\/ 0.5\/	\\ 0.5\\	25°C		0.1		рА
lio i	Input offset current (see	e Note 4)	$V_0 = 2.5 \text{ V},$	$V_{IC} = 2.5 V$	125°C		1.4	15	nA
	Lancet Indian accommend to a se	NI-1- 4\	V 05V	V 05V	25°C		0.6		pА
IB I	Input bias current (see	Note 4)	$V_0 = 2.5 V$,	$V_{IC} = 2.5 V$	125°C		9	35	nA
Vion	Common-mode input v	oltage range			25°C	0 to 4	-0.3 to 4.2		V
VICR ((see Note 5)				Full range	0 to 3.5			٧
					25°C	3.2	4.1		
V _{OH} F	High-level output voltag	je	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	−55°C	3	4.1		V
					125°C	3	4.2		
					25°C		0	50	
V _{OL} L	Low-level output voltag	е	$V_{ID} = -100 \text{ mV},$	IOL = 0	−55°C		0	50	mV
					125°C		0	50	
	l arga signal differentia	Luckogo			25°C	50	500		
	Large-signal differential amplification	rvollage	$V_0 = 0.25 \text{ V to 2 V},$	$R_L = 1 M\Omega$	−55°C	25	1000		V/mV
`	ampilioation				125°C	25	200		
					25°C	65	94		
CMRR (Common-mode rejection	on ratio	V _{IC} = V _{ICR} min		−55°C	60	95		dB
					125°C	60	85		
	Cupply voltage rejection	o rotio			25°C	70	97		
	Supply-voltage rejection (ΔVDD/ΔVIO)	ii i dliU	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	$V_0 = 1.4 \text{ V}$	−55°C	60	97		dB
	(= : 00, = : 10)				125°C	60	98		
		<u> </u>	V _O = 2.5 V,	V _{IC} = 2.5 V,	25°C		20	34	
IDD S	Supply current (two am	plifiers)	No load	ν ₁ C – 2.5 ν,	−55°C		35	60	μΑ
					125°C		14	24	

[†] 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.

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

	PARAMETER		TEST CONI	DITIONS	T _A †		_C27L2N _C27L7N		UNIT
						MIN	TYP	MAX	
		TLC27L2M	V _O = 1.4 V,	V _{IC} = 0,	25°C		1.1	10	\/
\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	lanut affaat valtaas	ILC2/L2M	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			12	mV
VIO	Input offset voltage	TI COZI 714	V _O = 1.4 V,	V _{IC} = 0,	25°C		190	800	\/
		TLC27L7M	$R_S = 50 \Omega$,	$R_L = 1 M\Omega$	Full range			4300	μV
ανιο	Average temperature co	efficient of			25°C to 125°C		1.4		μV/°C
	1	NI-1- 4)	., 5.,		25°C		0.1		pА
lio	Input offset current (see	Note 4)	$V_0 = 5 V$,	$V_{IC} = 5 V$	125°C		1.8	15	nA
		1 (1)	., 5.,	., 5.,	25°C		0.7		pА
IВ	Input bias current (see I	Note 4)	$V_O = 5 V$	$V_{IC} = 5 V$	125°C		10	35	nA
Visa	Common-mode input vo	Itage range			25°C	0 to 9	-0.3 to 9.2		V
VICR	(see Note 5)				Full range	0 to 8.5			V
					25°C	8	8.9		
Vон	High-level output voltage	Э	$V_{ID} = 100 \text{ mV},$	$R_L = 1 M\Omega$	−55°C	7.8	8.8		V
					125°C	7.8	9		
					25°C		0	50	
VOL	Low-level output voltage)	$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	−55°C		0	50	mV
					125°C		0	50	
	Lorge signal differential	voltogo			25°C	50	860		
AVD	Large-signal differential amplification	voitage	$V_0 = 1 \ V \ to 6 \ V,$	$R_L = 1 M\Omega$	−55°C	25	1750		V/mV
	ampilioation				125°C	25	380		
					25°C	65	97		
CMRR	Common-mode rejection	n ratio	$V_{IC} = V_{ICR}min$		−55°C	60	97		dB
					125°C	60	91		
	Supply-voltage rejection	ratio			25°C	70	97		
ksvr	(ΔVDD/ΔVIO)	TallO	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	$V_O = 1.4 V$	−55°C	60	97		dB
	(= · UU/ = · IU/				125°C	60	98		
			V _O = 5 V,	V _{IC} = 5 V,	25°C		29	46	
I_{DD}	Supply current (two amp	olifiers)	No load	VIC = 5 V,	−55°C		56	96	μΑ
					125°C		18	30	

[†] 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.

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operating characteristics, $V_{DD} = 5 \text{ V}$

	PARAMETER	TEST CO	NDITIONS	TA	TLC27L2C TLC27L2AC TLC27L2BC TLC27L7C			UNIT
					MIN	TYP	MAX	
				25°C		0.03		
			V _{I(PP)} = 1 V	0°C		0.04		
SR	Slow rate at unity gain	$R_L = 1 M\Omega$,		70°C		0.03		\//ua
J SK	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		0.03		V/μs
			V _{I(PP)} = 2.5 V	0°C		0.03		
				70°C		0.02		
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		68		nV/√ Hz
			_	25°C		5		
ВОМ	Maximum output-swing bandwidth	$V_O = V_{OH}$, $R_L = 1 M\Omega$,	C _L = 20 pF, See Figure 1	0°C		6		kHz
		17[- 1 17152,	See rigure r	70°C		4.5		
			_	25°C		85		
В1	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 pF,$	0°C		100		kHz
		See rigure 3		70°C		65		
		V 40 V	, 5	25°C		34°		
φm	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	0°C		36°		
		OL = 23 pi ,	cccguic c	70°C		30°		

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

	PARAMETER	TEST CO	NDITIONS	TA	TLC27L2C TLC27L2AC TLC27L2BC TLC27L7C			UNIT
					MIN	TYP	MAX	
				25°C		0.05		
			$V_{I(PP)} = 1 V$	0°C		0.05]
SR	Clay rate of unity gain	$R_L = 1 M\Omega$,		70°C		0.04		\//uo
SK.	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		0.04		V/μs
			$V_{I(PP)} = 5.5 V$	0°C		0.05		1
				70°C		0.04		1
V _n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		68		nV/√ Hz
			_	25°C		1		
ВОМ	Maximum output-swing bandwidth	$V_O = V_{OH}$, $R_L = 1 M\Omega$,	C _L = 20 pF, See Figure 1	0°C		1.3		kHz
		1 1 1 1 1 1 1 2 2 ,	occ riguic r	70°C		0.9]
			_	25°C		110		
В1	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 pF,$	0°C		125		kHz
		Jee rigule 3		70°C		90		
		V 40 V	, ,	25°C		38°		
φm	Phase margin	$V_{\parallel} = 10 \text{ mV},$ $C_{\parallel} = 20 \text{ pF},$	f = B ₁ , See Figure 3	0°C		40°		1
		OL = 20 pi ,	2201194100	70°C		34°		

operating characteristics, $V_{DD} = 5 \text{ V}$

PARAMETER		TEST CONDITIONS		ТА	TLC27L2I TLC27L2AI TLC27L2BI TLC27L7I		UNIT	
					MIN	TYP	MAX	
			$V_{I(PP)} = 1 V$ $25^{\circ}C$ $-40^{\circ}C$ $85^{\circ}C$	25°C		0.03		
				−40°C		0.04		
l e d	$R_L = 1 M\Omega$,			85°C		0.03) //···a
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		0.03		ν/μ5
		3	V _{I(PP)} = 2.5 V	-40°C		0.04		1 1
				85°C		0.02		
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		68		nV/√ Hz
			C _L = 20 pF,	25°C		5		kHz
ВОМ	Maximum output-swing bandwidth	$V_O = V_{OH}$, $R_L = 1 M\Omega$,		-40°C		7		
			See rigure r	85°C		4		1
		V _I = 10 mV, See Figure 3		25°C		85		
В1	Unity-gain bandwidth			$C_L = 20 pF$,	-40°C		130	
		occ rigure 3		85°C 55		1 1		
				25°C		34°		
φm	Phase margin	$V_{ } = 10 \text{ mV},$ $C_{ } = 20 \text{ pF},$	f = B ₁ , See Figure 3	-40°C		38°		
		C_ = 20 pr ,	2201.190.00	85°C		29°		1

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

PARAMETER		TEST CONDITIONS		T _A	TLC27L2I TLC27L2AI TLC27L2BI TLC27L7I MIN TYP MAX			UNIT
				25°C		0.05		
			V _{I(PP)} = 1 V	-40°C		0.06		1
	$R_L = 1 M\Omega$,	.(,	85°C		0.03		١.,,	
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		0.04		V/µs
		l coo i igaio i	V _{I(PP)} = 5.5 V	-40°C		0.05		1
		1		85°C		0.03]
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		68		nV/√ Hz
				25°C		1		kHz
ВОМ	Maximum output-swing bandwidth	$V_O = V_{OH}$, $R_L = 1 M\Omega$,	C _L = 20 pF, See Figure 1	-40°C		1.4		
			occ riguic r	85°C		0.8		1
		.,	_	25°C		110		
В1	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 \text{ pF},$	−40°C		155		kHz
		occ rigare s		85°C		80		
		14 40	4 D	25°C		38°		
φm	Phase margin	$V_{l} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	−40°C		42°		
		- L		85°C		32°		

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operating characteristics, $V_{DD} = 5 \text{ V}$

PARAMETER		TEST CONDITIONS		TA	TLC27L2M TLC27L7M			UNIT	
					MIN TYP		MAX	1 1	
				25°C		0.03			
			V _{I(PP)} = 1 V	−55°C		0.04			
SR	$R_L = 1 M\Omega$,		125°C		0.02		\//··a		
SK	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		0.03		V/μs	
			V _{I(PP)} = 2.5 V	−55°C		0.04		1 1	
				125°C		0.02		1 1	
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		68		nV/√ Hz	
			_	25°C		5			
ВОМ	Maximum output-swing bandwidth			η, C _L = 20 pF, Σ, See Figure 1	−55°C		8		kHz
			See rigure r	125°C		3			
				25°C		85			
В1			V _I = 10 mV, See Figure 3	$C_L = 20 pF$,	−55°C		140		kHz
		See rigure 3		125°C		45		1	
		25°C		34°					
φm	Phase margin	$V_{l} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	−55°C		39°			
		J_ = 20 pi ,	ccc . iguio c	125°C		25°			

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

PARAMETER		TEST CONDITIONS		TA	TLC27L2M TLC27L7M			UNIT		
					MIN	TYP	MAX			
				25°C		0.05				
SR			V _{I(PP)} = 1 V	−55°C		0.06				
	Clay rate at unity gain	$R_L = 1 M\Omega$,		125°C		0.03		\//ua		
J SK	SR Slew rate at unity gain $C_L = 20 \text{ pF},$ See Figure 1		25°C		0.04		V/μs			
			V _{I(PP)} = 5.5 V	−55°C		0.06				
				125°C		0.03				
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		68		nV/√ Hz		
				25°C		1				
ВОМ	Maximum output-swing bandwidth	$V_O = V_{OH}$, $R_L = 1 M\Omega$,	$C_L = 20 \text{ pF},$	−55°C		1.5		kHz		
		TKL = 1 10152,	See rigule i	125°C		0.7				
				25°C		110				
B ₁	Unity-gain bandwidth	$V_I = 10 \text{ mV},$ $C_L = 20 \text{ pF},$ See Figure 3	-	•		−55°C		165		kHz
			125°C		70					
		V 40V	, p	25°C		38°				
φm	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	f = B ₁ , See Figure 3	−55°C		43°				
		о_ = 20 рг,		125°C		29°				

PARAMETER MEASUREMENT INFORMATION

single-supply versus split-supply test circuits

Because the TLC27L2 and TLC27L7 are optimized for single-supply operation, circuit configurations used for the various tests often present some inconvenience since the input signal, in many cases, must be offset from ground. This inconvenience can be avoided by testing the device with split supplies and the output load tied to the negative rail. A comparison of single-supply versus split-supply test circuits is shown below. The use of either circuit gives the same result.

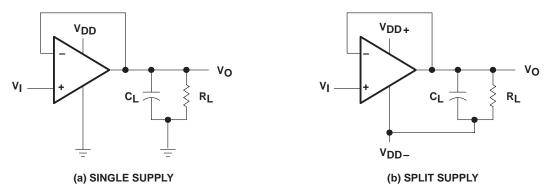


Figure 1. Unity-Gain Amplifier

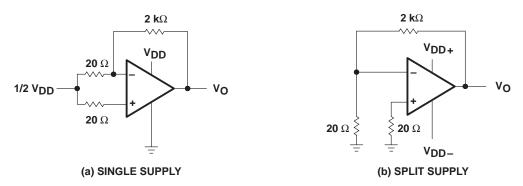


Figure 2. Noise-Test Circuit

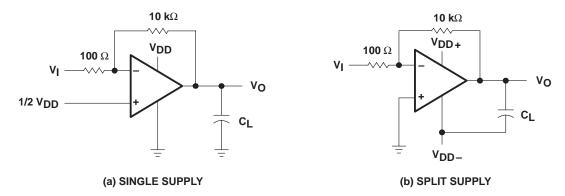


Figure 3. Gain-of-100 Inverting Amplifier

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PARAMETER MEASUREMENT INFORMATION

input bias current

Because of the high input impedance of the TLC27L2 and TLC27L7 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.
- 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.

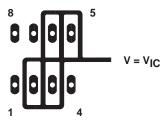


Figure 4. Isolation Metal Around Device Inputs (JG and P packages)

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.

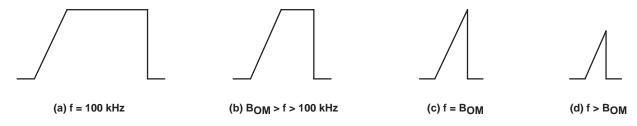


Figure 5. Full-Power-Response Output Signal

test time

Inadequate test time is a frequent problem, especially when testing CMOS high-volume, short-test-time environment. Internal capacitances are inherently higher in CMOS 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

			FIGURE
۷ _{IO}	Input offset voltage	Distribution	6, 7
ανιο	Temperature coefficient of input offset voltage	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	Large-signal differential voltage amplification	vs Supply voltage vs Free-air temperature vs Frequency	20 21 32, 33
I _{IB}	Input bias current	vs Free-air temperature	22
I _{IO}	Input offset current	vs Free-air temperature	22
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
B ₁	Unity-gain bandwidth	vs Free-air temperature vs Supply voltage	30 31
фm	Phase margin	vs Supply voltage vs Free-air temperature vs Load capacitance	34 35 36
٧n	Equivalent input noise voltage	vs Frequency	37
	Phase shift	vs Frequency	32, 33

TYPICAL CHARACTERISTICS

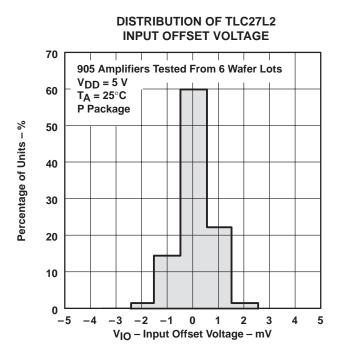


Figure 6

DISTRIBUTION OF TLC27LC AND TLC27L7

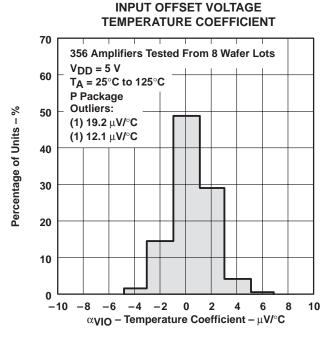


Figure 8

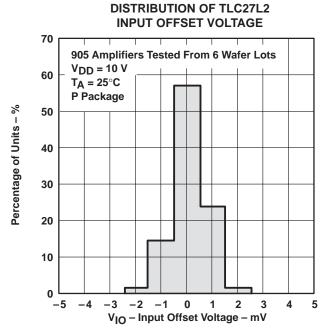


Figure 7

DISTRIBUTION OF TLC27LC AND TLC27L7 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

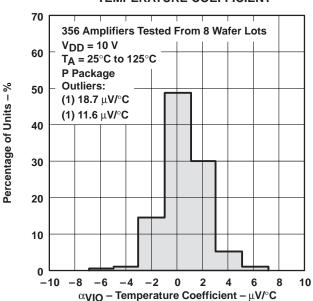


Figure 9

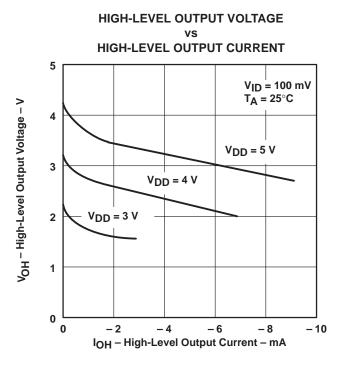


Figure 10

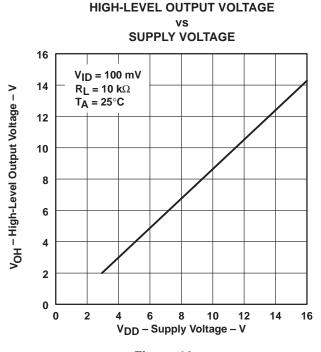


Figure 12

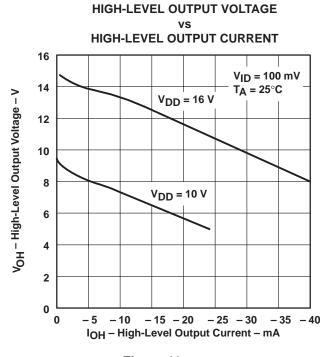


Figure 11

HIGH-LEVEL OUTPUT VOLTAGE

VS FREE-AIR TEMPERATURE V_{DD} -1.6 $I_{OH} = -5 \text{ mA}$ -1.7VOH - High-Level Output Voltage - V V_{ID} = 100 mA $V_{DD} = 5 V$ -1.8-1.9-2 $V_{DD} = 10 \text{ V}$

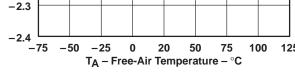


Figure 13

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



-2.1

-2.2

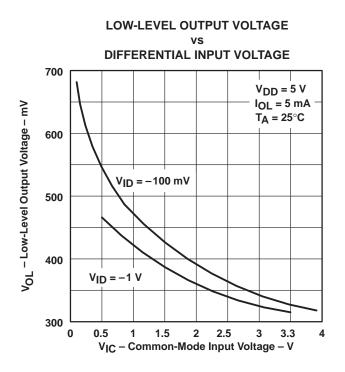


Figure 14

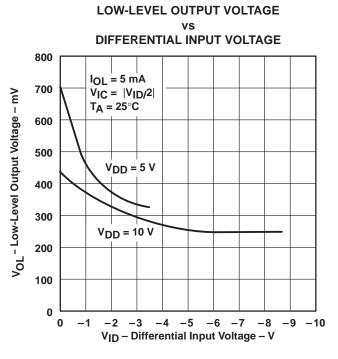


Figure 16

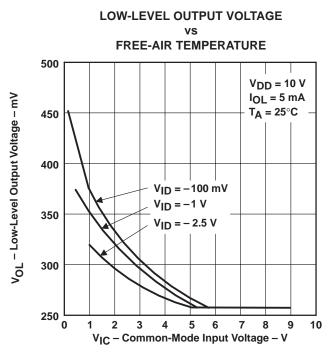


Figure 15

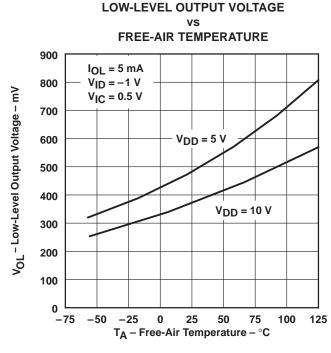
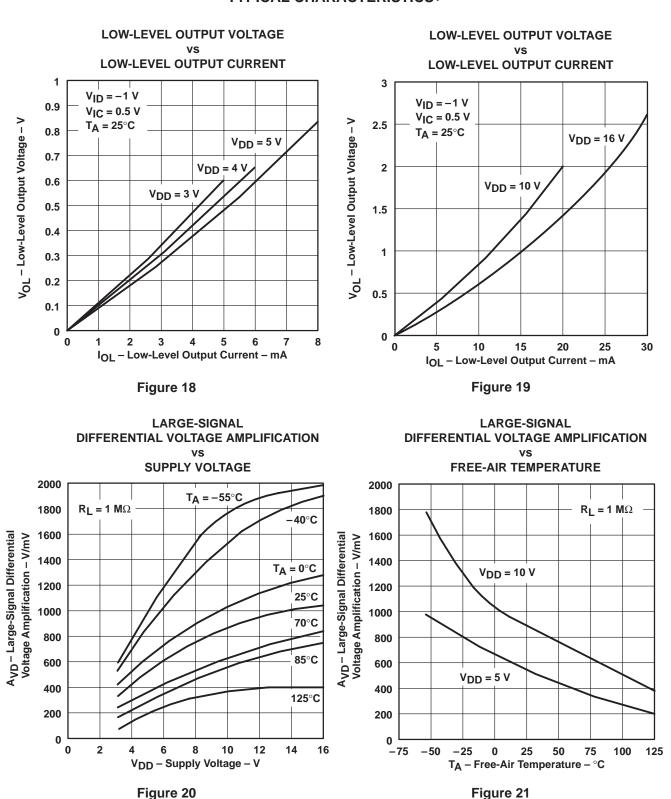


Figure 17

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





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



INPUT BIAS CURRENT AND INPUT OFFSET CURRENT

FREE-AIR TEMPERATURE 10000 IIB and I_{IO} - Input Bias and Offset Currents - pA $V_{DD} = 10 V$ $V_{IC} = 5 V$ See Note A 1000 **IIB** 100 lio 10 1 0.1 ______25 85 105 45 65 125 T_A - Free-Air Temperature - °C

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

Figure 22

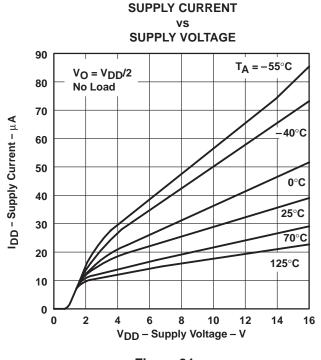


Figure 24

COMMON-MODE INPUT VOLTAGE POSITIVE LIMIT

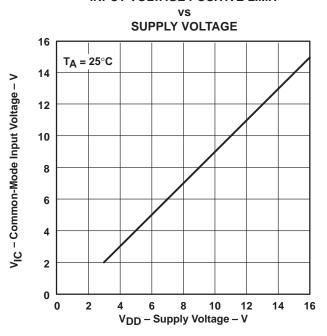


Figure 23

SUPPLY CURRENT

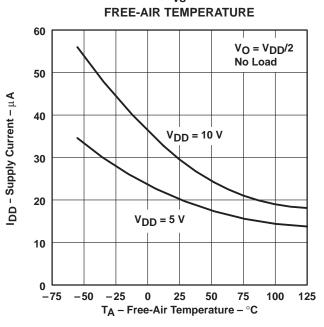
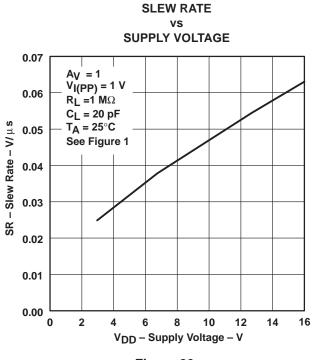


Figure 25

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





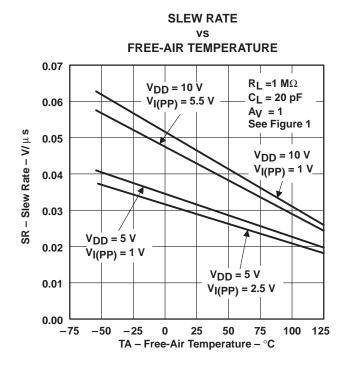
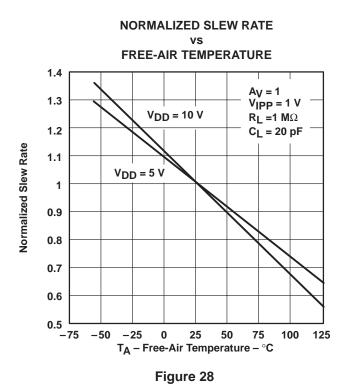
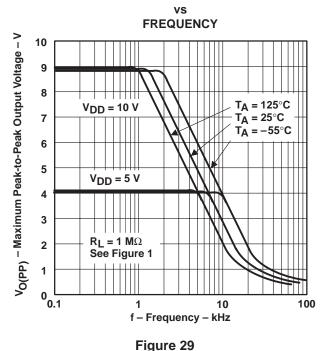


Figure 26

Figure 27



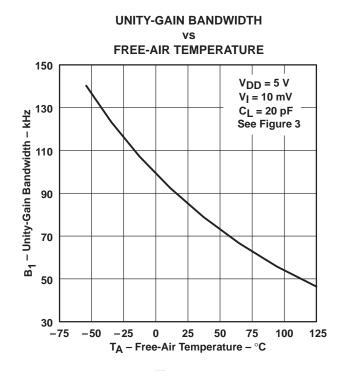
MAXIMUM-PEAK-TO-PEAK OUTPUT VOLTAGE



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



TYPICAL CHARACTERISTICS†



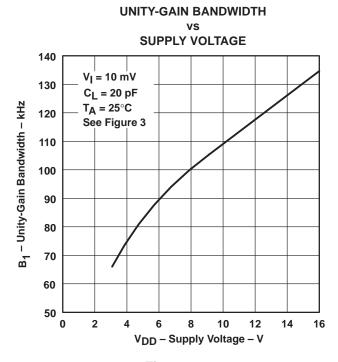


Figure 30 Figure 31

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT

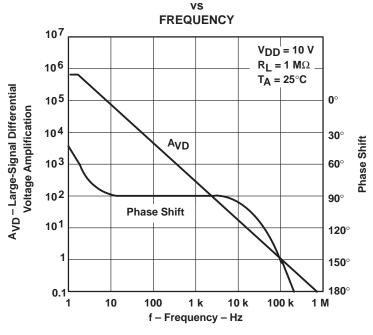


Figure 32

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



LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT

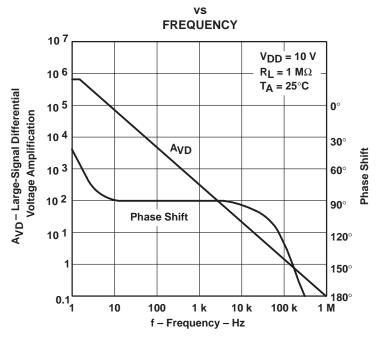
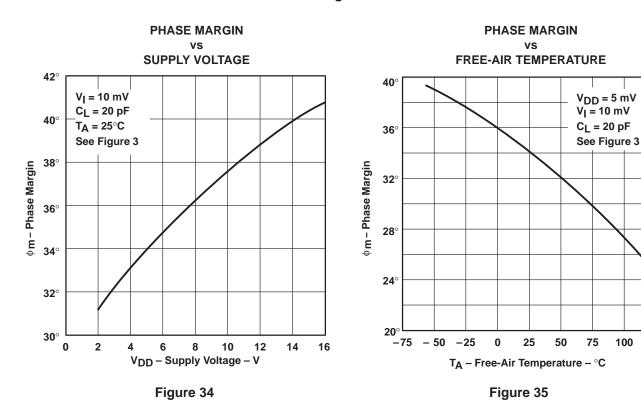


Figure 33

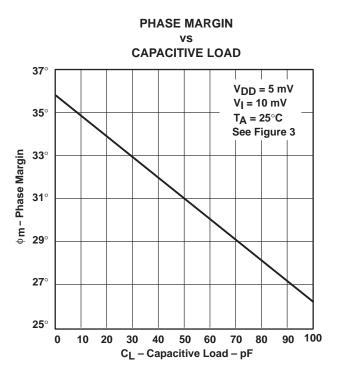


† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.



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TYPICAL CHARACTERISTICS





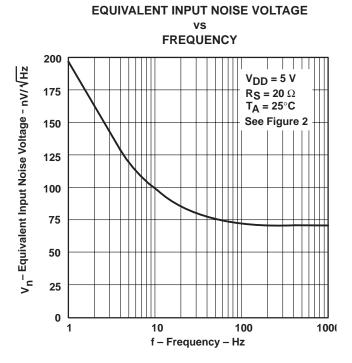


Figure 37

single-supply operation

While the TLC27L2 and TLC27L7 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 TLC27L2 and TLC27L7 permits the use of very large resistive values to implement the voltage divider, thus minimizing power consumption.

The TLC27L2 and TLC27L7 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.

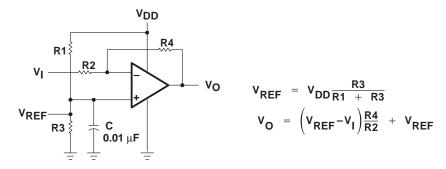


Figure 38. Inverting Amplifier With Voltage Reference

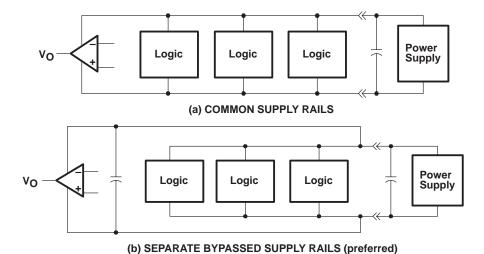


Figure 39. Common Versus Separate Supply Rails



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APPLICATION INFORMATION

input characteristics

The TLC27L2 and TLC27L7 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 TLC27L2 and TLC27L7 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 TLC27L2 and TLC27L7 are well suited for low-level signal processing; however, leakage currents on printed circuit boards and sockets can easily exceed bias current requirements and cause a degradation in device performance. It is good practice to include guard rings around inputs (similar to those of Figure 4 in the Parameter Measurement Information section). These guards should be driven from a low-impedance source at the same voltage level as the common-mode input (see Figure 40).

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

noise performance

The noise specifications in operational amplifier circuits are greatly dependent on the current in the first-stage differential amplifier. The low input bias current requirements of the TLC27L2 and TLC27L7 result in a very low noise current, which is insignificant in most applications. This feature makes the devices especially favorable over bipolar devices when using values of circuit impedance greater than 50 k Ω , since bipolar devices exhibit greater noise currents.

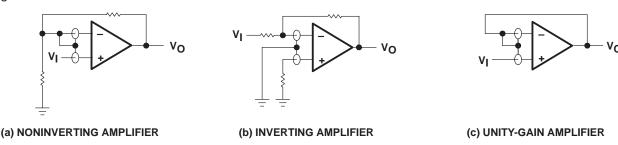


Figure 40. Guard-Ring Schemes

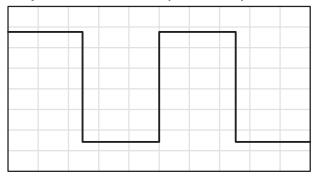
output characteristics

The output stage of the TLC27L2 and TLC27L7 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.

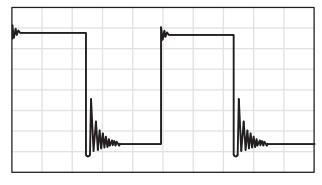
All operating characteristics of the TLC27L2 and TLC27L7 were measured using a 20-pF load. The devices drive higher capacitive loads; however, as output load capacitance increases, the resulting response pole occurs at lower frequencies, thereby causing ringing, peaking, or even oscillation (see Figure 41). In many cases, adding a small amount of resistance in series with the load capacitance alleviates the problem.



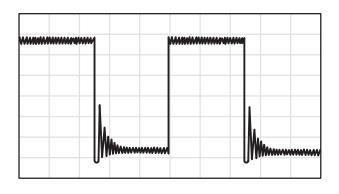
output characteristics (continued)



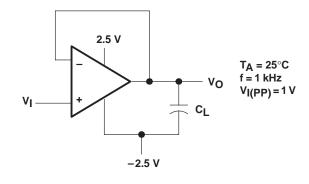
(a) $C_L = 20 pF$, $R_L = NO LOAD$



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



(c) $C_L = 310 \text{ pF}, R_L = NO \text{ LOAD}$



(d) TEST CIRCUIT

Figure 41. Effect of Capacitive Loads and Test Circuit

Although the TLC27L2 and TLC27L7 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 (Rp) 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.

output characteristics (continued)

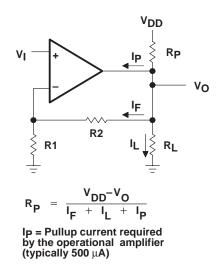


Figure 42. Resistive Pullup to Increase VOH

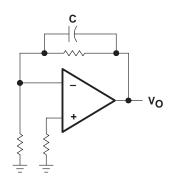


Figure 43. Compensation for Input Capacitance

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 TLC27L2 and TLC27L7 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 TLC27L2 and TLC27L7 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 μ F typical) located across the supply rails as close to the device as possible.

The current path established if latch-up occurs is usually between the positive supply rail and ground 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.

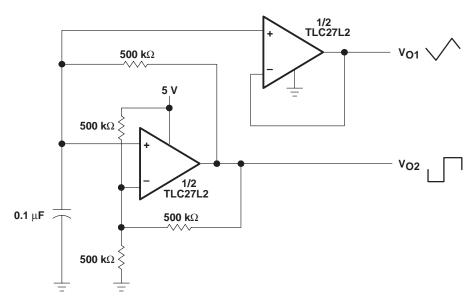
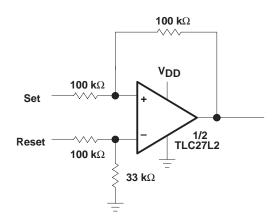
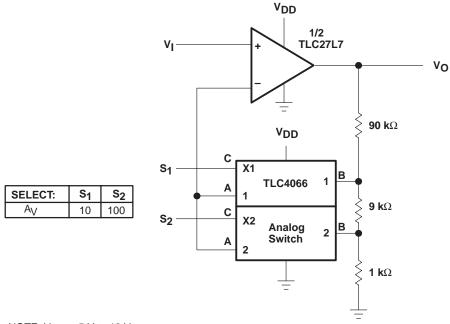


Figure 44. Multivibrator



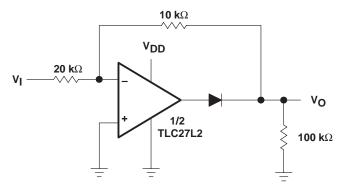
NOTE: $V_{DD} = 5 \text{ V}$ to 16 V

Figure 45. Set/Reset Flip-Flop



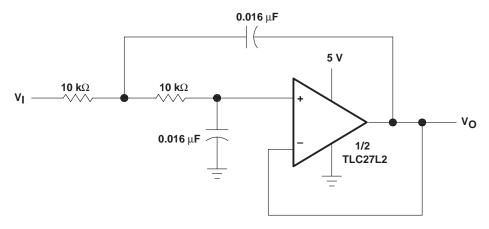
NOTE: $V_{DD} = 5 \text{ V to } 12 \text{ V}$

Figure 46. Amplifier With Digital Gain Selection



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

Figure 47. Full-Wave Rectifier



NOTE: Normalized to f_{C} = 1 kHz and R_{L} = 10 $k\Omega$

Figure 48. Two-Pole Low-Pass Butterworth Filter

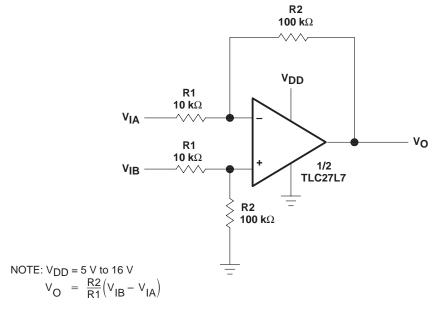


Figure 49. Difference Amplifier

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