10UT Γ

GND

1IN- [

1IN+ 🛮 3

2

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8 DVDD

7 1 20UT

6 🛮 2IN-

∏2IN+

D, JG, P, OR PW PACKAGE

(TOP VIEW)

Trimmed Offset Voltage:

TLC277 . . . 500 μ V 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)
- Low Noise . . . Typically 25 nV/√Hz at f = 1 kHz
- 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

NC NC 18Π 17 **20UT** 1IN-5 [NC 6 🛚 16 NC 1IN+ 2IN-15 NC NC 10 11 12 13

FK PACKAGE

(TOP VIEW)

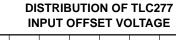
NC - No internal connection

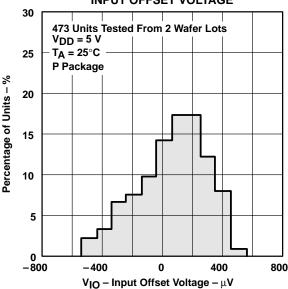
description

The TLC272 and TLC277 precision dual operational amplifiers combine a wide range of input offset voltage grades with low offset voltage drift, high input impedance, low noise, and speeds approaching those of general-purpose BiFET devices.

These devices use Texas Instruments silicongate 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 high slew rates make these cost-effective devices ideal for applications previously reserved for BiFET and NFET products. Four offset voltage grades are available (C-suffix and I-suffix types), ranging from the low-cost TLC272 (10 mV) to the high-precision TLC277 (500 $\mu\text{V}).$ 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.





LinCMOS is a trademark of Texas Instruments.

TEXAS INSTRUMENTS

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description (continued)

AVAILABLE OPTIONS

			PAC	KAGED DEVI	CES		OLUB
TA	V _{IO} max AT 25°C	SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP (PW)	CHIP FORM (Y)
	500 μV	TLC277CD	_	_	TLC277CP	_	_
	2 mV	TLC272BCD	_	_	TLC272BCP	_	_
0°C to 70°c	5 mV	TLC272ACD	_	_	TLC272ACP	_	_
	10mV	TLC272CD	_	_	TLC272CP	TLC272CPW	TLC272Y
	500 μV	TLC277ID	_	_	TLC277IP	_	
4000 4 0500	2 mV	TLC272BID	_	_	TLC272BIP	_	_
-40°C to 85°C	5 mV	TLC272AID	_	_	TLC272AIP	_	_
	10 mV	TLC272ID	_	_	TLC272IP	_	

The D package is available taped and reeled. Add R suffix to the device type (e.g., TLC277CDR).

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 TLC272 and TLC277. The devices also exhibit low voltage single-supply operation, 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.

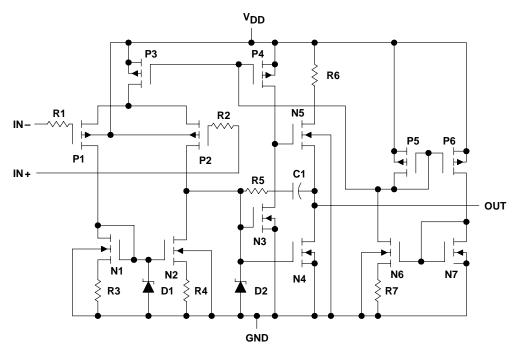
The device inputs and outputs are designed to withstand -100-mA surge currents without sustaining latch-up.

The TLC272 and TLC277 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.

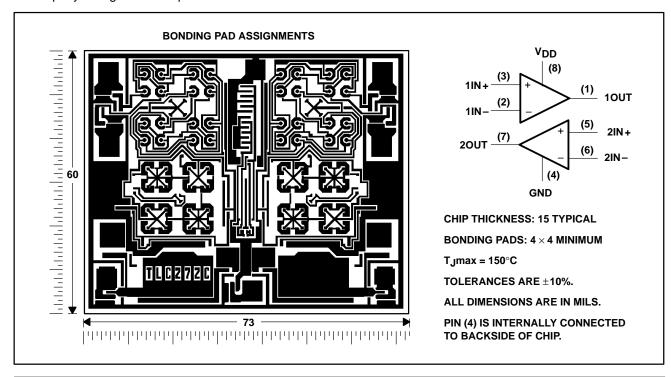


equivalent schematic (each amplifier)



TLC272Y chip information

This chip, when properly assembled, displays characteristics similar to the TLC272C. 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 range (unless otherwise noted)†

Supply voltage, V _{DD} (see Note 1)	
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, 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	
	See Dissipation Rating Table
Continuous total dissipation	See Dissipation Rating Table 0°C to 70°C
Continuous total dissipation	See Dissipation Rating Table 0°C to 70°C -40°C to 85°C
Continuous total dissipation Operating free-air temperature, T _A : C suffix I suffix M suffix	See Dissipation Rating Table
Continuous total dissipation	See Dissipation Rating Table
Continuous total dissipation Operating free-air temperature, T _A : C suffix I suffix M suffix Storage temperature range	See Dissipation Rating Table

[†] 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	N/A
FK	1375 mW	11 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	N/A
PW	525 mW	4.2 mW/°C	336 mW	N/A	N/A

recommended operating conditions

		C SU	FFIX	I SUF	FIX	M SU	FFIX	LINUT
		MIN	MAX	MIN	MAX	MIN	MAX	UNIT
Supply voltage, V _{DD}		3	16	4	16	4	16	V
0	V _{DD} = 5 V	-0.2	3.5	-0.2	3.5	0	3.5	
Common-mode input voltage, V _{IC}	V _{DD} = 10 V	-0.2	8.5	-0.2	8.5	0	8.5	٧
Operating free-air temperature, TA		0	70	-40	85	-55	125	°C

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

	PARAMETER		TEST CONDI	TIONS	T _A †	TLC272 TLC272			UNIT
						MIN	TYP	MAX	
		TI 00700	V _O = 1.4 V,	$V_{IC} = 0$,	25°C		1.1	10	
		TLC272C	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			12	>/
		TI 007040	V _O = 1.4 V,	V _{IC} = 0,	25°C		0.9	5	mV
l.,	Lead officer also	TLC272AC	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			6.5	
VIO	Input offset voltage	TI 0070D0	V _O = 1.4 V,	V _{IC} = 0,	25°C		230	2000	
		TLC272BC	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			3000	.,
		TI 00770	V _O = 1.4 V,	V _{IC} = 0,	25°C		200	500	μV
		TLC277C	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			1500	
α_{VIO}	Temperature coefficient of input	offset voltage			25°C to 70°C		1.8		μV/°C
					25°C		0.1	60	
ΙO	Input offset current (see Note 4)				70°C		7	300	рA
			$V_{O} = 2.5 \text{ V},$	$V_{IC} = 2.5 V$	25°C		0.6	60	
IВ	Input bias current (see Note 4)				70°C		40	600	pΑ
						-0.2	-0.3		
					25°C	to	to		V
VICR	Common-mode input voltage range (see Note 5)		4	4.2					
1011	(see Note 5)	Full range to		V					
					- un rungo	3.5			·
					25°C	3.2	3.8		
∨он	High-level output voltage		V _{ID} = 100 mV,	R _L = 10 kΩ	0°C	3	3.8		V
				_	70°C	3	3.8		
					25°C		0	50	
VOL	Low-level output voltage		$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	0°C		0	50	mV
"-				V -	70°C		0	50	
					25°C	5	23		
A_{VD}	Large-signal differential voltage	amplification	$V_{O} = 0.25 \text{ V to 2 V},$	$R_I = 10 \text{ k}\Omega$	0°C	4	27		V/mV
				_	70°C	4	20		
					25°C	65	80		
CMRR	Common-mode rejection ratio		V _{IC} = V _{ICR} min		0°C	60	84		dB
	•				70°C	60	85		
					25°C	65	95		
ksvr	Supply-voltage rejection ratio		$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	0°C	60	94		dB
]	$(\Delta V_{DD}/\Delta V_{IO})$			-	70°C	60	96		
					25°C		1.4	3.2	
IDD	Supply current (two amplifiers)		V _O = 2.5 V, No load	$V_{IC} = 2.5 V,$	0°C		1.6	3.6	mA
			INO IOAU		70°C		1.2	2.6	

[†] Full range is 0°C to 70°C.

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

5. This range also applies to each input individually.



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

	PARAMETER		TEST CONDI	TIONS	T _A †	TLC272 TLC272			UNIT
						MIN	TYP	MAX	
		TLC272C	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		1.1	10	
		TLG272G	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			12	ma\ /
		TI C070AC	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		0.9	5	mV
\/	land offert veltage	TLC272AC	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			6.5	
VIO	Input offset voltage	TI C070DC	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		290	2000	
		TLC272BC	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			3000	
		TI 00770	V _O = 1.4 V,	V _{IC} = 0,	25°C		250	800	μV
		TLC277C	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			1900	
α_{VIO}	Temperature coefficient of input of	ffset voltage			25°C to 70°C		2		μV/°C
	Innut offset surrent (see Note 4)				25°C		0.1	60	~ A
lo	Input offset current (see Note 4)		V - 5 V	V - 5 V	70°C		7	300	рA
	land bing amount (non Note 4)		$V_{O} = 5 V$,	$V_{IC} = 5 V$	25°C		0.7	60	- 4
ΙΒ	Input bias current (see Note 4)				70°C		50	600	pA
						-0.2	-0.3		
					25°C	to 9	to 9.2		V
VICR	Common-mode input voltage range (see Note 5)	ge				-0.2	9.2		
	(300 14010 3)		Full range	-0.2 to			V		
						8.5			
					25°C	8	8.5		
∨он	High-level output voltage		$V_{ID} = 100 \text{ mV},$	$R_L = 10 \text{ k}\Omega$	0°C	7.8	8.5		V
					70°C	7.8	8.4		
					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	10	36		
A _{VD}	Large-signal differential voltage a	mplification	$V_0 = 1 \text{ V to 6 V},$	$R_L = 10 \text{ k}\Omega$	0°C	7.5	42		V/mV
					70°C	7.5	32		
					25°C	65	85		
CMRR	Common-mode rejection ratio		V _{IC} = V _{ICR} min		0°C	60	88		dB
					70°C	60	88		
					25°C	65	95		
ksvr	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})		$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	0°C	60	94		dB
				-	70°C	60	96		
					25°C		1.9	4	
IDD	Supply current (two amplifiers)		V _O = 5 V, No load	$V_{IC} = 5 V$	0°C		2.3	4.4	mA
			140 1000		70°C		1.6	3.4	

 $^{^\}dagger$ 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, $V_{\mbox{DD}}$ = 5 V (unless otherwise noted)

Vio Input offset voltage TLC272I RS = 50 Ω Vio = 1.4 Vi RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω RL = 10 kΩ Full range 13 TLC272I RS = 50 Ω TLC272I TLC272I RS = 50 Ω TLC272I TLC272I RS = 50 Ω TLC272I TLC272I TLC272I RS = 50 Ω TLC272I		PARAMETER		TEST COND	ITIONS	τ _A †		2I, TLC2 2BI, TL0		UNIT
$V_{IO} \text{Input offset voltage} \begin{array}{c ccccccccccccccccccccccccccccccccccc$							MIN	TYP	MAX	
No			TI 00701	V _O = 1.4 V,	V _{IC} = 0,	25°C		1.1	10	
$V_{IO} \text{Input offset voltage} \begin{array}{c} T_{LC272AI} \\ V_{O} = 1.4 \ \text{V}, \\ R_{S} = 50 \ \Omega, \\ R_{S} = 10 \ \text{k} \Omega \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 25^{\circ}\text{C} \\ 200 \ 500 \\ \hline \end{array} \begin{array}{c} 3500 \\ 500 \\ \hline \end{array}$ $T_{LC272BI} \begin{array}{c} V_{O} = 1.4 \ \text{V}, \\ R_{S} = 50 \ \Omega, \\ R_{S} = 10 \ \text{k} \Omega \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 500 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 500 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 500 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 500 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 500 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 500 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline \end{array} \begin{array}{c} 25^{\circ}\text{C} \\ 200 \ 35 \\ \hline $			TLG272I	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			13	
Vico Input offset voltage RS = 00 12. RI = 10 kΩ Full range 7 TLC272BI VO = 1.4 V, RS = 50 Ω. RI = 10 kΩ Full range 3500 TLC277I VO = 1.4 V, RS = 50 Ω. RI = 10 kΩ Full range 3500 Full range 3500 Full range 3500 Full range 3500 Full range 3500 Full range 3500 Full range 3500 Full range 25°C 200 500 Full range 25°C 1.8 μV/°C Full range 25°C 0.1 60 PA Full range 25°C 0.6 60 PA Full range 25°C 0.			TI 007041	V _O = 1.4 V,	V _{IC} = 0,	25°C		0.9	5	mv
TLC272BI V _O = 1.4 V, V _{IC} = 0, R _L = 10 kΩ Full range 3500 TLC277I V _O = 1.4 V, V _{IC} = 0, R _L = 10 kΩ Full range 2000 TLC277I V _O = 1.4 V, R _S = 50 Ω R _L = 10 kΩ Full range 2000 TLC277I V _O = 1.4 V, R _S = 50 Ω R _L = 10 kΩ Full range 2000 TLC277I V _O = 1.4 V, R _S = 50 Ω R _L = 10 kΩ Full range 2000 TLC277I V _O = 1.4 V, R _S = 50 Ω R _L = 10 kΩ Full range 2000 TLC277I V _O = 1.4 V, V _{IC} = 0, R _S = 0 C 1.8 μV/°C TLC277I V _O = 1.4 V, V _{IC} = 0, R _S = 0 C 0.1 60 R _S = 0 C 0.6 60 TLC277I V _O = 2.5 V, V _{IC} = 2.5 V V _{IC} = 2.5 V V _{IC} = 2.5 V TLC277I V _O = 1.4 V, V _{IC} = 0, R _S = 0 C 0.1 60 R _S = 0 C 0.6 60 TLC277I V _O = 1.4 V, V _{IC} = 0, R _S = 0 C 0.1 60 R _S = 0 C 0.6 60 TLC277I V _O = 1.4 V, V _{IC} = 0, R _S = 0 C 0.1 60 R _S = 0 C 0.6 60 TLC277I V _O = 1.5 V, V _{IC} = 2.5 V, V _{IC} = 2.5 V, V _{IC} = 0.25 C 0.1 60 R _S = 0 C 0.1 60 TLC277I V _O = 1.4 V, V _{IC} = 0, R _C = 10 kΩ R _C = 0 kS = 0 C 0.1 60 TLC277I V _O = 1.4 V, V _{IC} = 0, R _C = 10 kΩ R _C = 0 kS = 0 C 0.1 60 TLC277I V _O = 1.4 V V _O	l.,	Lead officer allows	TLC2/2AI	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			7	
$ \frac{ \text{TLC272B} }{ \text{TLC277I}} = \frac{ \text{R}_{S} = 50 \ \Omega}{ \text{R}_{S} = 10 \ \text{k}\Omega} = \frac{ \text{Full range}}{ \text{Pull range}} = \frac{3500}{200} = \frac{3500}{ \text{pull range}} $ $ \frac{25^{\circ}\text{C}}{ \text{Common-mode input offset voltage}} = \frac{25^{\circ}\text{C}}{ \text{R}_{S} = 50 \ \Omega}, \frac{ \text{R}_{L} = 10 \ \text{k}\Omega}{ \text{R}_{L} = 10 \ \text{k}\Omega} = \frac{25^{\circ}\text{C}}{ \text{Input offset current (see Note 4)}} = \frac{25^{\circ}\text{C}}{ \text{R}_{S} = 50 \ \Omega}, \frac{ \text{R}_{L} = 10 \ \text{k}\Omega}{ \text{R}_{L} = 10 \ \text{k}\Omega} = \frac{25^{\circ}\text{C}}{ \text{R}_{S} = 50 \ \Omega}, \frac{ \text{R}_{L} = 10 \ \text{k}\Omega}{ \text{R}_{S} = 5^{\circ}\text{C}} = \frac{25^{\circ}\text{C}}{ \text{R}_{S} = 5^{\circ}\text{C}} = \frac{25^{\circ}\text{C}$	VIO	input offset voltage	TI 0070DI	V _O = 1.4 V,	V _{IC} = 0,	25°C		230	2000	
TLC277I N _S = 50 Ω N _L = 10 kΩ Full range 2000			TLC2/2BI	$R_S = 50 \Omega$,		Full range			3500	
RS = 50 12, RL = 10 kΩ Full range 2000			TI 00771	V _O = 1.4 V,	V _{IC} = 0,	25°C		200	500	μν
No Imput offset current (see Note 4) Input offset current (see Note 4) VO = 2.5 V, VIC = 2.5 V VIC =			TLC2//I	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			2000	
Input offset current (see Note 4) VO = 2.5 V, VIC = 2.5 V Se ^C C 0.6 60 PA	α_{VIO}	Temperature coefficient of input	offset voltage					1.8		μV/°C
In Input bias current (see Note 4) Vo = 2.5 V, Vo		Innut offeet eurrent (e.e. Note 4)				25°C		0.1	60	~ ^
Input bias current (see Note 4) 25°C 200 35 25°C 10 10 10 10 10 10 10 1	IO	input offset current (see Note 4)		V - 05 V	V - 05V	85°C		24	15	рА
Vocation		lanut bina aumant (ana Nata 4)		VO = 2.5 V,	AIC = 5.2 A	25°C		0.6	60	- 4
VICR Common-mode input voltage range (see Note 5) 25°C to to 4 4.2 V VOH High-level output voltage V _{ID} = 100 mV, R _L = 10 kΩ 25°C 3.2 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8	IB	input bias current (see Note 4)				85°C		200	35	рА
Vicro Vic							-0.2	-0.3		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$						25°C				V
$V_{OH} \text{High-level output voltage} \qquad V_{ID} = 100 \text{mV}, R_L = 10 \text{k}\Omega \qquad \frac{25^\circ \text{C}}{85^\circ \text{C}} \qquad 3.2 3.8 \qquad \text{V}$ $V_{OL} \text{Low-level output voltage} \qquad V_{ID} = -100 \text{mV}, I_{OL} = 0 \qquad \frac{25^\circ \text{C}}{85^\circ \text{C}} \qquad 3 3.8 \qquad \text{V}$ $V_{OL} \text{Low-level output voltage} \qquad V_{ID} = -100 \text{mV}, I_{OL} = 0 \qquad \frac{25^\circ \text{C}}{85^\circ \text{C}} \qquad 0 50 \text{mV}$ $V_{OL} \text{Large-signal differential voltage amplification} \qquad V_{OL} = 1 \text{V to 6 V}, R_L = 10 \text{k}\Omega \qquad \frac{25^\circ \text{C}}{85^\circ \text{C}} \qquad 0 50 \text{mV}$ $V_{OL} \text{Large-signal differential voltage amplification} \qquad V_{OL} = 1 \text{V to 6 V}, R_L = 10 \text{k}\Omega \qquad \frac{25^\circ \text{C}}{85^\circ \text{C}} \qquad 3.5 32 \text{V/mV}$ $V_{OL} \text{Large-signal differential voltage amplification} \qquad V_{OL} = 1 \text{V to 6 V}, R_L = 10 \text{k}\Omega \qquad \frac{25^\circ \text{C}}{85^\circ \text{C}} \qquad 3.5 32 \text{V/mV}$ $V_{OL} \text{Large-signal differential voltage amplification} \qquad V_{OL} = 1 \text{V to 6 V}, V_{OL} = 1.4 \text{V} \qquad \frac{25^\circ \text{C}}{65^\circ \text{C}} \qquad \frac{65^\circ \text{C}}{55^\circ \text{C}} \qquad \frac{65^\circ \text{C}}{55^\circ \text{C}} \qquad \frac{65^\circ \text{C}}{55^\circ \text{C}} \qquad 65^\circ \text$	VICR		nge					4.2		
$V_{OH} \text{High-level output voltage} V_{ID} = 100 \text{mV}, R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{3.2} \frac{3.2}{3.8} \text{V}$ $V_{OL} \text{Low-level output voltage} V_{ID} = -100 \text{mV}, I_{OL} = 0 \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $V_{OL} \text{Low-level output voltage} V_{ID} = -100 \text{mV}, I_{OL} = 0 \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{0}{3.3} \frac{50}{3.8} \text{mV}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{5}{3.2} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{5}{3.2} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{5}{3.2} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{25^\circ \text{C}}{85^\circ \text{C}} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{3}{3.8} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{3}{3.8} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{3}{3.8} \frac{3}{3.8} \frac{3}{3.8} \text{V}$ $R_L = 10 \text{k}\Omega \frac{3}{3.8} \frac{3}{$		(See Note 5)				Full range				V
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$						1 dil rango				v
$V_{OL} \text{Low-level output voltage} \qquad V_{ID} = -100 \text{mV}, I_{OL} = 0 \qquad \frac{25^{\circ}\text{C}}{85^{\circ}\text{C}} \qquad \frac{3}{3.8} \qquad \frac{3.8}{1000} \qquad \frac{25^{\circ}\text{C}}{8000} \qquad \frac{0}{500} \qquad \frac{50}{800} \qquad \frac{1}{1000} \qquad \frac{1}{10000} \qquad \frac{1}{1000} \qquad \frac{1}{1000} \qquad \frac{1}{1000} \qquad \frac{1}{1000} \qquad \frac{1}{10000} \qquad \frac{1}{100000} \qquad \frac{1}{1000000} \qquad \frac{1}{10000000000000000000000000000000000$						25°C	3.2	3.8		
$V_{OL} \text{Low-level output voltage} \qquad V_{ID} = -100 \text{mV}, I_{OL} = 0 \qquad \begin{array}{c} 85^{\circ}\text{C} & 3 & 3.8 \\ \hline \\ V_{OL} \text{Low-level output voltage} \\ \hline \\ A_{VD} \\ \\ Large-signal \ differential \ voltage \ amplification \\ \hline \\ A_{VD} \\ \\ Large-signal \ differential \ voltage \ amplification \\ \hline \\ A_{VD} \\ \\ V_{O} = 1 \text{V to 6 V}, \\ \\ R_{L} = 10 \text{k}\Omega \\ \hline \\ R_{L} = 10$	VOH	High-level output voltage		VID = 100 mV,	$R_I = 10 \text{ k}\Omega$	-40°C	3	3.8		V
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$					_	85°C	3	3.8		
						25°C		0	50	
	VOL	Low-level output voltage		$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	-40°C		0	50	mV
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$						85°C		0	50	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$						25°C	5	23		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	AVD	Large-signal differential voltage	amplification	$V_0 = 1 \text{ V to 6 V},$	R _L = 10 kΩ	-40°C	3.5	32		V/mV
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	'-				_	85°C	3.5	19		
$k_{SVR} \begin{array}{c} \text{Supply-voltage rejection ratio} \\ (\Delta V_{DD}/\Delta V_{IO}) \end{array} \qquad \begin{array}{c} 85^{\circ}\text{C} & 60 & 86 \\ \hline \\ V_{DD} = 5 \text{ V to 10 V}, V_{O} = 1.4 \text{ V} \\ \hline \\ 85^{\circ}\text{C} & 60 & 92 \\ \hline \\ 85^{\circ}\text{C} & 60 & 96 \\ \hline \\ 85^{\circ}\text{C} & 60 & 96 \\ \hline \\ V_{O} = 2.5 \text{ V}, \\ No \ load \\ \end{array} \qquad \begin{array}{c} V_{DD} = 5 \text{ V to 10 V}, V_{O} = 1.4 \text{ V} \\ \hline \\ V_{O} = 2.5 \text{ V}, \\ No \ load \\ \end{array} \qquad \begin{array}{c} 25^{\circ}\text{C} & 60 & 92 \\ \hline \\ 40^{\circ}\text{C} & 1.4 & 3.2 \\ \hline \\ -40^{\circ}\text{C} & 1.9 & 4.4 \\ \hline \end{array} \qquad \text{mA}$						25°C	65	80		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	CMRR	Common-mode rejection ratio		V _{IC} = V _{ICR} min		-40°C	60	81		dB
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		•				85°C	60	86		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$						25°C	65	95		
Supply current (two amplifiers) V _O = 2.5 V, V _{IC}	ksvr			$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	-40°C	60	92		dB
$V_{O} = 2.5 \text{ V},$ $V_{IC} = 2.5 \text{ V},$						85°C	60	96		
No load						25°C		1.4	3.2	
140 load	I_{DD}	Supply current (two amplifiers)			$V_{IC} = 2.5 V,$	-40°C		1.9	4.4	mA
85°C 1.1 2.4				140 load		85°C		1.1	2.4	

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

No supply current (two ampifiers) supply current (two ampifi		PARAMETER		TEST CONDI	TIONS	τ _A †		2I, TLC2 2BI, TL(UNIT
No continue							MIN	TYP	MAX	
No N			TI 00701	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		1.1	10	
\(\text{Normal input offset voltage} \) \(\text{Normal input offset current (see Note 4)} \) \(Normal input offset current (see			TLC272I	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			13	\
No			TI 0070AI	V _O = 1.4 V,	V _{IC} = 0,	25°C		0.9	5	mv
TLC272Bl NG = 1.4 \ N	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	land affect wells as	TLC272AI	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			7	
NS = 50 Å, NS = 10 Å	۷IO	input onset voltage	TI 0070DI	V _O = 1.4 V,	V _{IC} = 0,	25°C		290	2000	
$ \frac{ \nabla C }{ \nabla C } = \frac{ \nabla C }{$			TLC2/2BI	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			3500	
αVIO Temperature coefficient of input offset voltage Rg = 50 Ω, Rg = 10 Rg Full range 25°C to 25°C to 25°C to 25°C to 26°C 1000 25°C 26°C 1000 25°C 2000 26°C 2000 26°C 2000 2000 25°C 2000 2000 2000 25°C 2000 2000 2000 25°C 2000 20			TI 00771	V _O = 1.4 V,	V _{IC} = 0,	25°C		250	800	μν
No Imput offset current (see Note 4) No Input bias current (see Note 4) No In			TLC2//I	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			2900	
Input offset current (see Note 4)	α_{VIO}	Temperature coefficient of input of	offset voltage					2		μV/°C
No		Lead official consist (see New Alexand)				25°C		0.1	60	
Input bias current (see Note 4) S5°C S20 2000 PA	IO	input offset current (see Note 4)			.,	85°C		26	1000	рА
Vicro Common-mode input voltage range (see Note 5) V		Leading and the Nets A		VO = 5 V,	AIC = 2 A	25°C		0.7	60	
$ V_{ICR} = \begin{array}{c} Common-mode input voltage range \\ (see Note 5) \\ \hline \\ V_{OH} = V_{ID} = 100 mV, \\ \hline \\ \hline \\ V_{ID} = 100 mV, \\ \hline \\ \hline \\ V_{ID} = 100 mV, \\ \hline \\ \hline \\ V_{ID} = 100 mV, \\ \hline \\ \hline \\ V_{ID} = 100 mV, \\ \hline \\ \hline \\ V_{ID} = 100 mV, \\ \hline \\ \hline \\ \hline \\ V_{ID} = 100 mV, \\ \hline \\ $	IB	Input bias current (see Note 4)				85°C		220	2000	pА
Vocation							-0.2	-0.3		
$\begin{array}{c} V_{ICR} \\ (see Note 5) \\ \hline \\ V_{OH} \\ \hline \\ V_{O$						25°C				V
$V_{OH} \text{High-level output voltage} V_{ID} = 100 \text{mV}, R_L = 10 \text{k}\Omega 25^{\circ}\text{C} 8 & 8.5 \\ \hline & 25^{\circ}\text{C} & 8 & 8.5 \\ \hline & 25^{\circ}\text{C} & 7.8 & 8.5 \\ \hline & 85^{\circ}\text{C} & 7.8 & 8.5 \\ \hline & 25^{\circ}\text{C} & 0 & 50 \\ \hline & 85^{\circ}\text{C} & 7.8 & 8.5 \\ \hline & 25^{\circ}\text{C} & 0 & 50 \\ \hline & 85^{\circ}\text{C} & 0 & 85 \\ \hline & 46 & & & & & \\ \hline & 46 & & & & & \\ \hline & 85^{\circ}\text{C} & 65 & 85 \\ \hline & 40 & & & & \\ \hline & 85^{\circ}\text{C} & 60 & 88 \\ \hline & 85^{\circ}\text{C} & 60 & 96 \\ \hline & 85^$	VICR		ge				_	9.2		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1011	(see Note 5)				Full range				V
$\begin{array}{c} V_{OH} \\ V_{OH} \\ V_{OL} \\ V_{OL$						1 un range				V
$V_{OL} \text{Low-level output voltage} \qquad V_{ID} = -100 \text{mV}, I_{OL} = 0 \qquad \begin{array}{c} 85^{\circ}\text{C} & 7.8 & 8.5 \\ -40^{\circ}\text{C} & 0 & 50 \\ 85^{\circ}\text{C} & 0 & 50 \\ \hline \\ 85^{\circ}\text{C} & 10 & 36 \\ \hline \\ -40^{\circ}\text{C} & 7 & 46 \\ \hline \\ 85^{\circ}\text{C} & 7 & 31 \\ \hline \\ 25^{\circ}\text{C} & 65 & 85 \\ \hline \\ -40^{\circ}\text{C} & 60 & 87 \\ \hline \\ 85^{\circ}\text{C} & 60 & 88 \\ \hline \\ 85^{\circ}\text{C} & 60 & 96 \\ \hline \\ \\ 85^{\circ}\text{C} & 60 & 96 \\ \hline \\ \\ 85^{\circ}\text{C} & 60 & 96 \\ \hline \\ \\ \\ 85^{\circ}\text{C} & 60 & 96 \\ \hline \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $						25°C	8	8.5		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	VOH	High-level output voltage		VID = 100 mV,	$R_I = 10 \text{ k}\Omega$	-40°C	7.8	8.5		V
$ \begin{array}{c} \text{VOL} \text{Low-level output voltage} \\ \text{V}_{\text{ID}} = -100 \text{mV}, \text{I}_{\text{OL}} = 0 \\ \hline \\ \text{85}^{\circ}\text{C} \\ \hline \\ \text{0} 50 \\ \hline \\ \text{85}^{\circ}\text{C} \\ \hline \\ \text{0} 50 \\ \hline \\ \text{MV} \\ \hline \\ \text{AVD} \text{Large-signal differential voltage amplification} \\ \text{AVD} \text{Large-signal differential voltage amplification} \\ \text{V}_{\text{O}} = 1 \text{V to 6 V}, \text{R}_{\text{L}} = 10 \text{k}\Omega \\ \hline \\ \text{85}^{\circ}\text{C} \\ \hline \\ \text{7} 31 \\ \hline \\ \text{85}^{\circ}\text{C} \\ \hline \\ \text{60} 87 \\ \hline \\ \text{85}^{\circ}\text{C} \\ \hline \\ \text{60} 88 \\ \hline \\ \text{85}^{\circ}\text{C} \\ \hline \\ \text{60} 88 \\ \hline \\ \text{MSVR} \text{Supply-voltage rejection ratio} \\ \text{($\Delta V_{\text{DD}}/\Delta V_{\text{IO}}$)} \\ \text{V}_{\text{DD}} = 5 \text{V to 10 V}, \text{V}_{\text{O}} = 1.4 \text{V} \\ \hline \\ \text{V}_{\text{D}} = 5 \text{V}, \text{V}_{\text{IC}} = 5 \text{V}, \\ \text{No load} \\ \hline \end{array} \text{V}_{\text{IC}} = 5 \text{V}, \\ \text{No load} \\ \hline \end{array} \text{MA} \\ \hline \begin{array}{c} -40^{\circ}\text{C} \\ 65 \\ 85 \\ \hline \\ \text{60} 96 \\ \hline \end{array} \text{mA} \\ \hline \end{array} \text{MV}$	0				_	85°C	7.8	8.5		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$						25°C		0	50	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	VOI	Low-level output voltage		$V_{ID} = -100 \text{ mV},$	$I_{OL} = 0$	-40°C		0	50	mV
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	"	, 3		"	OL	85°C		0	50	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$						25°C	10	36		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	AVD	Large-signal differential voltage a	mplification	$V_{\Omega} = 1 \text{ V to 6 V},$	$R_I = 10 \text{ k}\Omega$	-40°C	7	46		V/mV
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	''		•		_	85°C	7	31		
						25°C	65	85		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	CMRR	Common-mode rejection ratio		VIC = VICRMIN		-40°C	60	87		dB
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		•				85°C	60	88		
							65	95		
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	ks//R			V _{DD} = 5 V to 10 V.	VO = 1.4 V					dB
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	"	(ΔΛDD/ΔΛΙΟ)			•	85°C	60	96		
$V_{O} = 5 \text{ V},$ $V_{IC} = 5 \text{ V},$ $V_{IC} = 5 \text{ V},$ No load $V_{IC} = 5 \text{ V},$								1.4	4	
No load	IDD	Supply current (two amplifiers)			$V_{IC} = 5 V$	-40°C			5	mA
		•		INO IOBO		85°C		1.5	3.2	

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

	DADAMETED		TEST COMP	ITIONS	- +	TLC27	2M, TLC	277M	
	PARAMETER		TEST COND	IIIONS	T _A †	MIN	TYP	MAX	UNIT
		TI 0070M	V _O = 1.4 V,	V _{IC} = 0,	25°C		1.1	10	>/
\ , .	land effect values	TLC272M	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			12	mV
V _{IO}	Input offset voltage	TLC277M	V _O = 1.4 V,	V _{IC} = 0,	25°C		200	500	
		TLC2//W	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			3750	μV
αVIO	Temperature coefficient of input or voltage	offset			25°C to 125°C		2.1		μV/°C
	least effect compat (a.e. Nata 4)				25°C		0.1	60	pА
lio	Input offset current (see Note 4)		V - 05 V	V - 0.5.V	125°C		1.4	15	nA
	lanut bina aumant (ana Nata 4)		$V_0 = 2.5 \text{ V}$	$V_{IC} = 2.5 V$	25°C		0.6	60	pA
ΙΒ	Input bias current (see Note 4)				125°C		9	35	nA
	Common-mode input voltage ran	ge			25°C	0 to 4	-0.3 to 4.2		V
VICR	(see Note 5)	•			Full range	0 to 3.5			V
					25°C	3.2	3.8		
∨он	High-level output voltage		$V_{ID} = 100 \text{ mV},$	$R_L = 10 \text{ k}\Omega$	−55°C	3	3.8		V
					125°C	3	3.8		
					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	
					25°C	5	23		
AVD	Large-signal differential voltage a	mplification	V _O = 0.25 V to 2 V	$R_L = 10 \text{ k}\Omega$	−55°C	3.5	35		V/mV
					125°C	3.5	16		
					25°C	65	80		
CMRR	Common-mode rejection ratio		V _{IC} = V _{ICR} min		−55°C	60	81		dB
					125°C	60	84		
	0				25°C	65	95		
ksvr	Supply-voltage rejection ratio (ΔVDD/ΔVIO)		$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	−55°C	60	90		dB
	(4 * UU/ 4 * IU/				125°C	60	97		
					25°C		1.4	3.2	
I_{DD}	Supply current (two amplifiers)		V _O = 2.5 V, No load	$V_{IC} = 2.5 V,$	−55°C		2	5	mA
					125°C		1	2.2	

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

	PARAMETER		TEST COND	ITIONS	T _A †	TLC272	2M, TLC	277M	LINUT
	PARAMETER		TEST COND	ITIONS	'A'	MIN	TYP	MAX	UNIT
		TLC272M	$V_0 = 1.4 V$,	$V_{IC} = 0$,	25°C		1.1	10	\/m
	land the standard	TLC272IVI	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			12	mV
VIO	Input offset voltage	TI 007714	V _O = 1.4 V,	V _{IC} = 0,	25°C		250	800	.,
		TLC277M	$R_S = 50 \Omega$,	$R_L = 10 \text{ k}\Omega$	Full range			4300	μV
ανιο	Temperature coefficient of input voltage	offset			25°C to 125°C		2.2		μV/°C
					25°C		0.1	60	pА
liO	Input offset current (see Note 4)		., -,,		125°C		1.8	15	nA
			$V_0 = 5 V$,	$V_{IC} = 5 V$	25°C		0.7	60	pА
IВ	Input bias current (see Note 4)				125°C		10	35	nA
V-05	Common-mode input voltage rai	nge			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	8.5		
Vон	High-level output voltage		$V_{ID} = 100 \text{ mV},$	$R_L = 10 \text{ k}\Omega$	−55°C	7.8	8.5		V
					125°C	7.8	8.4		
					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	
					25°C	10	36		
A_{VD}	Large-signal differential voltage amplification		$V_0 = 1 \text{ V to 6 V},$	$R_L = 10 \text{ k}\Omega$	−55°C	7	50		V/mV
	апринации				125°C	7	27		
					25°C	65	85		
CMRR	Common-mode rejection ratio		V _{IC} = V _{ICR} min		−55°C	60	87		dB
					125°C	60	86		
	_				25°C	65	95		
ksvr	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})		$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	−55°C	60	90		dB
	(A) DD/AVIO)			-	125°C	60	97		
					25°C		1.9	4	
IDD	Supply current (two amplifiers)		V _O = 5 V, No load	$V_{IC} = 5 V$	−55°C		3	6	mA
			140 loau		125°C		1.3	2.8	

†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, $V_{DD} = 5 V$, $T_A = 25$ °C (unless otherwise noted)

	DADAMETED	TEST CONI	DITIONS	Т	LC272Y		
	PARAMETER	TEST COND	DITIONS	MIN	TYP	MAX	UNIT
V _{IO}	Input offset voltage	$V_{O} = 1.4 \text{ V},$ $R_{S} = 50 \Omega,$	$V_{IC} = 0$, $R_L = 10 \text{ k}\Omega$		1.1	10	mV
α_{VIO}	Temperature coefficient of input offset voltage				1.8		μV/°C
IIO	Input offset current (see Note 4)	V- 05V	V - 05V		0.1		pА
I _{IB}	Input bias current (see Note 4)	$V_{O} = 2.5 \text{ V},$	$V_{IC} = 2.5 V$		0.6		pA
VICR	Common-mode input voltage range (see Note 5)			-0.2 to 4	-0.3 to 4.2		٧
Vон	High-level output voltage	V _{ID} = 100 mV,	$R_L = 10 \text{ k}\Omega$	3.2	3.8		V
VOL	Low-level output voltage	$V_{ID} = -100 \text{ mV},$	I _{OL} = 0		0	50	mV
AVD	Large-signal differential voltage amplification	$V_0 = 0.25 \text{ V to 2 V}$	$R_L = 10 \text{ k}\Omega$	5	23		V/mV
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICR} min		65	80		dB
ksvr	Supply-voltage rejection ratio ($\Delta V_{DD} / \Delta V_{IO}$)	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	65	95		dB
IDD	Supply current (two amplifiers)	V _O = 2.5 V, No load	V _{IC} = 2.5 V,		1.4	3.2	mA

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

electrical characteristics, V_{DD} = 10 V, T_A = 25°C (unless otherwise noted)

	PARAMETER	TEST CON	DITIONS	Т	LC272Y		UNIT
	FARAMETER	1EST CONI		MIN	TYP	MAX	UNII
V _{IO}	Input offset voltage	$V_{O} = 1.4 \text{ V},$ $R_{S} = 50 \Omega,$	$V_{IC} = 0$, $R_L = 10 \text{ k}\Omega$		1.1	10	mV
α_{VIO}	Temperature coefficient of input offset voltage				1.8		μV/°C
lο	Input offset current (see Note 4)	V 5V			0.1		pА
I _{IB}	Input bias current (see Note 4)	$V_{O} = 5 V$,	$V_{IC} = 5 V$		0.7		pA
VICR	Common-mode input voltage range (see Note 5)			-0.2 to 9	-0.3 to 9.2		V
Vон	High-level output voltage	$V_{ID} = 100 \text{ mV},$	$R_L = 10 \text{ k}\Omega$	8	8.5		V
VOL	Low-level output voltage	$V_{ID} = -100 \text{ mV},$	I _{OL} = 0		0	50	mV
A _{VD}	Large-signal differential voltage amplification	$V_0 = 1 \text{ V to 6 V},$	$R_L = 10 \text{ k}\Omega$	10	36		V/mV
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICR} min		65	85		dB
ksvr	Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO})	$V_{DD} = 5 \text{ V to } 10 \text{ V},$	V _O = 1.4 V	65	95		dB
I _{DD}	Supply current (two amplifiers)	V _O = 5 V, No load	V _{IC} = 5 V,		1.9	4	mA

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.

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

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

	PARAMETER		TEST CONDITIONS		TLC272		UNIT											
				TA	MIN	TYP	MAX											
				25°C		3.6												
			V _{IPP} = 1 V	0°C		4												
	Observation of the section	$R_L = 10 \text{ k}\Omega$		70°C		3		\// ·										
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		2.9		V/μs										
		gara .	V _{IPP} = 2.5 V	0°C		3.1												
				70°C		2.5												
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		25		nV/√ Hz										
		$V_O = V_{OH}$, $R_I = 10 \text{ k}\Omega$,		_						_				25°C		320		
Вом	Maximum output-swing bandwidth			0°C		340		kHz										
		$K_{\perp} = 10 \text{ Ks2},$	See rigure r	70°C		260												
				25°C		1.7												
В1	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 pF$,	0°C		2		MHz										
		See rigule 3		70°C		1.3												
		.,		25°C		46°												
φm	Phase margin	$V_I = 10 \text{ mV}, $ f $C_L = 20 \text{ pF}, $ S	$V_{I} = 10 \text{ mV},$	$V_{I} = 10 \text{ mV},$	$V_1 = 10 \text{ mV},$	$V_{I} = 10 \text{ mV},$	$V_{I} = 10 \text{ mV},$	t = B ₁ ,	0°C	47°								
	·		See rigure 3	70°C		43°												

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

PARAMETER		TEST CO	TEST CONDITIONS		TLC272C, TLC272AC, TLC272BC, TLC277C			UNIT					
				TA	MIN	TYP	MAX						
				25°C		5.3							
			V _{IPP} = 1 V	0°C		5.9							
CD.	Clausesta at units main	$R_L = 10 \text{ k}\Omega$		70°C		4.3		116.5					
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		4.6		V/μs					
			V _{IPP} = 5.5 V	0°C		5.1							
				70°C		3.8							
٧n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		25		nV/√ Hz					
				25°C		200							
Вом	Maximum output-swing bandwidth	$V_O = V_{OH}$, $R_I = 10 \text{ k}\Omega$,	C _L = 20 pF,	0°C		220		kHz					
		TC = 10 K32,	occ rigure r	70°C		140							
		., ,,	0 00 5	25°C		2.2							
B ₁	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 \text{ pF},$	0°C		2.5		MHz					
		occ r iguic o		70°C		1.8							
				25°C		49°							
φm	Phase margin	$V_{I} = 10 \text{ mV},$	$V_{I} = 10 \text{ mV},$	V _I = 10 mV, C _L = 20 pF,	$V_{I} = 10 \text{ mV},$	$V_{I} = 10 \text{ mV},$	$V_1 = 10 \text{ mV},$	f = B ₁ , See Figure 3	0°C		50°	50°	
	-	ο _L – 20 μι,	Oce i iguie o	70°C		46°							

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

	PARAMETER		TEST CONDITIONS		TLC272		UNIT							
				TA	MIN	TYP	MAX							
				25°C		3.6								
			V _{IPP} = 1 V	−40°C		4.5								
OD.	Class and and smith and in	$R_L = 10 \text{ k}\Omega$		85°C		2.8		Miss						
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		2.9		V/μs						
		Gee rigule r	Ŭ	V _{IPP} = 2.5 V	−40°C		3.5							
				85°C		2.3								
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		25		nV/√ Hz						
		imum output-swing bandwidth $V_O = V_{OH}$, $C_L = 20 \text{ pF}$ $R_I = 10 \text{ k}\Omega$, See Figure		25°C		320								
ВОМ	Maximum output-swing bandwidth										−40°C		380	
			L = 10 ksz, See Figure 1	85°C		250								
				25°C		1.7								
В1	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 pF$,	−40°C		2.6		MHz						
	See Fig.	See Figure 3	See Figure 3	See rigule 3	See Figure 3		85°C		1.2					
				25°C		46°								
φm	Phase margin	$V_I = 10 \text{ mV}, $ f $C_L = 20 \text{ pF}, $ S	$V_{l} = 10 \text{ mV},$	$V_{I} = 10 \text{ mV},$	$V_{\parallel} = 10 \text{ mV},$	$V_{\parallel} = 10 \text{ mV},$	$V_{\parallel} = 10 \text{ mV},$	mV, $f = B_1$, pF, See Figure 3 -40° C 49	49°					
			See rigule 3	85°C		43°								

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

	PARAMETER		TEST CONDITIONS		TLC272I, TLC272AI, TLC272BI, TLC277I			UNIT					
			TA	MIN	TYP	MAX							
				25°C		5.3							
			V _{IPP} = 1 V	−40°C		6.8							
	Clausesta at socia	$R_L = 10 \text{ k}\Omega$		85°C		4		Miss					
SK	· · · · · · · · · · · · · · · · · · ·	C _L = 20 pF, See Figure 1		25°C		4.6		V/μs					
		Oce rigure r		V _{IPP} = 5.5 V	−40°C		5.8						
						I			85°C		3.5		
Vn	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		25		nV/√ Hz					
				25°C		200							
ВОМ	Maximum output-swing bandwidth	$V_{O} = V_{OH}$	VO = VOH,	VO = VOH,	VO = VOH,	VO = VOH,	V _O = V _{OH} ,	C _L = 20 pF,	−40°C		260)	kHz
		$R_{L} = 10 \text{ Ks2},$	$_{-}$ = 10 kΩ, See Figure 1	85°C		130							
				25°C		2.2							
B ₁	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 \text{ pF},$	−40°C		3.1		MHz					
	See Figure 3		85°C		1.7								
				25°C		49°							
φm	Phase margin	$V_I = 10 \text{ mV},$ $C_L = 20 \text{ pF},$	$V_{\parallel} = 10 \text{ mV},$	$V_{\parallel} = 10 \text{ mV},$	$V_{\parallel} = 10 \text{ mV},$	$V_{\parallel} = 10 \text{ mV},$	f = B ₁ ,	−40°C		52°			
	·		See Figure 3	gure 3 85°C		46°							

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

	DADAMETED	TEST 60	NDITIONS	-	TLC272	2M, TLC	277M						
	PARAMETER	IESI CO	NDITIONS	TA	MIN	TYP	MAX	UNIT					
				25°C		3.6							
			V _{IPP} = 1 V	−55°C		4.7							
OD.	Class and and smith and in	$R_L = 10 \text{ k}\Omega$		125°C		2.3		V//					
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		2.9		V/μs					
		l ccc i igaic i	V _{IPP} = 2.5 V	−55°C		3.7							
				125°C		2							
V _n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		25		nV/√ Hz					
						25°C		320					
ВОМ	Maximum output-swing bandwidth		$O = V_{OH}$, $C_L = 20 \text{ pF}$, $L = 10 \text{ k}\Omega$, See Figure 1	−55°C		400		kHz					
				125°C		230							
				25°C		1.7							
B ₁	Unity-gain bandwidth	V _I = 10 mV, See Figure 3	$C_L = 20 pF$,	−55°C		2.9		MHz					
	See Figure	See rigule 3	ee i igule 3	125°C		1.1							
				25°C		46°							
φm	Phase margin	$V_{I} = 10 \text{ mV},$ $C_{L} = 20 \text{ pF},$	$V_{I} = 10 \text{ mV},$	V _I = 10 mV,	V _I = 10 mV,	V _I = 10 mV,	$V_{I} = 10 \text{ mV},$	f = B ₁ , See Figure 3	−55°C		49°		
	-		See rigure 3	125°C		41°							

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

PARAMETER		TEST CO	NDITIONS	т.	TLC27	TLC272M, TLC277M							
	FARAWETER	1231 00	NDITIONS	TA	MIN	TYP	MAX	UNIT					
				25°C		5.3							
			V _{IPP} = 1 V	−55°C		7.1							
	Observation of the section	$R_L = 10 \text{ k}\Omega$		125°C		3.1		\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \					
SR	Slew rate at unity gain	C _L = 20 pF, See Figure 1		25°C		4.6		V/μs					
		l ccc i gaire i	V _{IPP} = 5.5 V	−55°C		6.1							
				125°C		2.7							
V _n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	$R_S = 20 \Omega$,	25°C		25		nV/√ Hz					
		$V_O = V_{OH}$, $R_L = 10 \text{ k}\Omega$,	V _O = V _{OH} ,	V _O = V _{OH} ,	V _O = V _{OH} ,		25°C		200				
ВОМ	Maximum output-swing bandwidth					VO = VOH, Ri = 10 kO	VO = VOH,	C _L = 20 pF, See Figure 1	−55°C		280		kHz
			Ccc rigare r	125°C		110							
		., ,,	0 00 5	25°C		2.2							
B ₁	Unity-gain bandwidth		$V_I = 10 \text{ mV}, C_L = 20 \text{ pF},$ See Figure 3	−55°C		3.4		MHz					
		occ r igure o		125°C		1.6							
		V _I = 10 mV, C _L = 20 pF,	, ,	25°C		49°							
φm	Phase margin		$V_{I} = 10 \text{ mV},$	$V_{I} = 10 \text{ mV},$	$V_{ } = 10 \text{ mV},$	V _I = 10 mV,	$V_{I} = 10 \text{ mV},$	t = B ₁ , See Figure 3	−55°C		52°		
			See rigule 3	See Figure 3	See Figure 3	125°C		44°	•				

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

	PARAMETER	_	TEST CONDITIONS			TLC272Y		
	FARAMETER	1				TYP	MAX	UNIT
OD.	Classicate at social	$R_L = 10 \text{ k}\Omega$,	C _L = 20 pF,	V _{IPP} = 1 V		3.6		Mhia
SR	Slew rate at unity gain	See Figure 1		V _{IPP} = 2.5 V		2.9		V/μs
Vn	Equivalent input noise voltage	f = 1 kHz,	$R_S = 20 \Omega$,	See Figure 2		25		nV/√ Hz
ВОМ	Maximum output-swing bandwidth	V _O = V _{OH} , See Figure 1	C _L = 20 pF,	$R_L = 10 \text{ k}\Omega$,		320		kHz
B ₁	Unity-gain bandwidth	V _I = 10 mV,	C _L = 20 pF,	See Figure 3		1.7		MHz
φm	Phase margin	V _I = 10 mV, See Figure 3	f = B ₁ ,	C _L = 20 pF,		46°		

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

	PARAMETER	_	TEST CONDITIONS			TLC272Y		
	PARAMETER	11				TYP	MAX	UNIT
op.	Classicate at society as in	$R_L = 10 \text{ k}\Omega$,	C _L = 20 pF,	V _{IPP} = 1 V		5.3		\// -
SR	Slew rate at unity gain	See Figure 1		$V_{IPP} = 5.5 V$	4.6			V/μs
Vn	Equivalent input noise voltage	f = 1 kHz,	$R_S = 20 \Omega$,	See Figure 2		25		nV/√ Hz
ВОМ	Maximum output-swing bandwidth	V _O = V _{OH} , See Figure 1	$C_L = 20 pF,$	$R_L = 10 \text{ k}\Omega$,		200		kHz
B ₁	Unity-gain bandwidth	V _I = 10 mV,	$C_L = 20 pF$,	See Figure 3		2.2		MHz
φm	Phase margin	V _I = 10 mV, See Figure 3	f = B ₁ ,	C _L = 20 pF,		49°		

PARAMETER MEASUREMENT INFORMATION

single-supply versus split-supply test circuits

Because the TLC272 and TLC277 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.

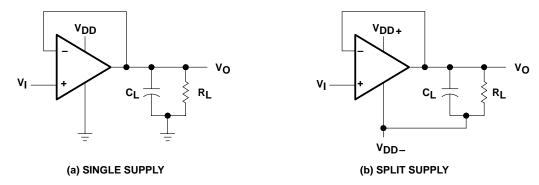


Figure 1. Unity-Gain Amplifier

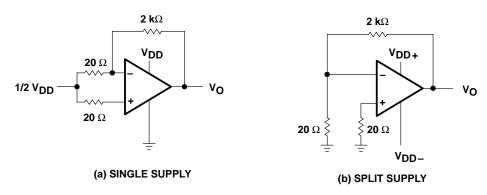


Figure 2. Noise-Test Circuit

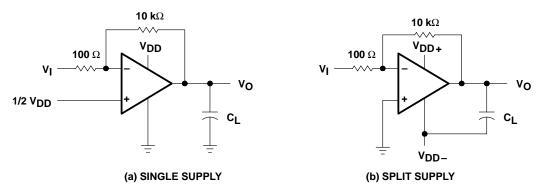


Figure 3. Gain-of-100 Inverting Amplifier



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PARAMETER MEASUREMENT INFORMATION

input bias current

Because of the high input impedance of the TLC272 and TLC277 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.

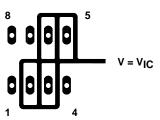


Figure 4. Isolation Metal Around Device Inputs (JG and P packages)

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 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.

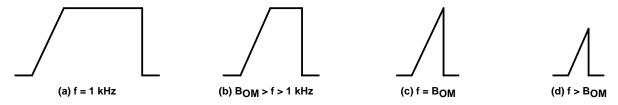


Figure 5. Full-Power-Response Output Signal

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

			FIGURE
VIO	Input offset voltage	Distribution	6, 7
αVIO	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
lιο	Input offset current	vs Free-air temperature	22
VIC	Common-mode input voltage	vs Supply voltage	23
I _{DD}	Supply current	vs Supply voltage vs Free-air temperature	24 25
SR	Slew rate	vs Supply voltage vs Free-air temperature	26 27
	Normalized slew rate	vs Free-air temperature	28
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
φm	Phase margin	vs Supply voltage vs Free-air temperature vs Load capacitance	34 35 36
Vn	Equivalent input noise voltage	vs Frequency	37
	Phase shift	vs Frequency	32, 33

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TYPICAL CHARACTERISTICS

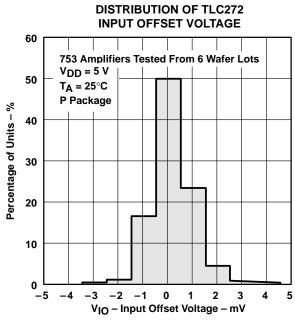


Figure 6

DISTRIBUTION OF TLC272 AND TLC277 INPUT OFFSET VOLTAGE

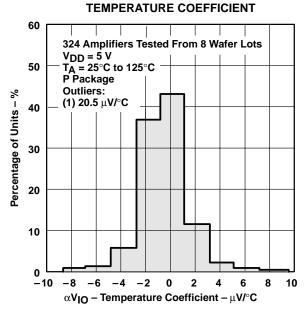


Figure 8

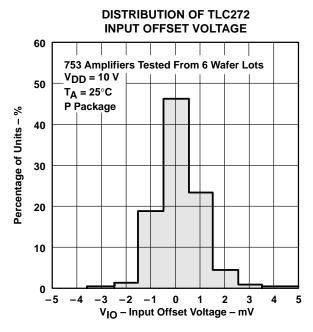


Figure 7

DISTRIBUTION OF TLC272 AND TLC277 INPUT OFFSET VOLTAGE

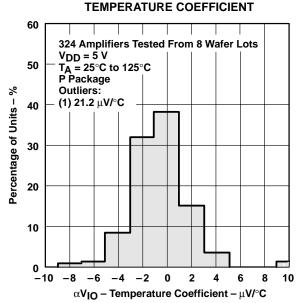
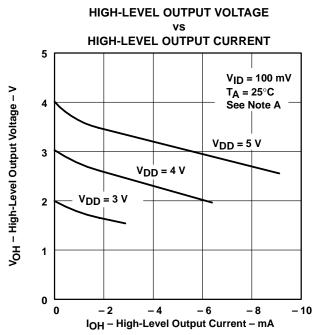


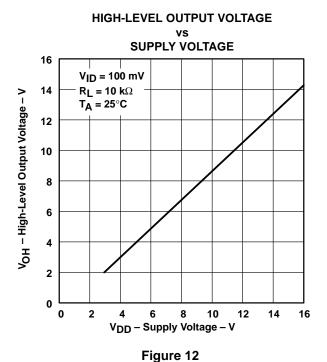
Figure 9

TYPICAL CHARACTERISTICS[†]



NOTE A: The 3-V curve only applies to the C version.

Figure 10



HIGH-LEVEL OUTPUT VOLTAGE

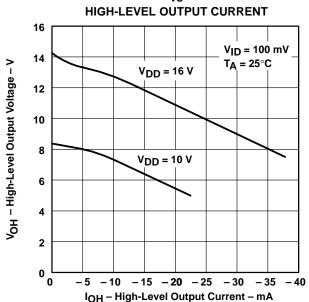


Figure 11

HIGH-LEVEL OUTPUT VOLTAGE

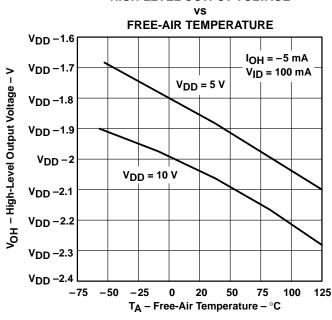


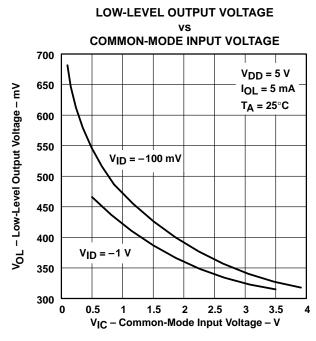
Figure 13

[†] 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[†]



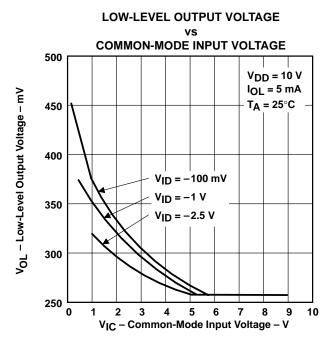
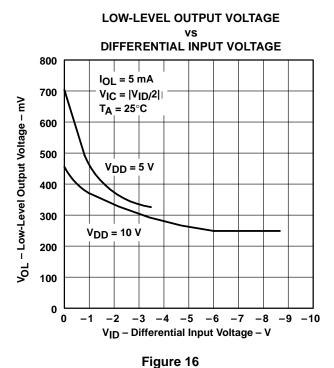


Figure 14





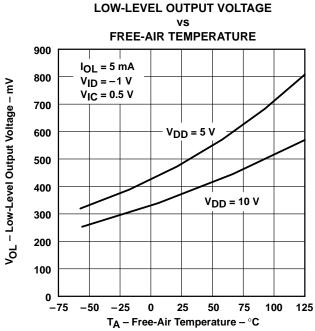
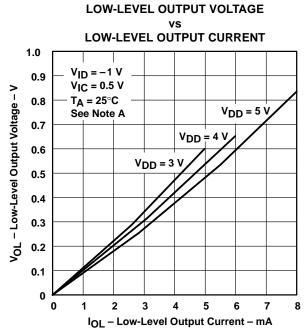


Figure 17

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



TYPICAL CHARACTERISTICS[†]



NOTE A: The 3-V curve only applies to the C version. Figure 18

LARGE-SIGNAL

DIFFERENTIAL VOLTAGE AMPLIFICATION

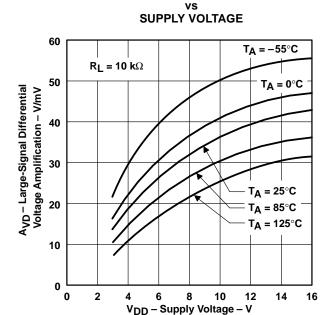


Figure 20

LOW-LEVEL OUTPUT VOLTAGE LOW-LEVEL OUTPUT CURRENT 3.0 $V_{ID} = -1 V$ V_{IC} = 0.5 V 2.5 T_A = 25°C $V_{DD} = 16 V_{DD}$ 2.0

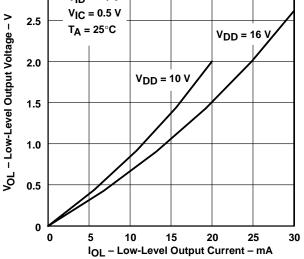
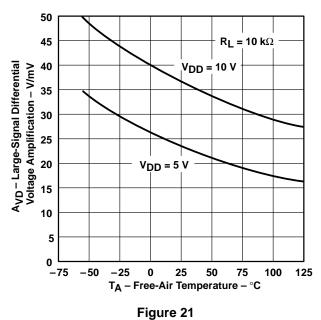


Figure 19

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



[†] 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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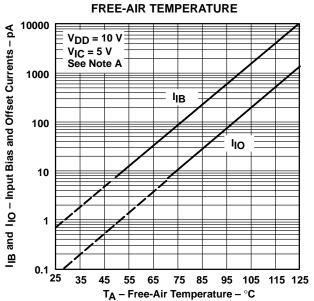
TYPICAL CHARACTERISTICS[†]

0

0

2

INPUT BIAS CURRENT AND INPUT OFFSET CURRENT vs

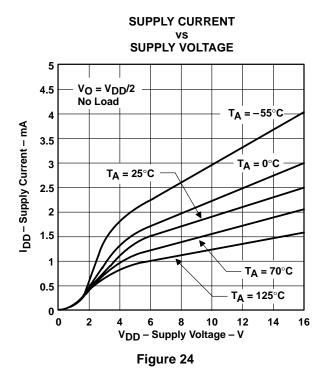


NOTE A: The typical values of input bias current and input offset current below 5 pA were determined mathematically.

COMMON-MODE

Figure 23

Figure 22



SUPPLY CURRENT vs

8

V_{DD} – Supply Voltage – V

10

12

14

16

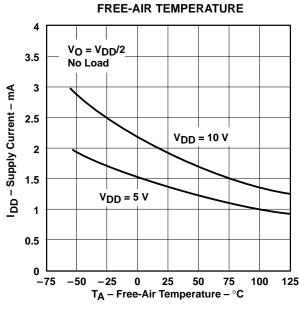


Figure 25

[†] 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[†]

8

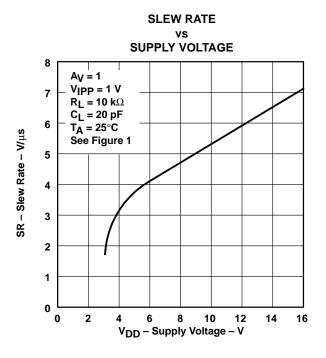
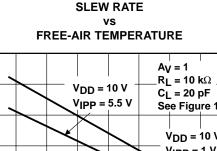


Figure 26

NORMALIZED SLEW RATE FREE-AIR TEMPERATURE 1.5 $A_V = 1$ 1.4 $V_{IPP} = 1 V$ $R_L = 10 \text{ k}\Omega$ $V_{DD} = 10 V$ 1.3 $C_L = 20 pF$ Normalized Slew Rate 1.2 1.1 $V_{DD} = 5 V$ 1.0 0.9 0.8 0.7 0.6 0.5 -75 -50 -25 25 50 75 100 125 T_A – Free-Air Temperature – $^{\circ}$ C

Figure 28



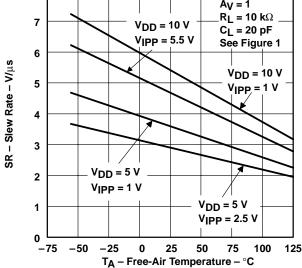


Figure 27

MAXIMUM PEAK OUTPUT VOLTAGE

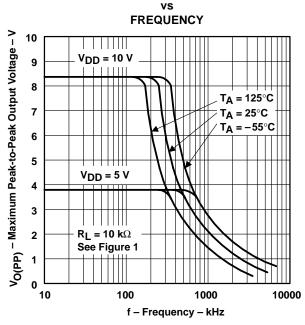


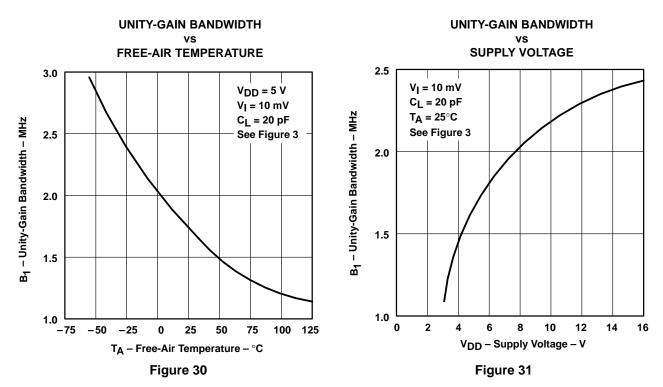
Figure 29

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

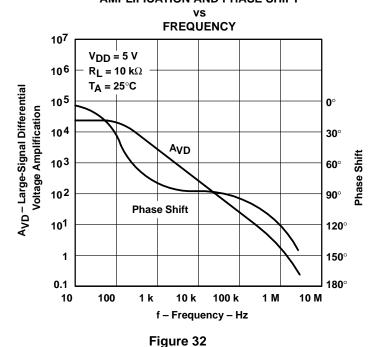


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TYPICAL CHARACTERISTICS[†]



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.



TYPICAL CHARACTERISTICS[†]

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT

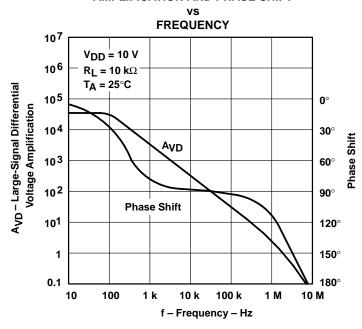
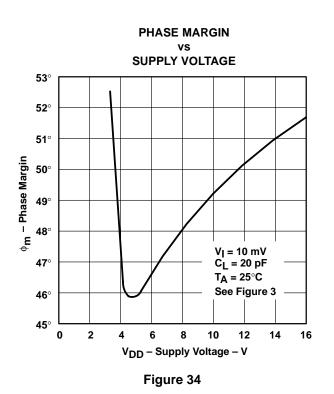
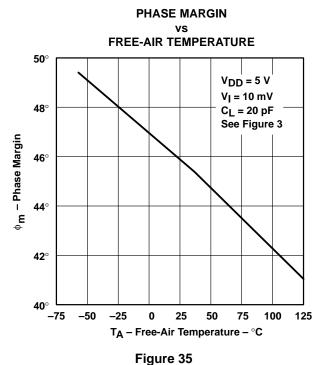


Figure 33



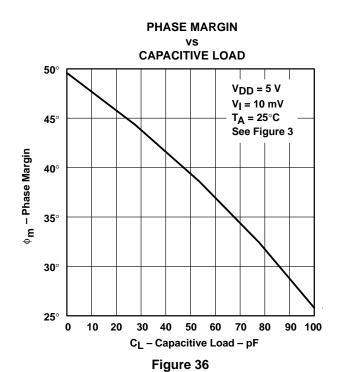


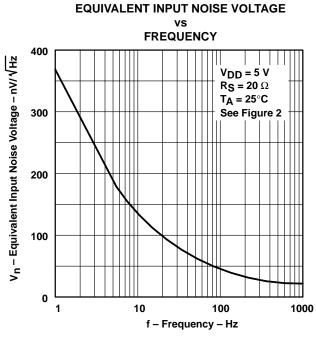
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.



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TYPICAL CHARACTERISTICS





APPLICATION INFORMATION

single-supply operation

While the TLC272 and TLC277 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 TLC272 and TLC277 permits the use of very large resistive values to implement the voltage divider, thus minimizing power consumption.

The TLC272 and TLC277 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.

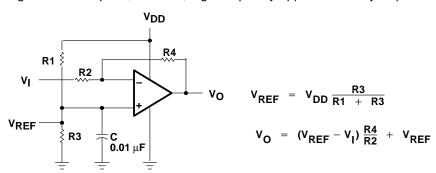


Figure 38. Inverting Amplifier With Voltage Reference

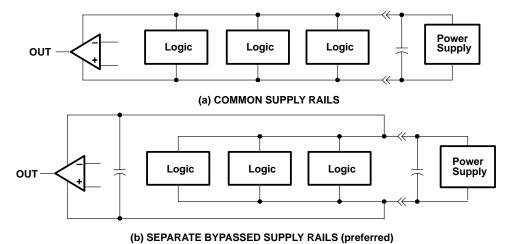


Figure 39. Common vs Separate Supply Rails

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APPLICATION INFORMATION

input characteristics

The TLC272 and TLC277 are specified with a minimum and a maximum input voltage that, if exceeded at either input, could cause the device to malfunction. Exceeding this specified range is a common problem, especially in single-supply operation. Note that the lower range limit includes the negative rail, while the upper range limit is specified at $V_{DD} - 1$ V at $T_A = 25^{\circ}$ 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 TLC272 and TLC277 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 μV/month, including the first month of operation.

Because of the extremely high input impedance and resulting low bias current requirements, the TLC272 and TLC277 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 TLC272 and TLC277 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.

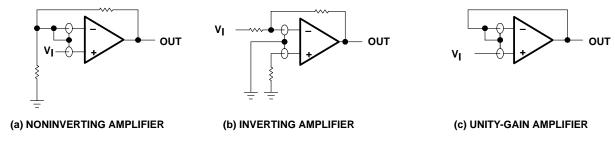


Figure 40. Guard-Ring Schemes

output characteristics

The output stage of the TLC272 and TLC277 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 TLC272 and TLC277 are measured using a 20-pF load. The devices can drive higher capacitive loads; however, as output load capacitance increases, the resulting response pole occurs at lower frequencies, thereby causing ringing, peaking, or even oscillation (see Figure 41). In many cases, adding a small amount of resistance in series with the load capacitance alleviates the problem.



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(d) TEST CIRCUIT

APPLICATION INFORMATION

output characteristics (continued)

(c) $C_L = 150 \text{ pF}, R_L = NO \text{ LOAD}$

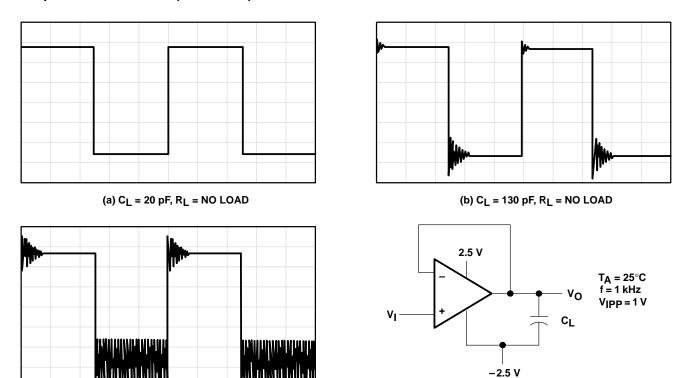


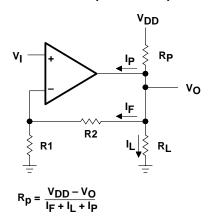
Figure 41. Effect of Capacitive Loads and Test Circuit

Although the TLC272 and TLC277 possess excellent high-level output voltage and current capability, methods for boosting this capability are available, if needed. The simplest method involves the use of a pullup resistor (R_P) connected from the output to the positive supply rail (see Figure 42). There are two disadvantages to the use of this circuit. First, the NMOS pulldown transistor N4 (see equivalent schematic) must sink a comparatively large amount of current. In this circuit, N4 behaves like a linear resistor with an on resistance between approximately 60 Ω and 180 Ω , depending on how hard the operational amplifier input is driven. With very low values of R_P, a voltage offset from 0 V at the output occurs. Second, pullup resistor R_P acts as a drain load to N4 and the gain of the operational amplifier is reduced at output voltage levels where N5 is not supplying the output current.

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APPLICATION INFORMATION

output characteristics (continued)



 I_p = Pullup current required by the operational amplifier (typically 500 μ A)

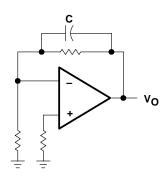


Figure 42. Resistive Pullup to Increase VOH

Figure 43. Compensation for Input Capacitance

feedback

Operational amplifier circuits almost 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 TLC272 and TLC277 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

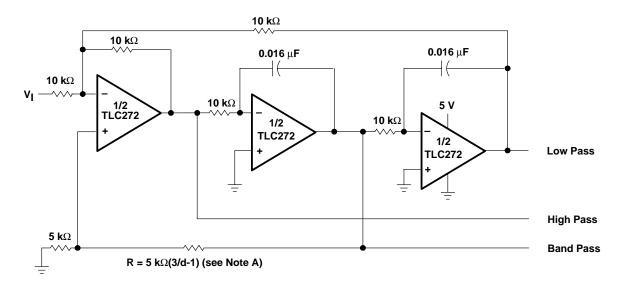
Because CMOS devices are susceptible to latch-up due to their inherent parasitic thyristors, the TLC272 and TLC277 inputs and outputs were designed to withstand -100-mA surge currents without sustaining latch-up; however, techniques should be used to reduce the chance of latch-up whenever possible. Internal 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.



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APPLICATION INFORMATION



NOTE A: d = damping factor, 1/Q

Figure 44. State-Variable Filter

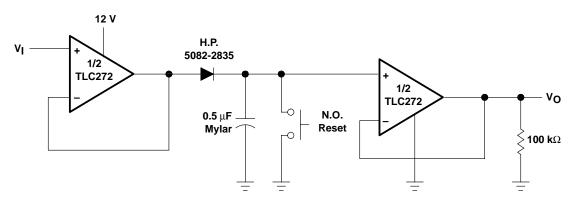
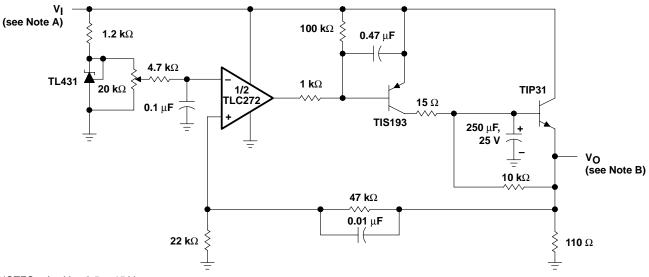


Figure 45. Positive-Peak Detector

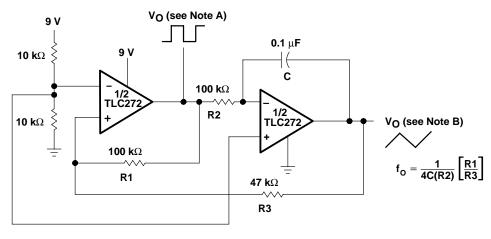
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APPLICATION INFORMATION



NOTES: A. $V_I = 3.5 \text{ to } 15 \text{ V}$ B. $V_O = 2 \text{ V}, 0 \text{ to } 1 \text{ A}$

Figure 46. Logic-Array Power Supply

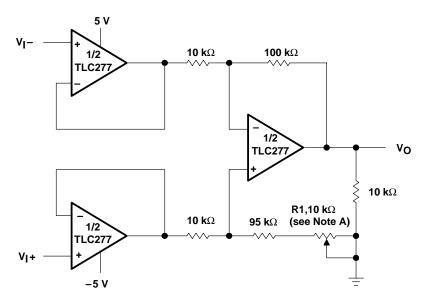


NOTES: A. $V_{O(PP)} = 8 \text{ V}$ B. $V_{O(PP)} = 4 \text{ V}$

Figure 47. Single-Supply Function Generator

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APPLICATION INFORMATION



NOTE B: CMRR adjustment must be noninductive.

Figure 48. Low-Power Instrumentation Amplifier

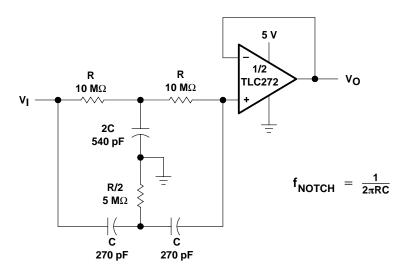


Figure 49. Single-Supply Twin-T Notch Filter

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