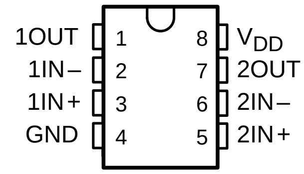
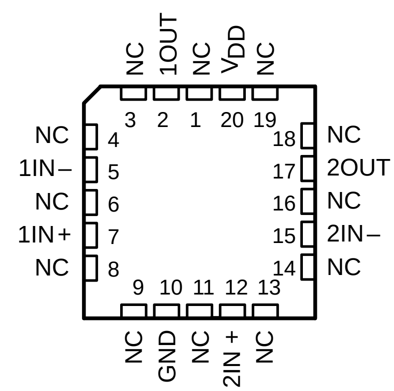
- **Trimmed Offset Voltage:**
  TLC277 . . . 500 µV Max at 25°C, V_{DD} = 5 V
- **Input Offset Voltage Drift . . . Typically 0.1 µV/Month, Including the First 30 Days**
- **Wide Range of Supply Voltages Over Specified Temperature Range:**
  0°C to 70°C . . . 3 V to 16 V
  −40°C to 85°C . . . 4 V to 16 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)**
- **Low Noise . . . Typically 25 nV/√Hz at f = 1 kHz**
- **Output Voltage Range Includes Negative Rail**
- **High Input impedance . . . 10^{12} Ω Typ**
- **ESD-Protection Circuitry**
- **Small-Outline Package Option Also Available in Tape and Reel**
- **Designed-In Latch-Up Immunity**

D, JG, P, OR PW PACKAGE
(TOP VIEW)



FK PACKAGE
(TOP VIEW)



NC – No internal connection

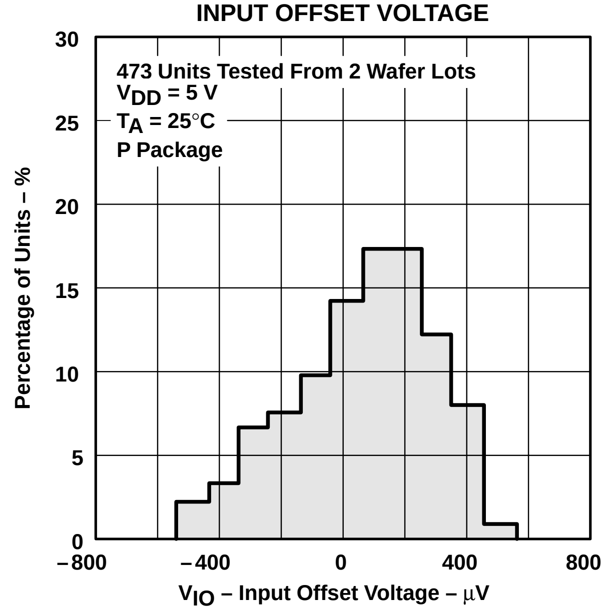
description

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 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 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 µV). These advantages, in combination with good common-mode rejection and supply voltage rejection, make these devices a good choice for new state-of-the-art designs as well as for upgrading existing designs.

DISTRIBUTION OF TLC277
INPUT OFFSET VOLTAGE



LinCMOS is a trademark of Texas Instruments.

description (continued)

AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES					CHIP FORM (Y)
		SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP (PW)	
0°C to 70°c	500 µV	TLC277CD	—	—	TLC277CP	—	—
	2 mV	TLC272BCD	—	—	TLC272BCP	—	—
	5 mV	TLC272ACD	—	—	TLC272ACP	—	—
	10mV	TLC272CD	—	—	TLC272CP	TLC272CPW	TLC272Y
–40°C to 85°C	500 µV	TLC277ID	—	—	TLC277IP	—	—
	2 mV	TLC272BID	—	—	TLC272BIP	—	—
	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.

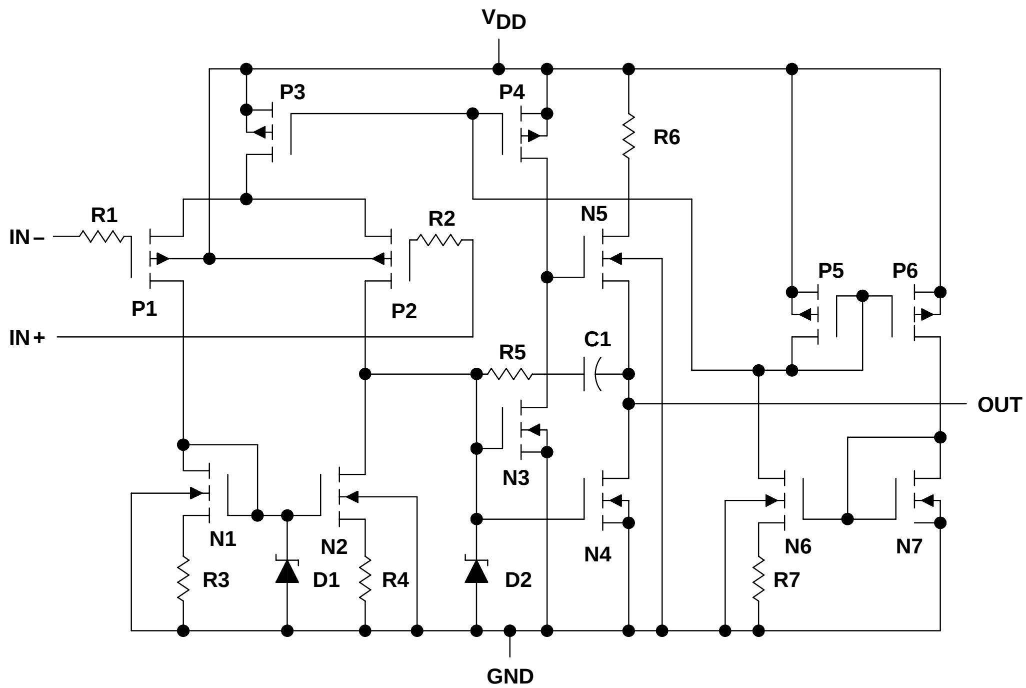
A wide range of packaging options is available, including small-outline and chip carrier versions for high-density system applications.

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.

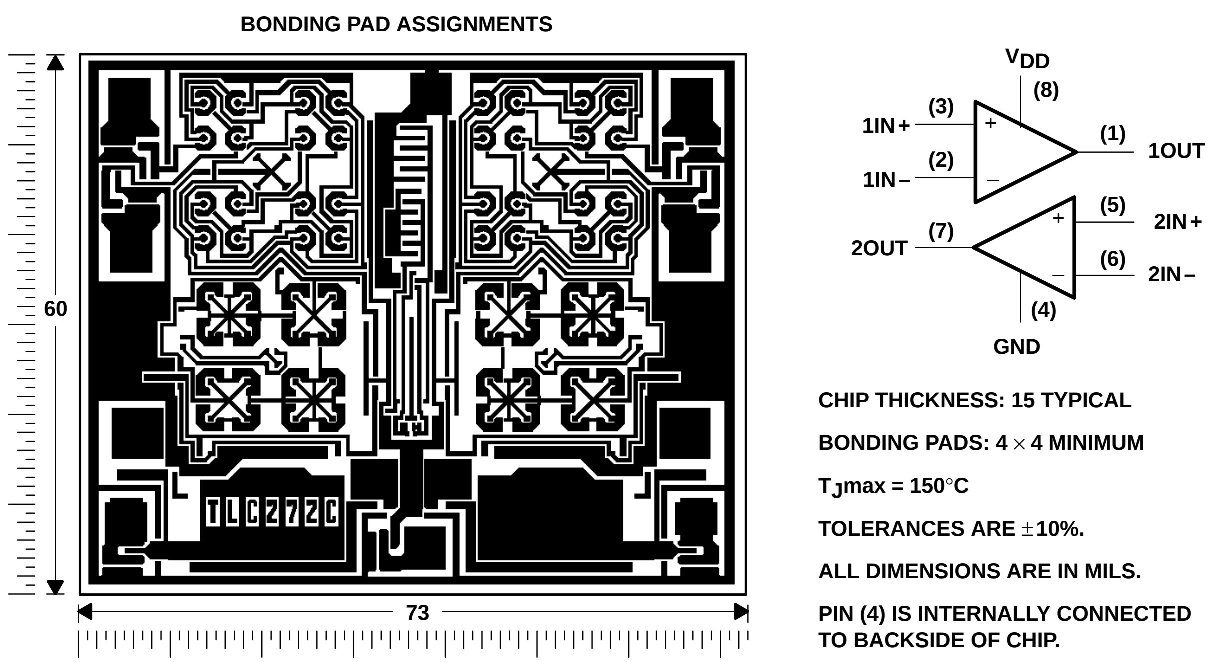
The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C.

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.



CHIP THICKNESS: 15 TYPICAL

BONDING PADS: 4 × 4 MINIMUM

$T_J$max = 150°C

TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

PIN (4) IS INTERNALLY CONNECTED TO BACKSIDE OF CHIP.

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

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

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

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

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ 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
P	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 SUFFIX		I SUFFIX		M SUFFIX		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{DD}		3	16	4	16	4	16	V
Common-mode input voltage, V_{IC}	V_{DD} = 5 V	–0.2	3.5	–0.2	3.5	0	3.5	V
	V_{DD} = 10 V	–0.2	8.5	–0.2	8.5	0	8.5	
Operating free-air temperature, T_A		0	70	–40	85	–55	125	°C

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

PARAMETER			TEST CONDITIONS		T_A†	TLC272C, TLC272AC, TLC272BC, TLC277C			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC272C	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		1.1	10	mV
					Full range			12	
		TLC272AC	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		0.9	5	
					Full range			6.5	
		TLC272BC	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		230	2000	μV
					Full range			3000	
		TLC277C	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		200	500	
					Full range			1500	
α_{VIO}	Temperature coefficient of input offset voltage				25°C to 70°C		1.8		μV/°C
I_{IO}	Input offset current (see Note 4)		V_O = 2.5 V,	V_{IC} = 2.5 V	25°C		0.1	60	pA
					70°C		7	300	
I_{IB}	Input bias current (see Note 4)				25°C		0.6	60	pA
					70°C		40	600	
V_{ICR}	Common-mode input voltage range (see Note 5)				25°C	−0.2 to 4	−0.3 to 4.2		V
					Full range	−0.2 to 3.5			V
V_{OH}	High-level output voltage		V_{ID} = 100 mV,	R_L = 10 kΩ	25°C	3.2	3.8		V
					0°C	3	3.8		
					70°C	3	3.8		
V_{OL}	Low-level output voltage		V_{ID} = –100 mV,	I_{OL} = 0	25°C		0	50	mV
					0°C		0	50	
					70°C		0	50	
A_{VD}	Large-signal differential voltage amplification		V_O = 0.25 V to 2 V,	R_L = 10 kΩ	25°C	5	23		V/mV
					0°C	4	27		
					70°C	4	20		
CMRR	Common-mode rejection ratio		$V_{IC} = V_{ICR}min$		25°C	65	80		dB
					0°C	60	84		
					70°C	60	85		
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5 V to 10 V,	V_O = 1.4 V	25°C	65	95		dB
					0°C	60	94		
					70°C	60	96		
I_{DD}	Supply current (two amplifiers)		V_O = 2.5 V, No load	V_{IC} = 2.5 V,	25°C		1.4	3.2	mA
					0°C		1.6	3.6	
					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.

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

PARAMETER			TEST CONDITIONS	T_A†	TLC272C, TLC272AC, TLC272BC, TLC277C MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	TLC272C	V_O = 1.4 V, V_{IC} = 0, R_S = 50 Ω, R_L = 10 kΩ	25°C		1.1	10	mV
				Full range			12	mV
		TLC272AC	V_O = 1.4 V, V_{IC} = 0, R_S = 50 Ω, R_L = 10 kΩ	25°C		0.9	5	mV
				Full range			6.5	mV
		TLC272BC	V_O = 1.4 V, V_{IC} = 0, R_S = 50 Ω, R_L = 10 kΩ	25°C		290	2000	µV
				Full range			3000	µV
		TLC277C	V_O = 1.4 V, V_{IC} = 0, R_S = 50 Ω, R_L = 10 kΩ	25°C		250	800	µV
				Full range			1900	µV
α_{VIO}	Temperature coefficient of input offset voltage			25°C to 70°C		2		µV/°C
I_{IO}	Input offset current (see Note 4)		V_O = 5 V, V_{IC} = 5 V	25°C		0.1	60	pA
				70°C		7	300	pA
I_{IB}	Input bias current (see Note 4)		V_O = 5 V, V_{IC} = 5 V	25°C		0.7	60	pA
				70°C		50	600	pA
V_{ICR}	Common-mode input voltage range (see Note 5)			25°C	−0.2 to 9	−0.3 to 9.2		V
				Full range	−0.2 to 8.5			V
V_{OH}	High-level output voltage		V_{ID} = 100 mV, R_L = 10 kΩ	25°C	8	8.5		V
				0°C	7.8	8.5		V
				70°C	7.8	8.4		V
V_{OL}	Low-level output voltage		V_{ID} = –100 mV, I_{OL} = 0	25°C		0	50	mV
				0°C		0	50	mV
				70°C		0	50	mV
A_{VD}	Large-signal differential voltage amplification		V_O = 1 V to 6 V, R_L = 10 kΩ	25°C	10	36		V/mV
				0°C	7.5	42		V/mV
				70°C	7.5	32		V/mV
CMRR	Common-mode rejection ratio		$V_{IC} = V_{ICR}min$	25°C	65	85		dB
				0°C	60	88		dB
				70°C	60	88		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5 V to 10 V, V_O = 1.4 V	25°C	65	95		dB
				0°C	60	94		dB
				70°C	60	96		dB
I_{DD}	Supply current (two amplifiers)		V_O = 5 V, V_{IC} = 5 V, No load	25°C		1.9	4	mA
				0°C		2.3	4.4	mA
				70°C		1.6	3.4	mA

† 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.

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

PARAMETER			TEST CONDITIONS		T_A†	TLC272I, TLC272AI, TLC272BI, TLC277I			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC272I	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		1.1	10	mV
					Full range			13	
		TLC272AI	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		0.9	5	
					Full range			7	
		TLC272BI	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		230	2000	μV
					Full range			3500	
		TLC277I	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		200	500	
					Full range			2000	
α_{VIO}	Temperature coefficient of input offset voltage				25°C to 85°C		1.8		μV/°C
I_{IO}	Input offset current (see Note 4)		V_O = 2.5 V,	V_{IC} = 2.5 V	25°C		0.1	60	pA
					85°C		24	15	
I_{IB}	Input bias current (see Note 4)				25°C		0.6	60	pA
					85°C		200	35	
V_{ICR}	Common-mode input voltage range (see Note 5)				25°C	–0.2 to 4	–0.3 to 4.2		V
					Full range	–0.2 to 3.5			V
V_{OH}	High-level output voltage		V_{ID} = 100 mV,	R_L = 10 kΩ	25°C	3.2	3.8		V
					–40°C	3	3.8		
					85°C	3	3.8		
V_{OL}	Low-level output voltage		V_{ID} = –100 mV,	I_{OL} = 0	25°C		0	50	mV
					–40°C		0	50	
					85°C		0	50	
A_{VD}	Large-signal differential voltage amplification		V_O = 1 V to 6 V,	R_L = 10 kΩ	25°C	5	23		V/mV
					–40°C	3.5	32		
					85°C	3.5	19		
CMRR	Common-mode rejection ratio		$V_{IC} = V_{ICR}min$		25°C	65	80		dB
					–40°C	60	81		
					85°C	60	86		
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5 V to 10 V,	V_O = 1.4 V	25°C	65	95		dB
					–40°C	60	92		
					85°C	60	96		
I_{DD}	Supply current (two amplifiers)		V_O = 2.5 V, No load	V_{IC} = 2.5 V,	25°C		1.4	3.2	mA
					–40°C		1.9	4.4	
					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.

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

PARAMETER			TEST CONDITIONS		T_A†	TLC272I, TLC272AI, TLC272BI, TLC277I MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	TLC272I	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		1.1	10	mV
					Full range			13	
		TLC272AI	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		0.9	5	
					Full range			7	
		TLC272BI	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		290	2000	µV
					Full range			3500	
		TLC277I	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		250	800	
					Full range			2900	
α_{VIO}	Temperature coefficient of input offset voltage				25°C to 85°C		2		µV/°C
I_{IO}	Input offset current (see Note 4)		V_O = 5 V,	V_{IC} = 5 V	25°C		0.1	60	pA
					85°C		26	1000	
I_{IB}	Input bias current (see Note 4)				25°C		0.7	60	pA
					85°C		220	2000	
V_{ICR}	Common-mode input voltage range (see Note 5)				25°C	−0.2 to 9	−0.3 to 9.2		V
					Full range	−0.2 to 8.5			V
V_{OH}	High-level output voltage		V_{ID} = 100 mV,	R_L = 10 kΩ	25°C	8	8.5		V
					−40°C	7.8	8.5		
					85°C	7.8	8.5		
V_{OL}	Low-level output voltage		V_{ID} = –100 mV,	I_{OL} = 0	25°C		0	50	mV
					−40°C		0	50	
					85°C		0	50	
A_{VD}	Large-signal differential voltage amplification		V_O = 1 V to 6 V,	R_L = 10 kΩ	25°C	10	36		V/mV
					−40°C	7	46		
					85°C	7	31		
CMRR	Common-mode rejection ratio		$V_{IC} = V_{ICR}min$		25°C	65	85		dB
					−40°C	60	87		
					85°C	60	88		
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5 V to 10 V,	V_O = 1.4 V	25°C	65	95		dB
					−40°C	60	92		
					85°C	60	96		
I_{DD}	Supply current (two amplifiers)		V_O = 5 V, No load	V_{IC} = 5 V,	25°C		1.4	4	mA
					−40°C		2.8	5	
					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.

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

PARAMETER			TEST CONDITIONS		T_A†	TLC272M, TLC277M			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC272M	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		1.1	10	mV
					Full range			12	
		TLC277M	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		200	500	μV
					Full range			3750	
α_{VIO}	Temperature coefficient of input offset voltage				25°C to 125°C		2.1		μV/°C
I_{IO}	Input offset current (see Note 4)		V_O = 2.5 V	V_{IC} = 2.5 V	25°C		0.1	60	pA
					125°C		1.4	15	nA
I_{IB}	Input bias current (see Note 4)				25°C		0.6	60	pA
					125°C		9	35	nA
V_{ICR}	Common-mode input voltage range (see Note 5)				25°C	0 to 4	–0.3 to 4.2		V
					Full range	0 to 3.5			V
V_{OH}	High-level output voltage		V_{ID} = 100 mV,	R_L = 10 kΩ	25°C	3.2	3.8		V
					–55°C	3	3.8		
					125°C	3	3.8		
V_{OL}	Low-level output voltage		V_{ID} = –100 mV,	I_{OL} = 0	25°C		0	50	mV
					–55°C		0	50	
					125°C		0	50	
A_{VD}	Large-signal differential voltage amplification		V_O = 0.25 V to 2 V	R_L = 10 kΩ	25°C	5	23		V/mV
					–55°C	3.5	35		
					125°C	3.5	16		
CMRR	Common-mode rejection ratio		$V_{IC} = V_{ICR}$min		25°C	65	80		dB
					–55°C	60	81		
					125°C	60	84		
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5 V to 10 V,	V_O = 1.4 V	25°C	65	95		dB
					–55°C	60	90		
					125°C	60	97		
I_{DD}	Supply current (two amplifiers)		V_O = 2.5 V, No load	V_{IC} = 2.5 V,	25°C		1.4	3.2	mA
					–55°C		2	5	
					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.

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

PARAMETER			TEST CONDITIONS		T_A†	TLC272M, TLC277M			UNIT
						MIN	TYP	MAX	
V_{IO}	Input offset voltage	TLC272M	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		1.1	10	mV
					Full range			12	mV
		TLC277M	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ	25°C		250	800	μV
					Full range			4300	μV
α_{VIO}	Temperature coefficient of input offset voltage				25°C to 125°C		2.2		μV/°C
I_{IO}	Input offset current (see Note 4)		V_O = 5 V,	V_{IC} = 5 V	25°C		0.1	60	pA
					125°C		1.8	15	nA
I_{IB}	Input bias current (see Note 4)				25°C		0.7	60	pA
					125°C		10	35	nA
V_{ICR}	Common-mode input voltage range (see Note 5)				25°C	0 to 9	–0.3 to 9.2		V
					Full range	0 to 8.5			V
V_{OH}	High-level output voltage		V_{ID} = 100 mV,	R_L = 10 kΩ	25°C	8	8.5		V
					–55°C	7.8	8.5		
					125°C	7.8	8.4		
V_{OL}	Low-level output voltage		V_{ID} = –100 mV,	I_{OL} = 0	25°C		0	50	mV
					–55°C		0	50	
					125°C		0	50	
A_{VD}	Large-signal differential voltage amplification		V_O = 1 V to 6 V,	R_L = 10 kΩ	25°C	10	36		V/mV
					–55°C	7	50		
					125°C	7	27		
CMRR	Common-mode rejection ratio		$V_{IC} = V_{ICR}$min		25°C	65	85		dB
					–55°C	60	87		
					125°C	60	86		
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		V_{DD} = 5 V to 10 V,	V_O = 1.4 V	25°C	65	95		dB
					–55°C	60	90		
					125°C	60	97		
I_{DD}	Supply current (two amplifiers)		V_O = 5 V, No load	V_{IC} = 5 V,	25°C		1.9	4	mA
					–55°C		3	6	
					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.

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

PARAMETER		TEST CONDITIONS		TLC272Y MIN	TLC272Y TYP	TLC272Y MAX	UNIT
V_{IO}	Input offset voltage	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ		1.1	10	mV
α_{VIO}	Temperature coefficient of input offset voltage				1.8		µV/°C
I_{IO}	Input offset current (see Note 4)	V_O = 2.5 V,	V_{IC} = 2.5 V		0.1		pA
I_{IB}	Input bias current (see Note 4)				0.6		pA
V_{ICR}	Common-mode input voltage range (see Note 5)			–0.2 to 4	–0.3 to 4.2		V
V_{OH}	High-level output voltage	V_{ID} = 100 mV,	R_L = 10 kΩ	3.2	3.8		V
V_{OL}	Low-level output voltage	V_{ID} = –100 mV,	I_{OL} = 0		0	50	mV
A_{VD}	Large-signal differential voltage amplification	V_O = 0.25 V to 2 V	R_L = 10 kΩ	5	23		V/mV
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}min$		65	80		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD} / \Delta V_{IO}$)	V_{DD} = 5 V to 10 V,	V_O = 1.4 V	65	95		dB
I_{DD}	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.
5. This range also applies to each input individually.

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

PARAMETER		TEST CONDITIONS		TLC272Y MIN	TLC272Y TYP	TLC272Y MAX	UNIT
V_{IO}	Input offset voltage	V_O = 1.4 V, R_S = 50 Ω,	V_{IC} = 0, R_L = 10 kΩ		1.1	10	mV
α_{VIO}	Temperature coefficient of input offset voltage				1.8		µV/°C
I_{IO}	Input offset current (see Note 4)	V_O = 5 V,	V_{IC} = 5 V		0.1		pA
I_{IB}	Input bias current (see Note 4)				0.7		pA
V_{ICR}	Common-mode input voltage range (see Note 5)			–0.2 to 9	–0.3 to 9.2		V
V_{OH}	High-level output voltage	V_{ID} = 100 mV,	R_L = 10 kΩ	8	8.5		V
V_{OL}	Low-level output voltage	V_{ID} = –100 mV,	I_{OL} = 0		0	50	mV
A_{VD}	Large-signal differential voltage amplification	V_O = 1 V to 6 V,	R_L = 10 kΩ	10	36		V/mV
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}min$		65	85		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD} / \Delta V_{IO}$)	V_{DD} = 5 V to 10 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.

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

PARAMETER		TEST CONDITIONS		T_A	TLC272C, TLC272AC, TLC272BC, TLC277C			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	R_L = 10 kΩ, C_L = 20 pF, See Figure 1	V_{IPP} = 1 V	25°C		3.6		V/μs
				0°C		4		
				70°C		3		
			V_{IPP} = 2.5 V	25°C		2.9		
				0°C		3.1		
				70°C		2.5		
V_n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	R_S = 20 Ω,	25°C		25		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	$V_O = V_{OH}$, R_L = 10 kΩ,	C_L = 20 pF, See Figure 1	25°C		320		kHz
				0°C		340		
				70°C		260		
B_1	Unity-gain bandwidth	V_I = 10 mV, See Figure 3	C_L = 20 pF,	25°C		1.7		MHz
				0°C		2		
				70°C		1.3		
ϕ_m	Phase margin	V_I = 10 mV, C_L = 20 pF,	f = B_1, See Figure 3	25°C		46°		
				0°C		47°		
				70°C		43°		

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

PARAMETER		TEST CONDITIONS		T_A	TLC272C, TLC272AC, TLC272BC, TLC277C			UNIT
					MIN	TYP	MAX	
SR	Slew rate at unity gain	R_L = 10 kΩ, C_L = 20 pF, See Figure 1	V_{IPP} = 1 V	25°C		5.3		V/μs
				0°C		5.9		
				70°C		4.3		
			V_{IPP} = 5.5 V	25°C		4.6		
				0°C		5.1		
				70°C		3.8		
V_n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	R_S = 20 Ω,	25°C		25		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	$V_O = V_{OH}$, R_L = 10 kΩ,	C_L = 20 pF, See Figure 1	25°C		200		kHz
				0°C		220		
				70°C		140		
B_1	Unity-gain bandwidth	V_I = 10 mV, See Figure 3	C_L = 20 pF,	25°C		2.2		MHz
				0°C		2.5		
				70°C		1.8		
ϕ_m	Phase margin	V_I = 10 mV, C_L = 20 pF,	f = B_1, See Figure 3	25°C		49°		
				0°C		50°		
				70°C		46°		

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

PARAMETER		TEST CONDITIONS		T_A	TLC272I, TLC272AI, TLC272BI, TLC277I MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	R_L = 10 kΩ, C_L = 20 pF, See Figure 1	V_{IPP} = 1 V	25°C		3.6		V/μs
				–40°C		4.5		
				85°C		2.8		
			V_{IPP} = 2.5 V	25°C		2.9		
				–40°C		3.5		
				85°C		2.3		
V_n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	R_S = 20 Ω,	25°C		25		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	$V_O = V_{OH}$, R_L = 10 kΩ,	C_L = 20 pF, See Figure 1	25°C		320		kHz
				–40°C		380		
				85°C		250		
B_1	Unity-gain bandwidth	V_I = 10 mV, See Figure 3	C_L = 20 pF,	25°C		1.7		MHz
				–40°C		2.6		
				85°C		1.2		
ϕ_m	Phase margin	V_I = 10 mV, C_L = 20 pF,	f = B_1, See Figure 3	25°C		46°		
				–40°C		49°		
				85°C		43°		

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

PARAMETER		TEST CONDITIONS		T_A	TLC272I, TLC272AI, TLC272BI, TLC277I MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	R_L = 10 kΩ, C_L = 20 pF, See Figure 1	V_{IPP} = 1 V	25°C		5.3		V/μs
				–40°C		6.8		
				85°C		4		
			V_{IPP} = 5.5 V	25°C		4.6		
				–40°C		5.8		
				85°C		3.5		
V_n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	R_S = 20 Ω,	25°C		25		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	$V_O = V_{OH}$, R_L = 10 kΩ,	C_L = 20 pF, See Figure 1	25°C		200		kHz
				–40°C		260		
				85°C		130		
B_1	Unity-gain bandwidth	V_I = 10 mV, See Figure 3	C_L = 20 pF,	25°C		2.2		MHz
				–40°C		3.1		
				85°C		1.7		
ϕ_m	Phase margin	V_I = 10 mV, C_L = 20 pF,	f = B_1, See Figure 3	25°C		49°		
				–40°C		52°		
				85°C		46°		

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

PARAMETER		TEST CONDITIONS		T_A	TLC272M, TLC277M MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	R_L = 10 kΩ, C_L = 20 pF, See Figure 1	V_{IPP} = 1 V	25°C		3.6		V/µs
				–55°C		4.7		
				125°C		2.3		
			V_{IPP} = 2.5 V	25°C		2.9		
				–55°C		3.7		
				125°C		2		
V_n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	R_S = 20 Ω,	25°C		25		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	$V_O = V_{OH}$, R_L = 10 kΩ,	C_L = 20 pF, See Figure 1	25°C		320		kHz
				–55°C		400		
				125°C		230		
B_1	Unity-gain bandwidth	V_I = 10 mV, See Figure 3	C_L = 20 pF,	25°C		1.7		MHz
				–55°C		2.9		
				125°C		1.1		
ϕ_m	Phase margin	V_I = 10 mV, C_L = 20 pF,	f = B_1, See Figure 3	25°C		46°		
				–55°C		49°		
				125°C		41°		

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

PARAMETER		TEST CONDITIONS		T_A	TLC272M, TLC277M MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	R_L = 10 kΩ, C_L = 20 pF, See Figure 1	V_{IPP} = 1 V	25°C		5.3		V/µs
				–55°C		7.1		
				125°C		3.1		
			V_{IPP} = 5.5 V	25°C		4.6		
				–55°C		6.1		
				125°C		2.7		
V_n	Equivalent input noise voltage	f = 1 kHz, See Figure 2	R_S = 20 Ω,	25°C		25		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	$V_O = V_{OH}$, R_L = 10 kΩ,	C_L = 20 pF, See Figure 1	25°C		200		kHz
				–55°C		280		
				125°C		110		
B_1	Unity-gain bandwidth	V_I = 10 mV, See Figure 3	C_L = 20 pF,	25°C		2.2		MHz
				–55°C		3.4		
				125°C		1.6		
ϕ_m	Phase margin	V_I = 10 mV, C_L = 20 pF,	f = B_1, See Figure 3	25°C		49°		
				–55°C		52°		
				125°C		44°		

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

PARAMETER		TEST CONDITIONS		TLC272Y MIN	TLC272Y TYP	TLC272Y MAX	UNIT
SR	Slew rate at unity gain	R_L = 10 kΩ, C_L = 20 pF, See Figure 1	V_{IPP} = 1 V		3.6		V/μs
			V_{IPP} = 2.5 V		2.9		
V_n	Equivalent input noise voltage	f = 1 kHz, R_S = 20 Ω, See Figure 2			25		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	V_O = V_{OH}, C_L = 20 pF, R_L = 10 kΩ, See Figure 1			320		kHz
B_1	Unity-gain bandwidth	V_I = 10 mV, C_L = 20 pF, See Figure 3			1.7		MHz
ϕ_m	Phase margin	V_I = 10 mV, f = B_1, C_L = 20 pF, See Figure 3			46°		

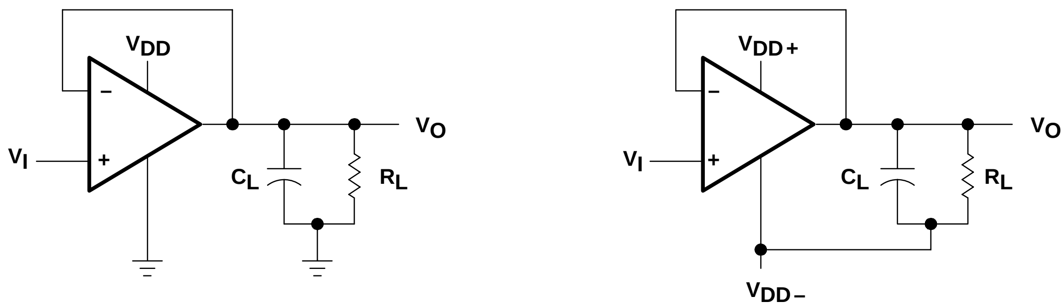
operating characteristics, V_{DD} = 10 V, T_A = 25°C

PARAMETER		TEST CONDITIONS		TLC272Y MIN	TLC272Y TYP	TLC272Y MAX	UNIT
SR	Slew rate at unity gain	R_L = 10 kΩ, C_L = 20 pF, See Figure 1	V_{IPP} = 1 V		5.3		V/μs
			V_{IPP} = 5.5 V		4.6		
V_n	Equivalent input noise voltage	f = 1 kHz, R_S = 20 Ω, See Figure 2			25		nV/√Hz
B_{OM}	Maximum output-swing bandwidth	V_O = V_{OH}, C_L = 20 pF, R_L = 10 kΩ, See Figure 1			200		kHz
B_1	Unity-gain bandwidth	V_I = 10 mV, C_L = 20 pF, See Figure 3			2.2		MHz
ϕ_m	Phase margin	V_I = 10 mV, f = B_1, C_L = 20 pF, See Figure 3			49°		

PARAMETER MEASUREMENT INFORMATION

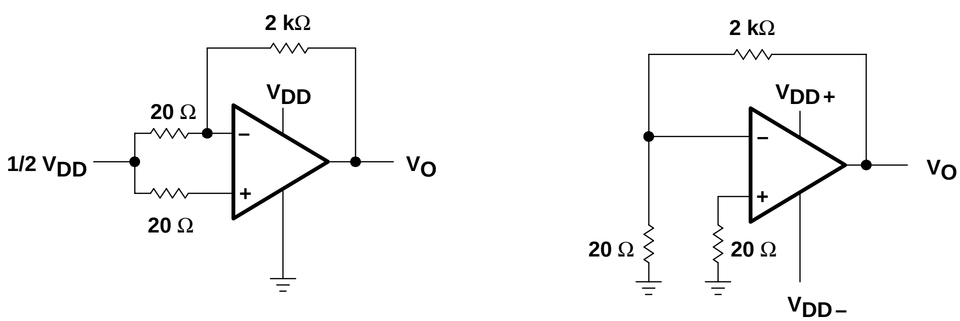
single-supply versus split-supply test circuits

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.



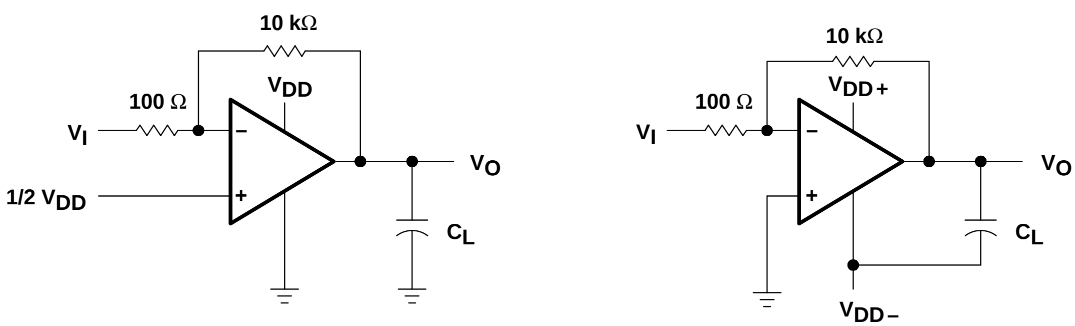
(a) SINGLE SUPPLY (b) SPLIT SUPPLY

Figure 1. Unity-Gain Amplifier



(a) SINGLE SUPPLY (b) SPLIT SUPPLY

Figure 2. Noise-Test Circuit



(a) SINGLE SUPPLY (b) SPLIT SUPPLY

Figure 3. Gain-of-100 Inverting Amplifier

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.
2. Compensate for the leakage of the test socket by actually performing an input bias current test (using a picoammeter) with no device in the test socket. The actual input bias current can then be calculated by subtracting the open-socket leakage readings from the readings obtained with a device in the test socket.

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

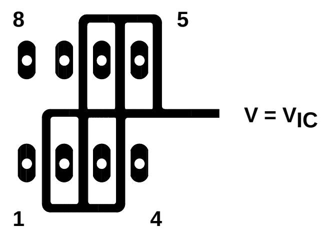


Figure 4. Isolation Metal Around Device Inputs (JG and P packages)

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.

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.

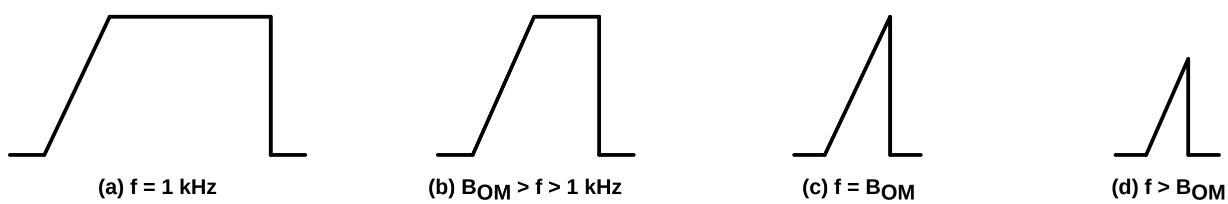


Figure 5. Full-Power-Response Output Signal

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.

TYPICAL CHARACTERISTICS

Table of Graphs

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

TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLC272 INPUT OFFSET VOLTAGE

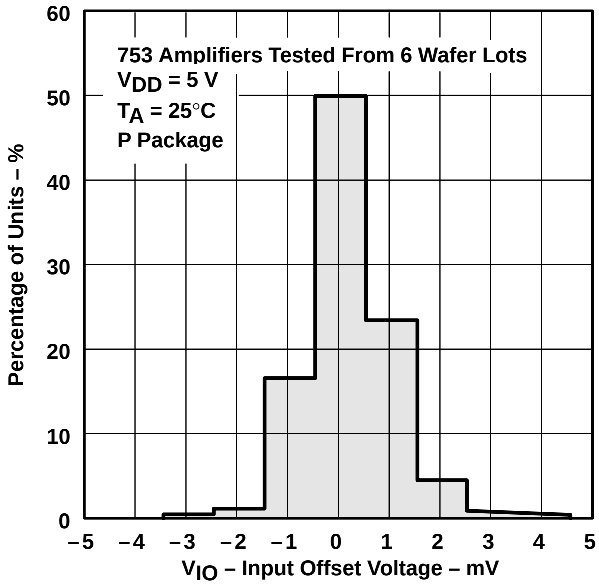


Figure 6

DISTRIBUTION OF TLC272 INPUT OFFSET VOLTAGE

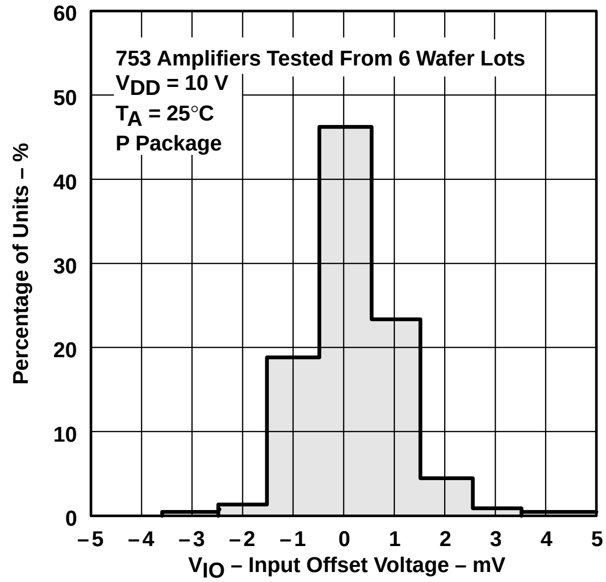


Figure 7

DISTRIBUTION OF TLC272 AND TLC277 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

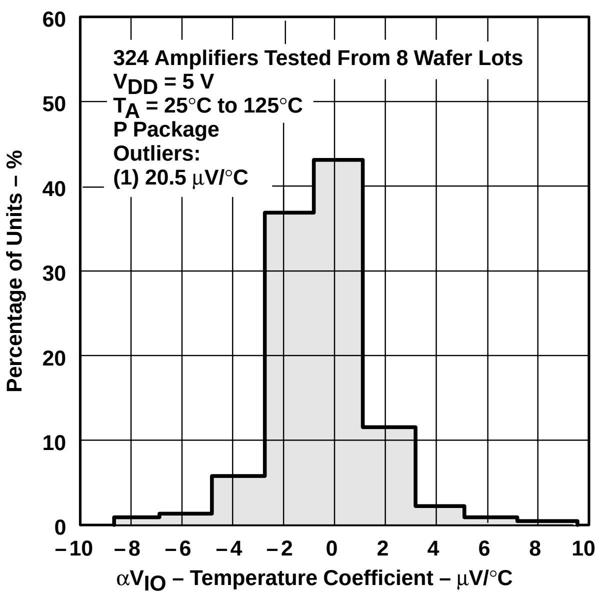


Figure 8

DISTRIBUTION OF TLC272 AND TLC277 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT

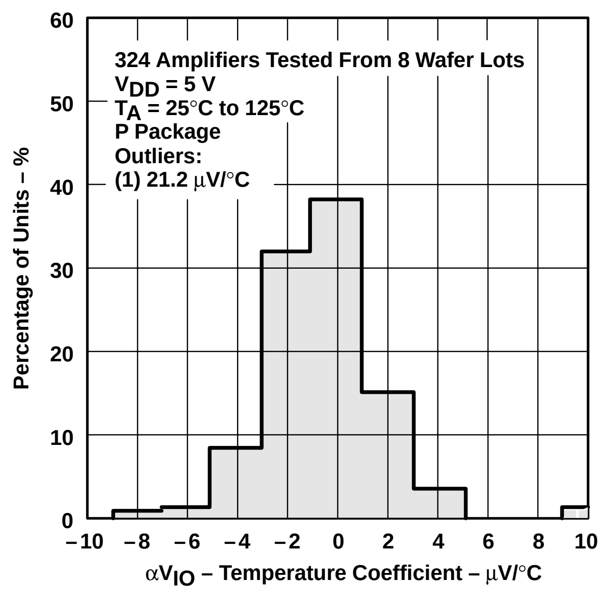
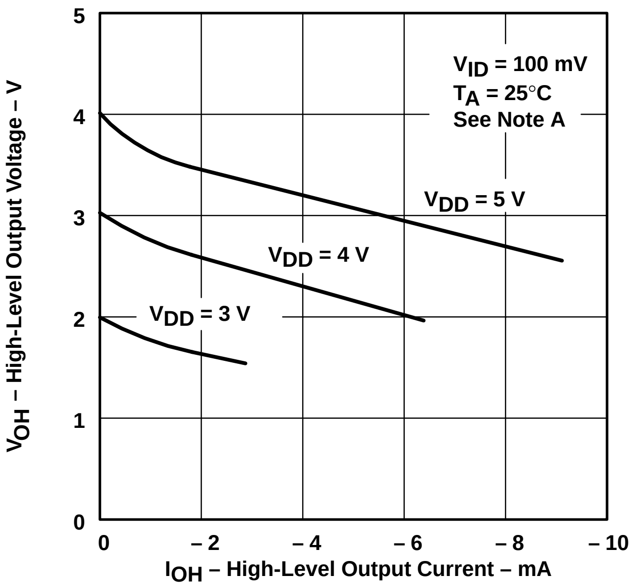


Figure 9

TYPICAL CHARACTERISTICS†

HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT



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

Figure 10

HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

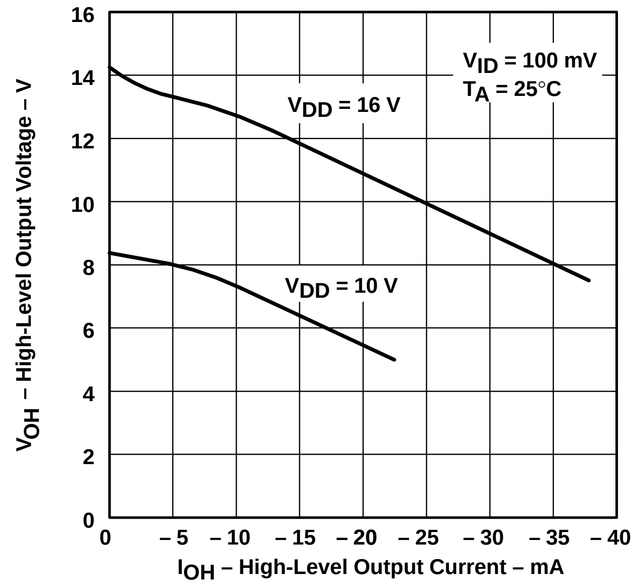


Figure 11

HIGH-LEVEL OUTPUT VOLTAGE
vs
SUPPLY VOLTAGE

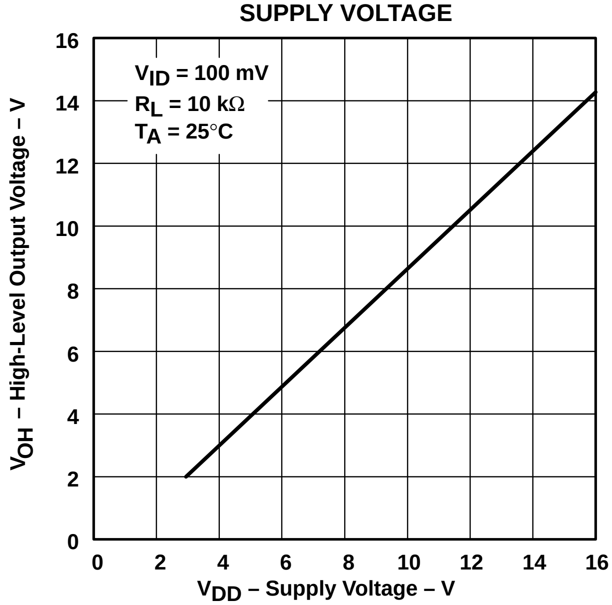


Figure 12

HIGH-LEVEL OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE

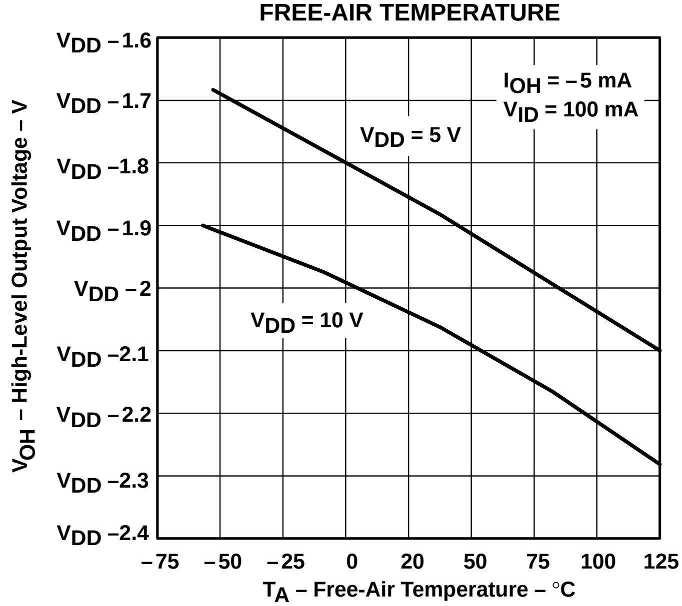


Figure 13

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

TYPICAL CHARACTERISTICS†

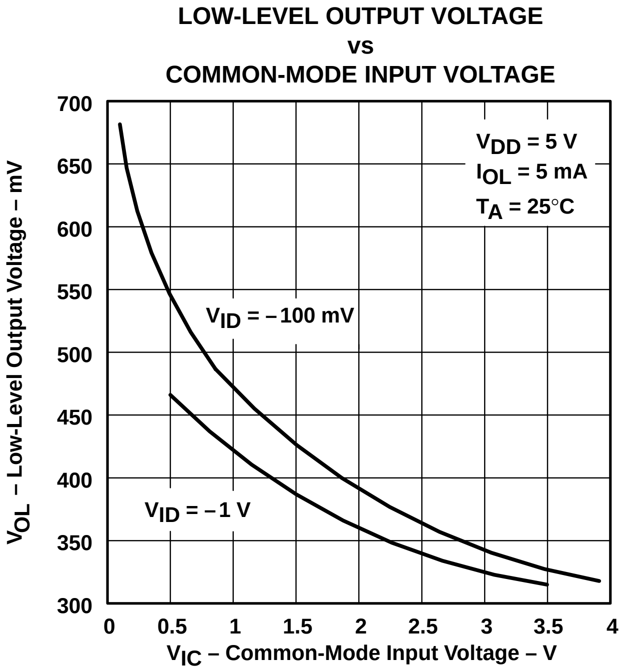


Figure 14

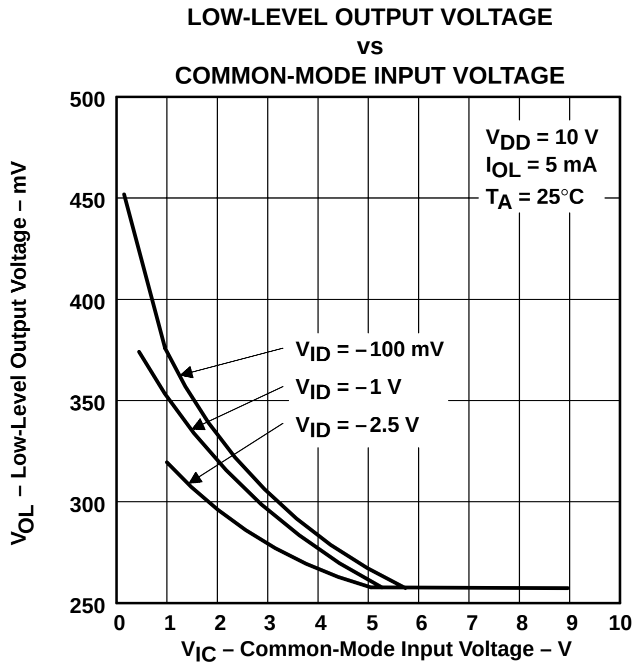


Figure 15

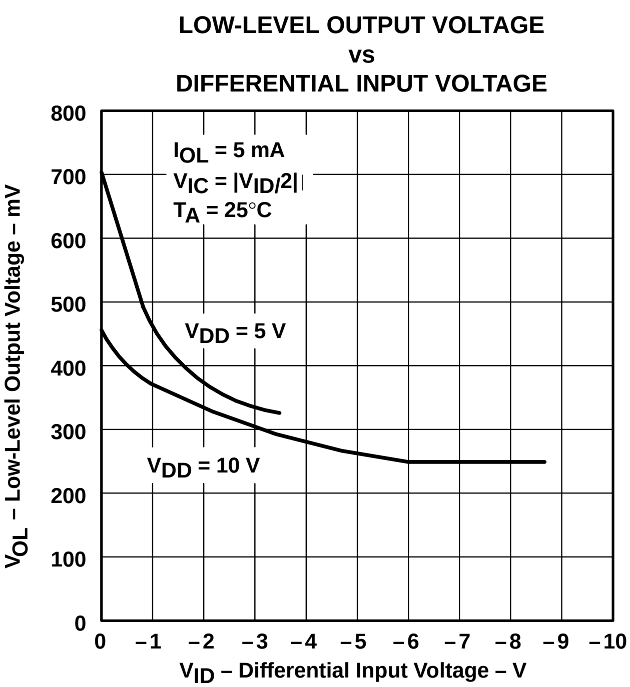


Figure 16

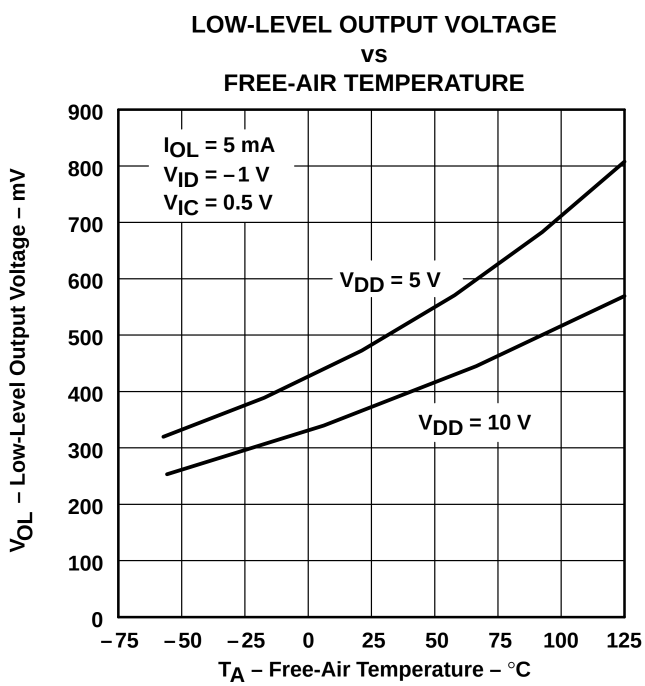
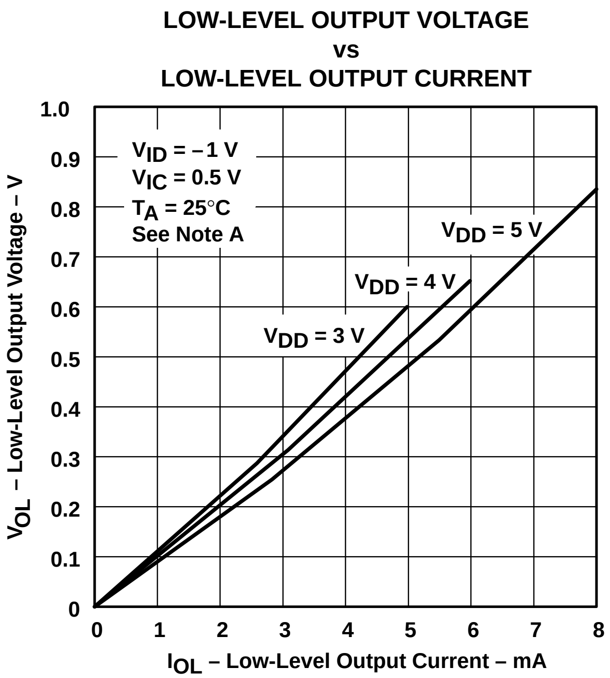


Figure 17

† 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

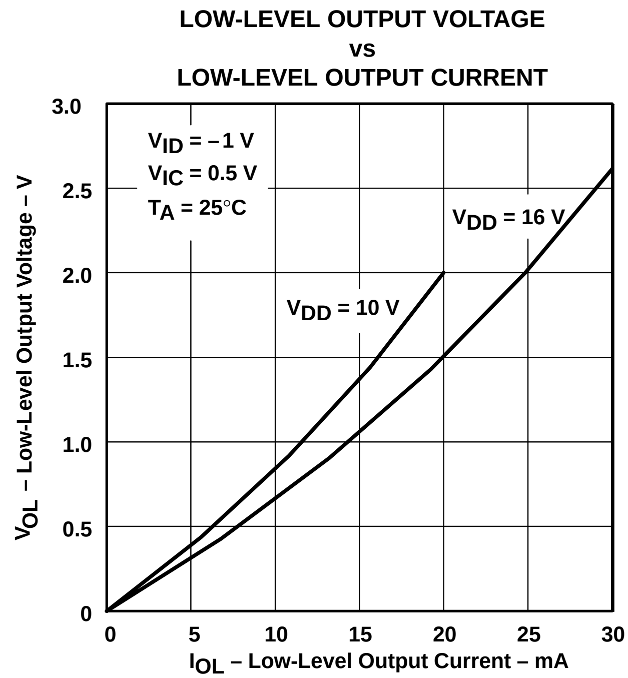


Figure 19

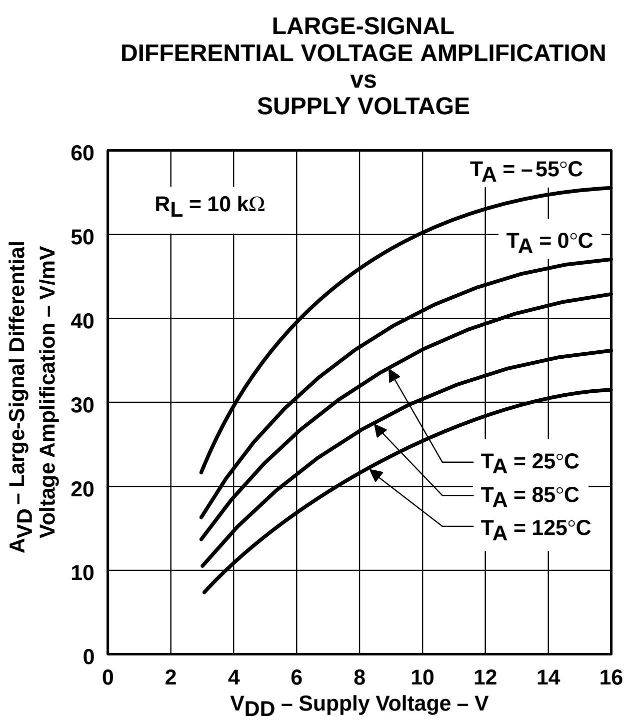


Figure 20

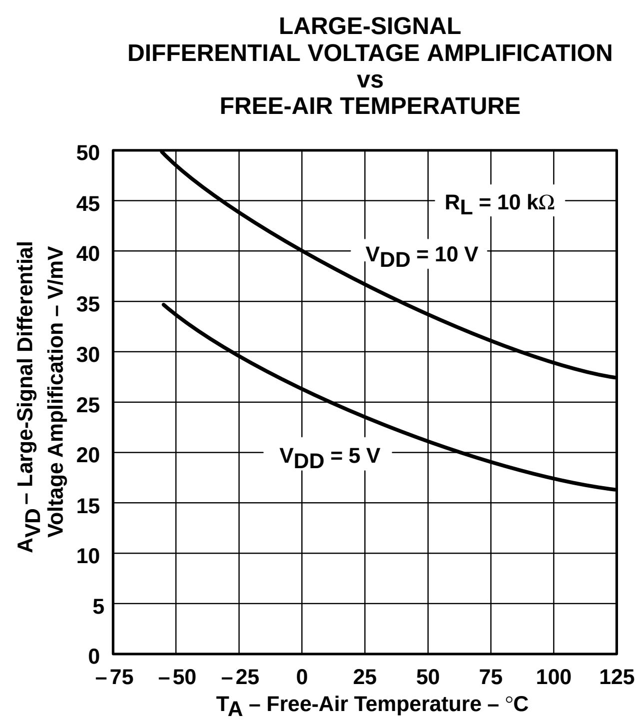
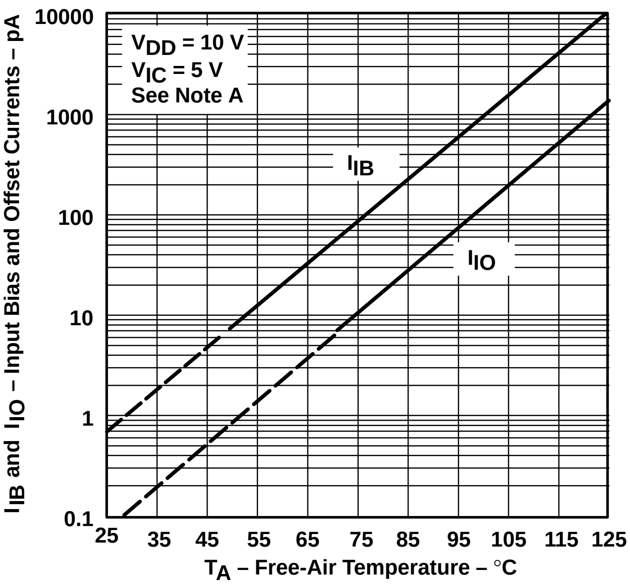


Figure 21

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

TYPICAL CHARACTERISTICS†

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



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

Figure 22

COMMON-MODE
INPUT VOLTAGE POSITIVE LIMIT
vs
SUPPLY VOLTAGE

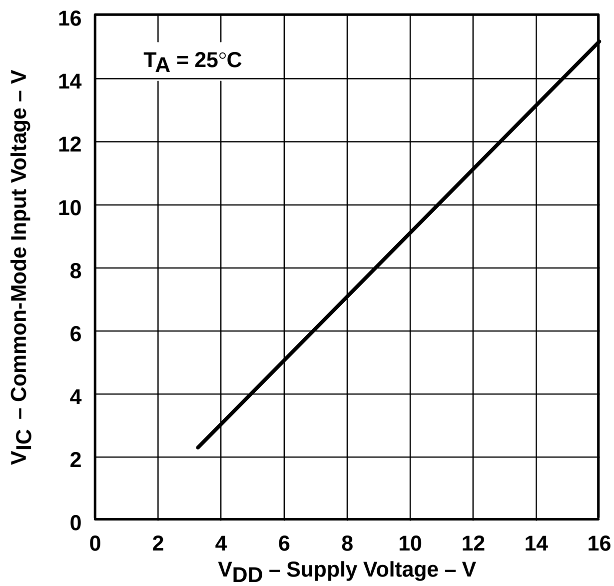


Figure 23

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

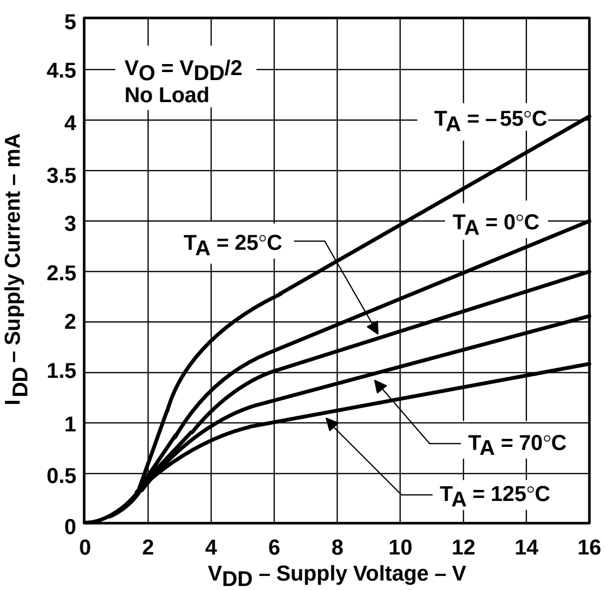


Figure 24

SUPPLY CURRENT
vs
FREE-AIR TEMPERATURE

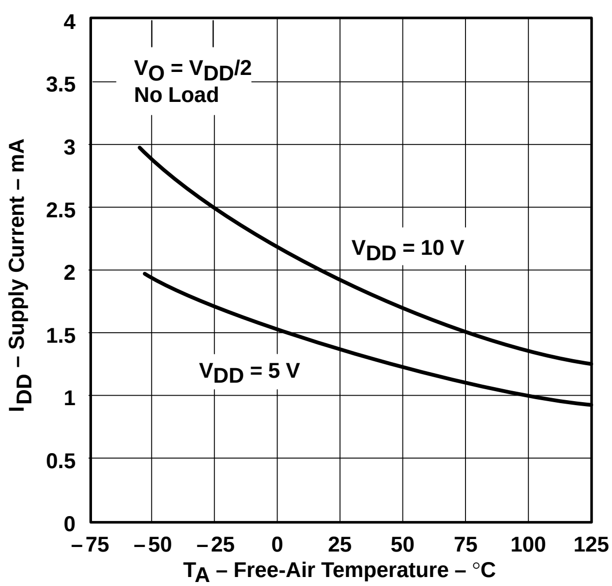


Figure 25

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

TYPICAL CHARACTERISTICS†

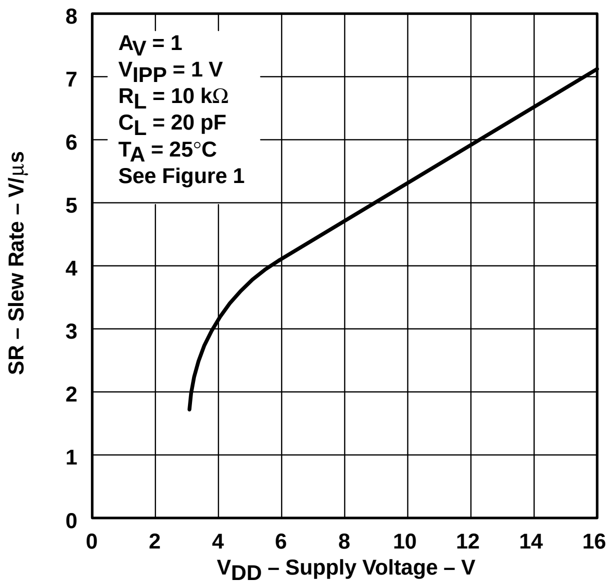


Figure 26

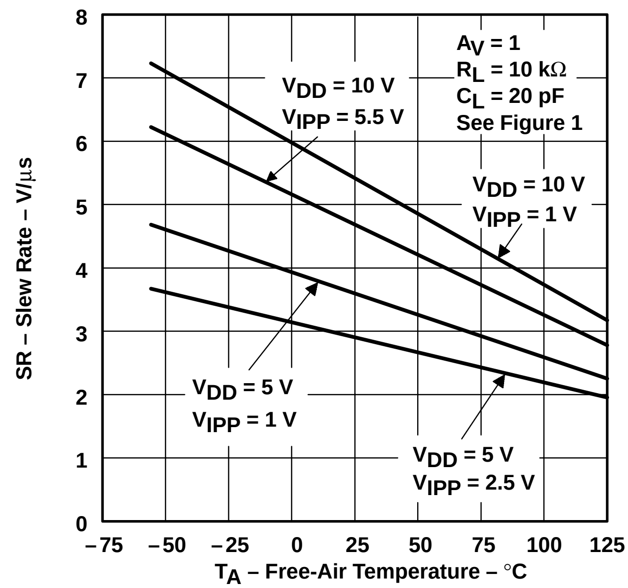


Figure 27

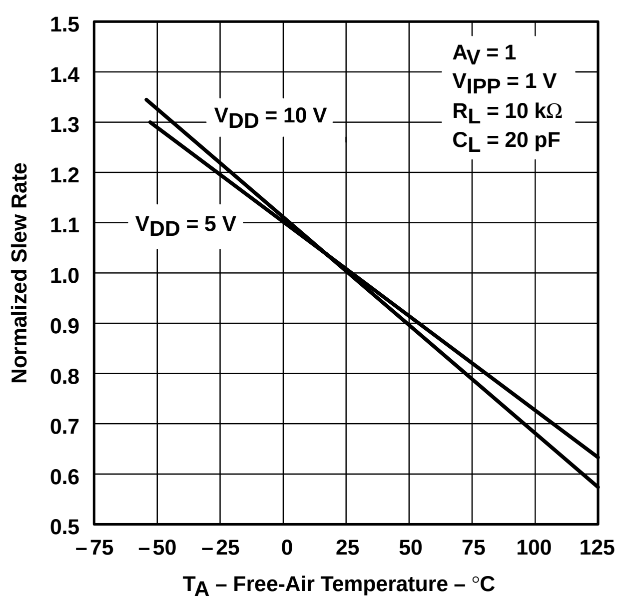


Figure 28

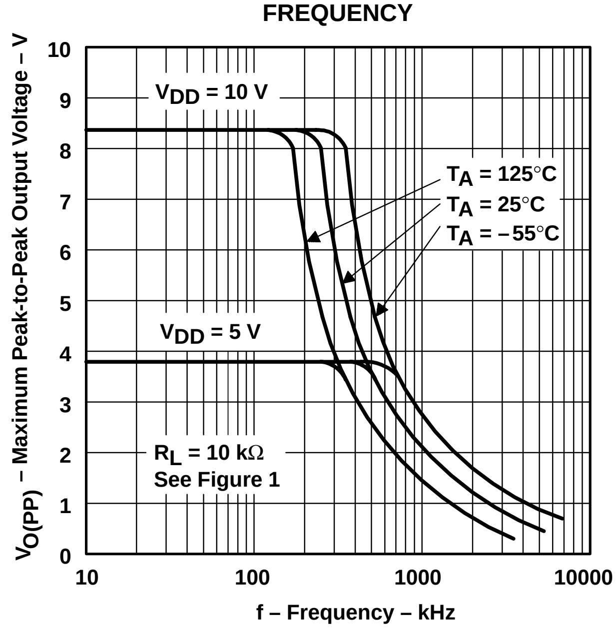


Figure 29

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

TYPICAL CHARACTERISTICS†

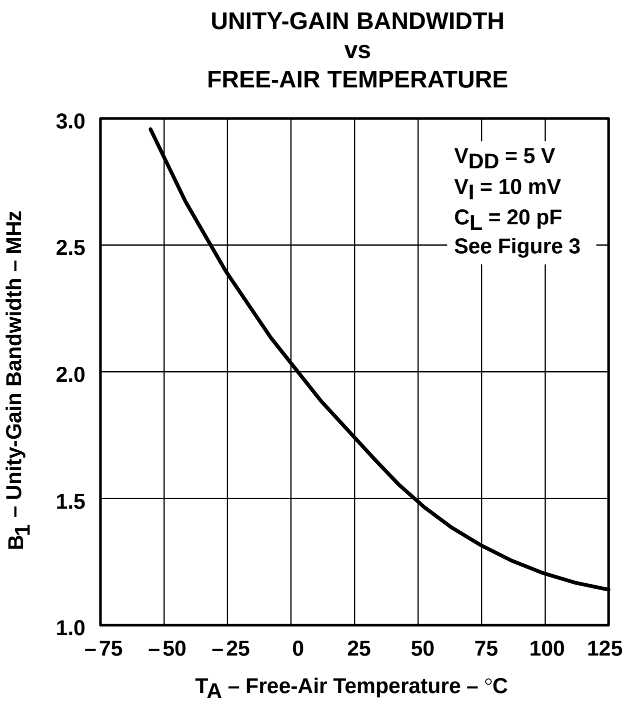


Figure 30

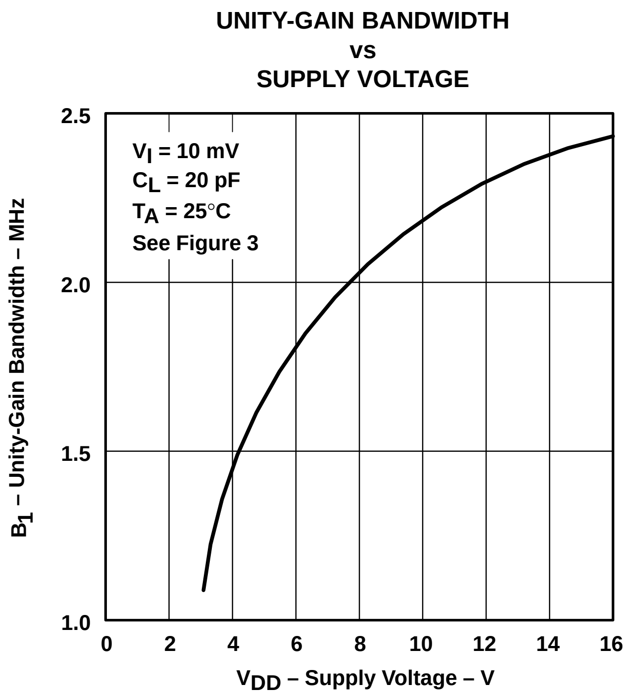


Figure 31

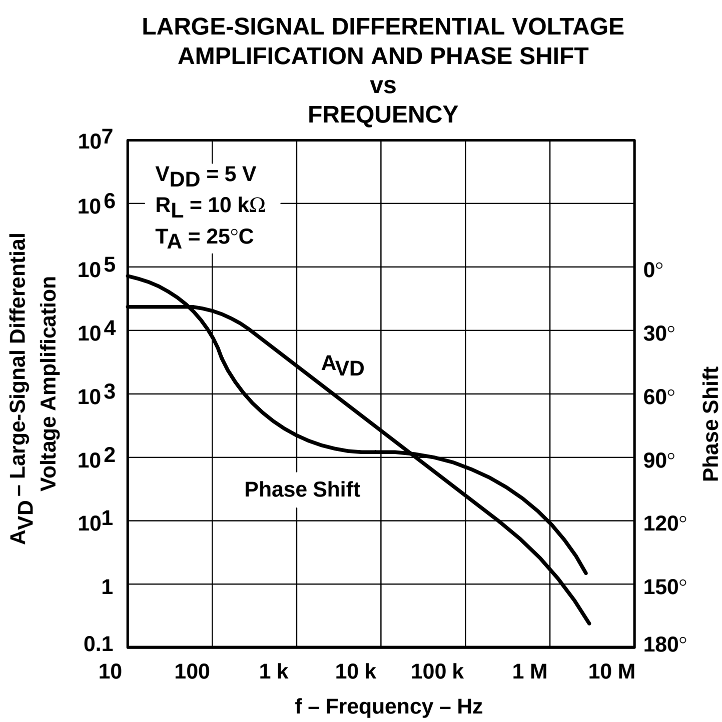


Figure 32

† 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 vs FREQUENCY

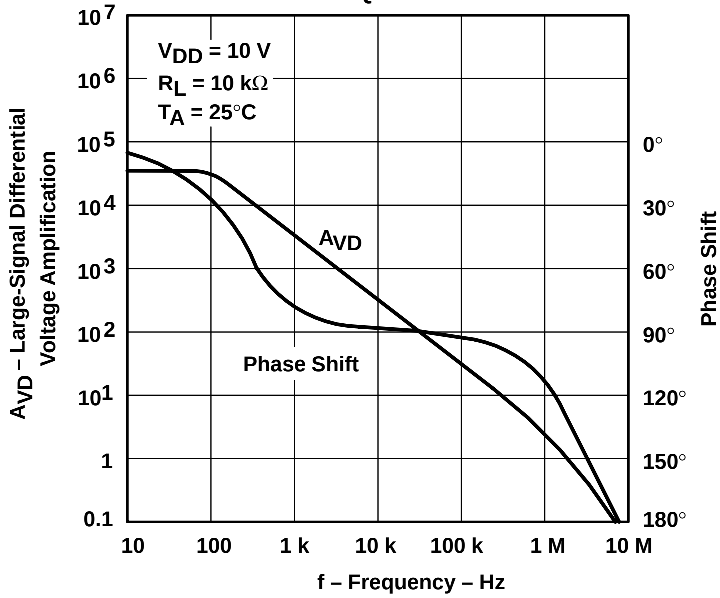


Figure 33

PHASE MARGIN vs SUPPLY VOLTAGE

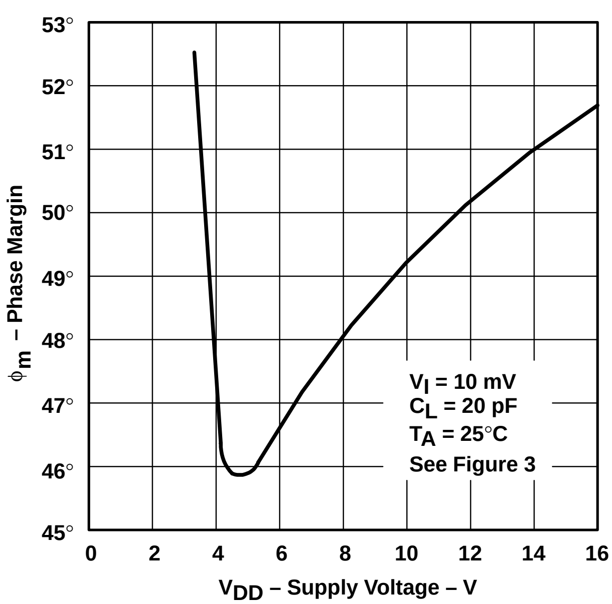


Figure 34

PHASE MARGIN vs FREE-AIR TEMPERATURE

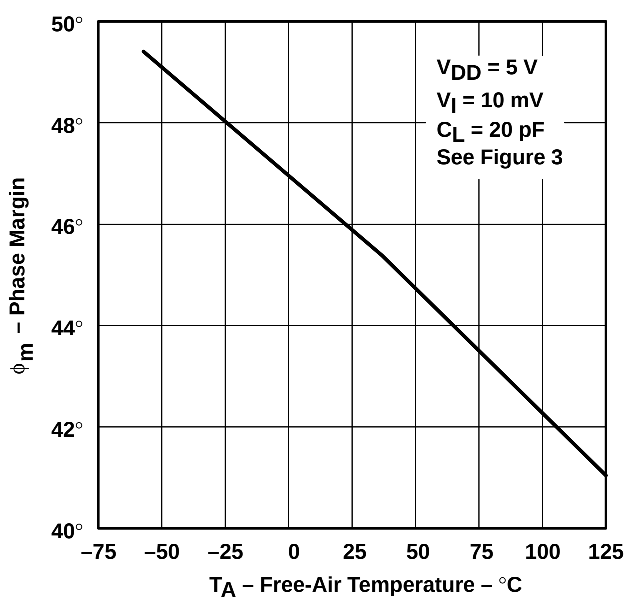


Figure 35

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

TYPICAL CHARACTERISTICS

PHASE MARGIN vs CAPACITIVE LOAD

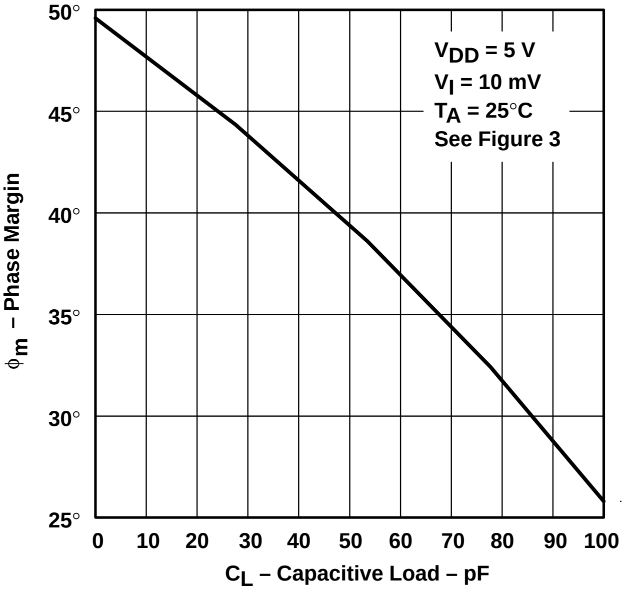


Figure 36

EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

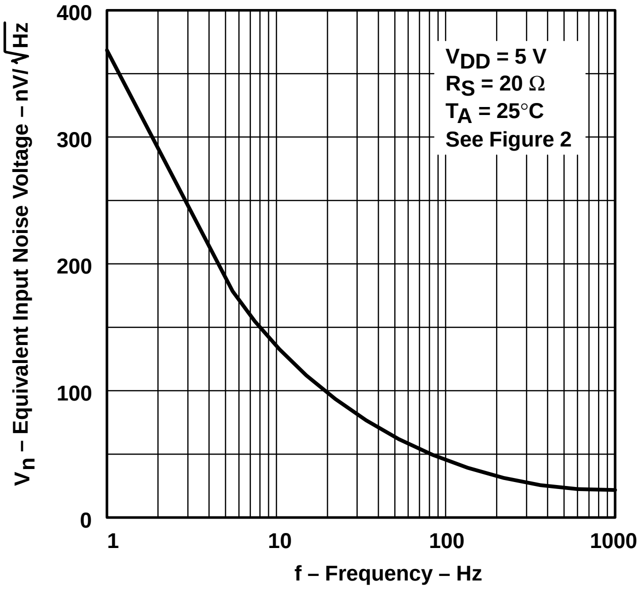


Figure 37

APPLICATION INFORMATION

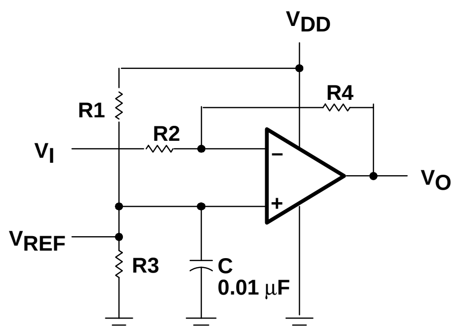
single-supply operation

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:

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



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

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

Figure 38. Inverting Amplifier With Voltage Reference

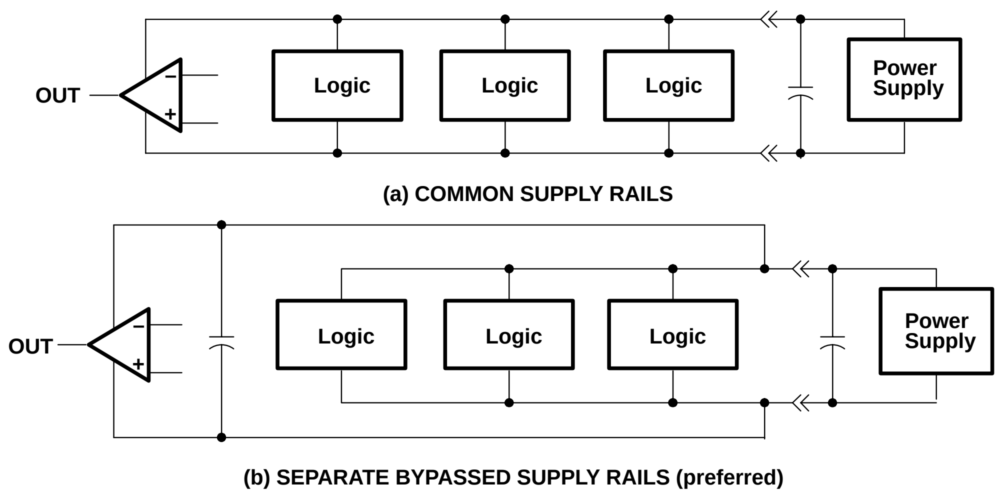


Figure 39. Common vs Separate Supply Rails

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°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 kΩ, since bipolar devices exhibit greater noise currents.

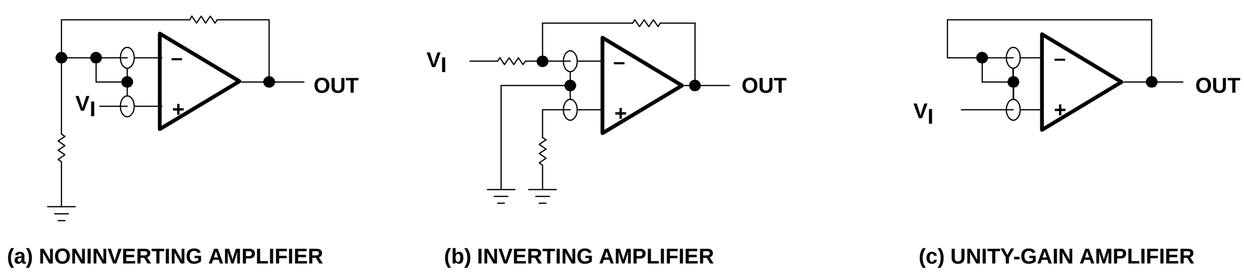


Figure 40. Guard-Ring Schemes

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.

APPLICATION INFORMATION

output characteristics (continued)

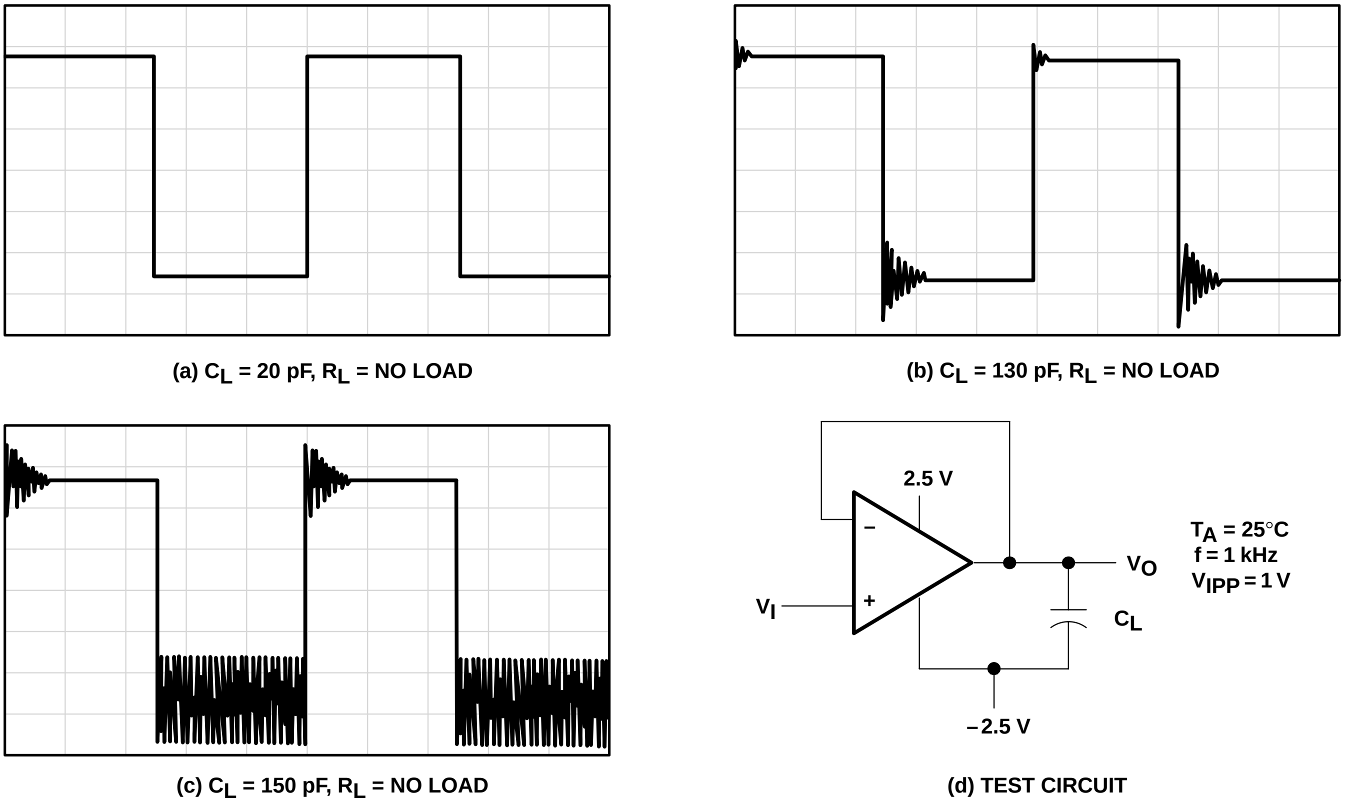
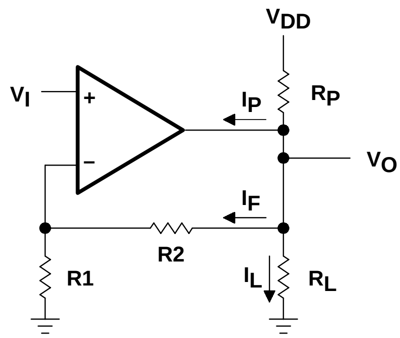


Figure 41. Effect of Capacitive Loads and Test Circuit

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.

APPLICATION INFORMATION

output characteristics (continued)



$$R_P = \frac{V_{DD} - V_O}{I_F + I_L + I_P}$$

I_P = Pullup current required by the operational amplifier (typically 500 µA)

Figure 42. Resistive Pullup to Increase V_{OH}

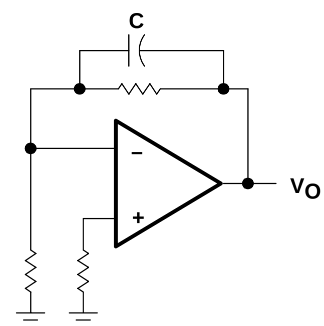


Figure 43. Compensation for Input Capacitance

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

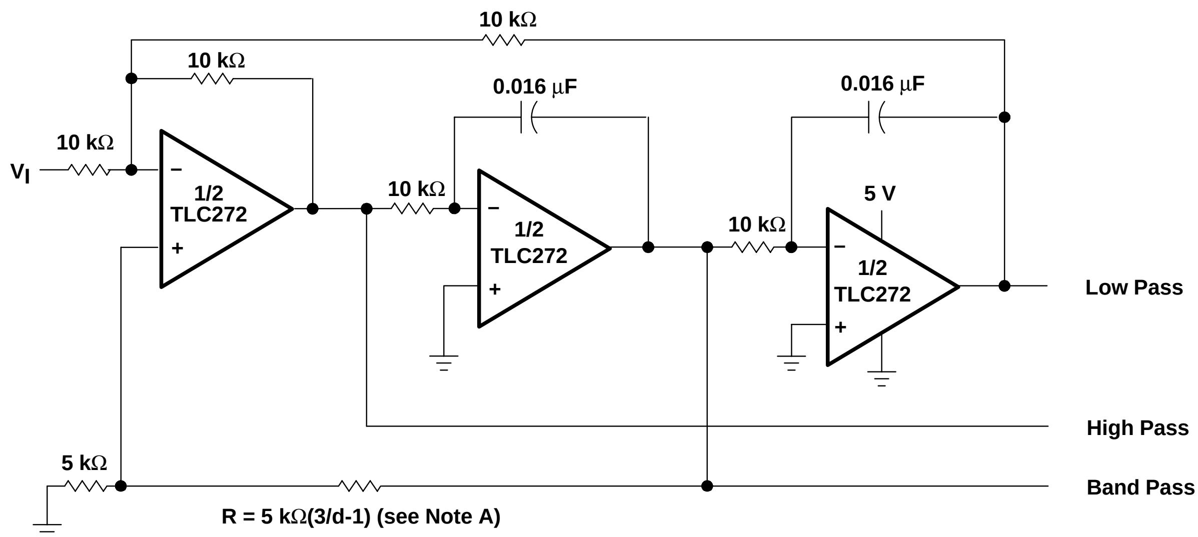
The TLC272 and TLC277 incorporate an internal electrostatic discharge (ESD) protection circuit that prevents functional failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015.2. Care should be exercised, however, when handling these devices as exposure to ESD may result in the degradation 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 µF 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.

APPLICATION INFORMATION



NOTE A: d = damping factor, 1/Q

Figure 44. State-Variable Filter

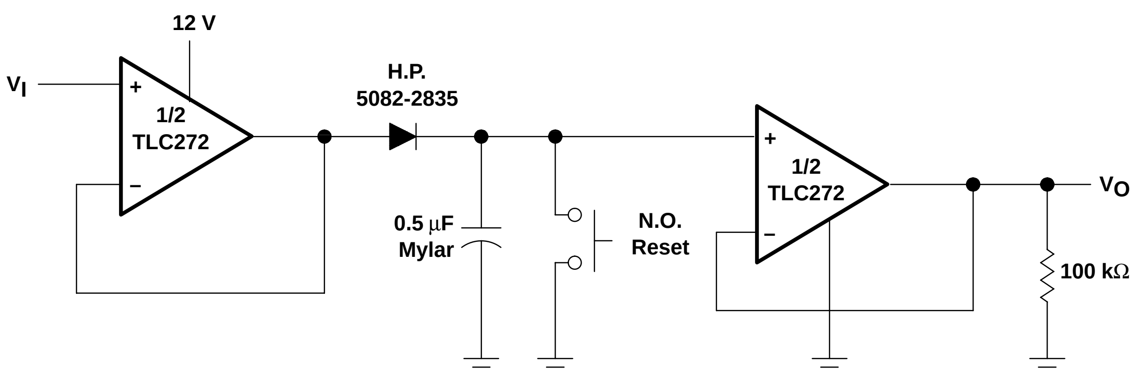
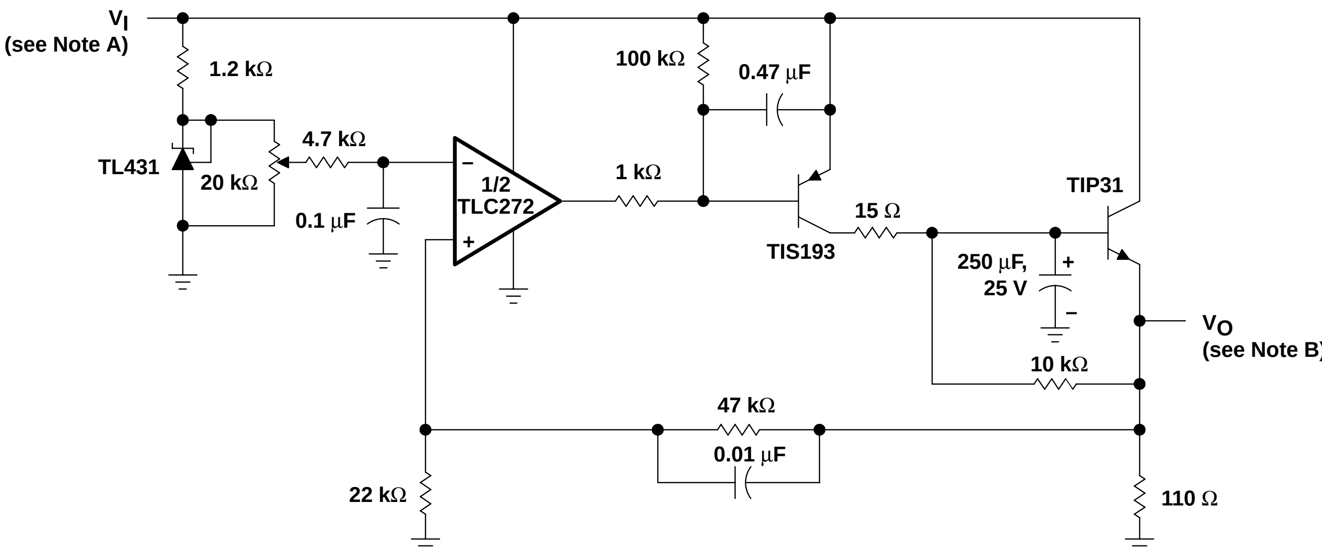


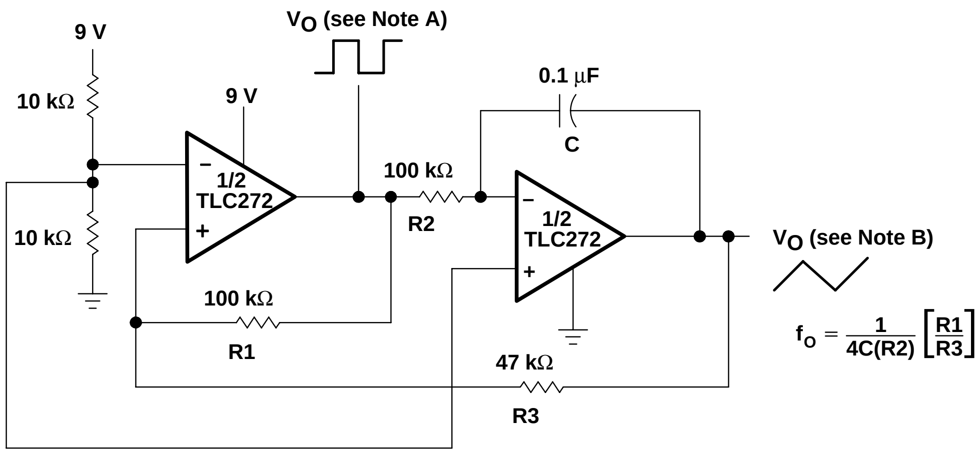
Figure 45. Positive-Peak Detector

APPLICATION INFORMATION



NOTES: A. V_I = 3.5 to 15 V
B. V_O = 2 V, 0 to 1 A

Figure 46. Logic-Array Power Supply

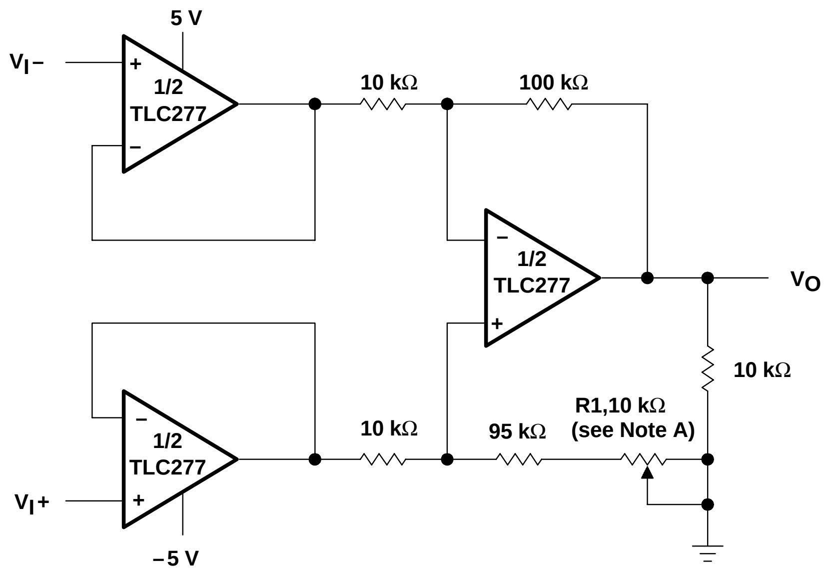


$$f_O = \frac{1}{4C(R2)}\left[\frac{R1}{R3}\right]$$

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

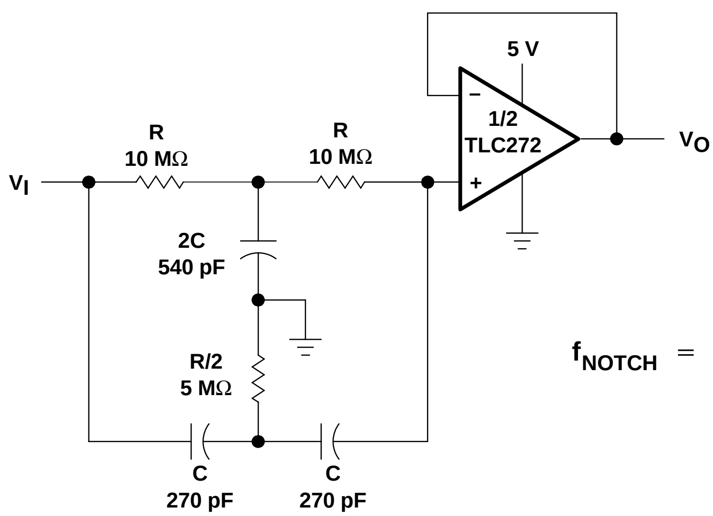
Figure 47. Single-Supply Function Generator

APPLICATION INFORMATION



NOTE B: CMRR adjustment must be noninductive.

Figure 48. Low-Power Instrumentation Amplifier



$$f_{NOTCH} = \frac{1}{2\pi RC}$$

Figure 49. Single-Supply Twin-T Notch Filter

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
5962-89494022A	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI	-55 to 125		
TLC272ACD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272AC	Samples
TLC272ACDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272AC	Samples
TLC272ACDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272AC	Samples
TLC272ACDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272AC	Samples
TLC272ACP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC272ACP	Samples
TLC272ACPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC272ACP	Samples
TLC272AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272AI	Samples
TLC272AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272AI	Samples
TLC272AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272AI	Samples
TLC272AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272AI	Samples
TLC272AIP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC272AIP	Samples
TLC272AIPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC272AIP	Samples
TLC272BCD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272BC	Samples
TLC272BCDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272BC	Samples
TLC272BCDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272BC	Samples
TLC272BCDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272BC	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
TLC272BCP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC272BCP	Samples
TLC272BCPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC272BCP	Samples
TLC272BID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272BI	Samples
TLC272BIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272BI	Samples
TLC272BIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272BI	Samples
TLC272BIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272BI	Samples
TLC272BIP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC272BIP	Samples
TLC272BIPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC272BIP	Samples
TLC272CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272C	Samples
TLC272CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272C	Samples
TLC272CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272C	Samples
TLC272CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	272C	Samples
TLC272CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC272CP	Samples
TLC272CPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC272CP	Samples
TLC272CPSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P272	Samples
TLC272CPSRG4	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P272	Samples
TLC272CPW	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P272C	Samples
TLC272CPWG4	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P272C	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
TLC272CPWLE	OBSOLETE	TSSOP	PW	8		TBD	Call TI	Call TI	0 to 70		
TLC272CPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P272C	Samples
TLC272CPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P272C	Samples
TLC272ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272I	Samples
TLC272IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272I	Samples
TLC272IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272I	Samples
TLC272IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	272I	Samples
TLC272IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC272IP	Samples
TLC272IPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC272IP	Samples
TLC272MFKB	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI	-55 to 125		
TLC272MJG	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI	-55 to 125		
TLC272MJGB	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI	-55 to 125		
TLC272P-M	PREVIEW	PDIP	P	8		TBD	Call TI	Call TI			
TLC277CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		277C	Samples
TLC277CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		277C	Samples
TLC277CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		277C	Samples
TLC277CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		277C	Samples
TLC277CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type		TLC277CP	Samples
TLC277CPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type		TLC277CP	Samples
TLC277CPSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		P277	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
TLC277CPSRG4	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		P277	Samples
TLC277ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		277I	Samples
TLC277IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		277I	Samples
TLC277IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		277I	Samples
TLC277IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		277I	Samples
TLC277IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type		TLC277IP	Samples
TLC277IPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type		TLC277IP	Samples
TLC277MFKB	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI	-55 to 125		
TLC277MJG	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI	-55 to 125		
TLC277MJGB	OBSOLETE	CDIP	JG	8		TBD	Call TI	Call TI	-55 to 125		

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

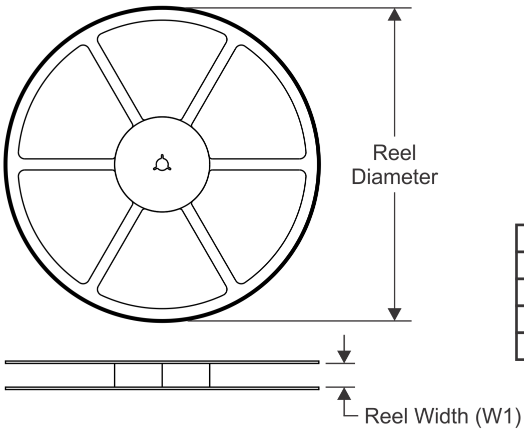
(4) Only one of markings shown within the brackets will appear on the physical device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

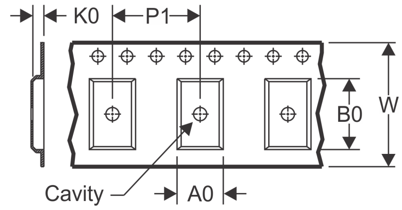
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

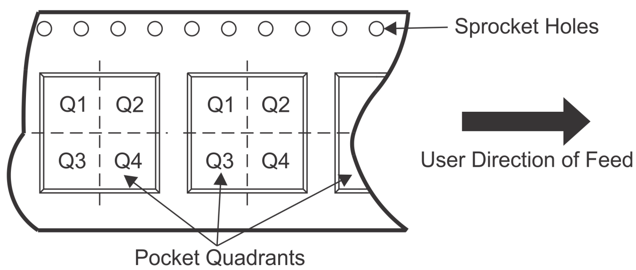


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

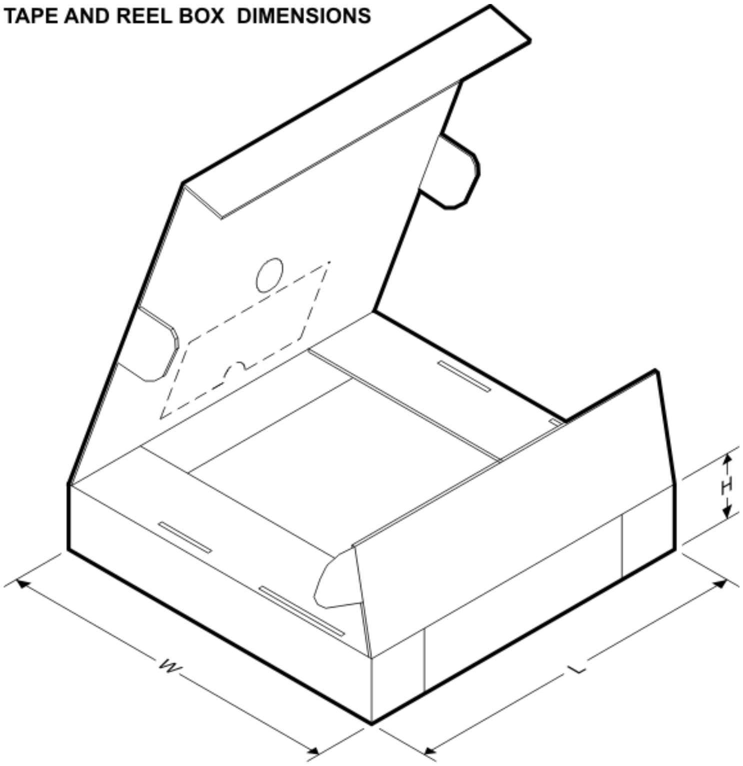
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLC272ACDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC272AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC272BCDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC272BIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC272CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC272CPSR	SO	PS	8	2000	330.0	16.4	8.2	6.6	2.5	12.0	16.0	Q1
TLC272CPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
TLC272IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC277CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC277CPSR	SO	PS	8	2000	330.0	16.4	8.2	6.6	2.5	12.0	16.0	Q1
TLC277IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

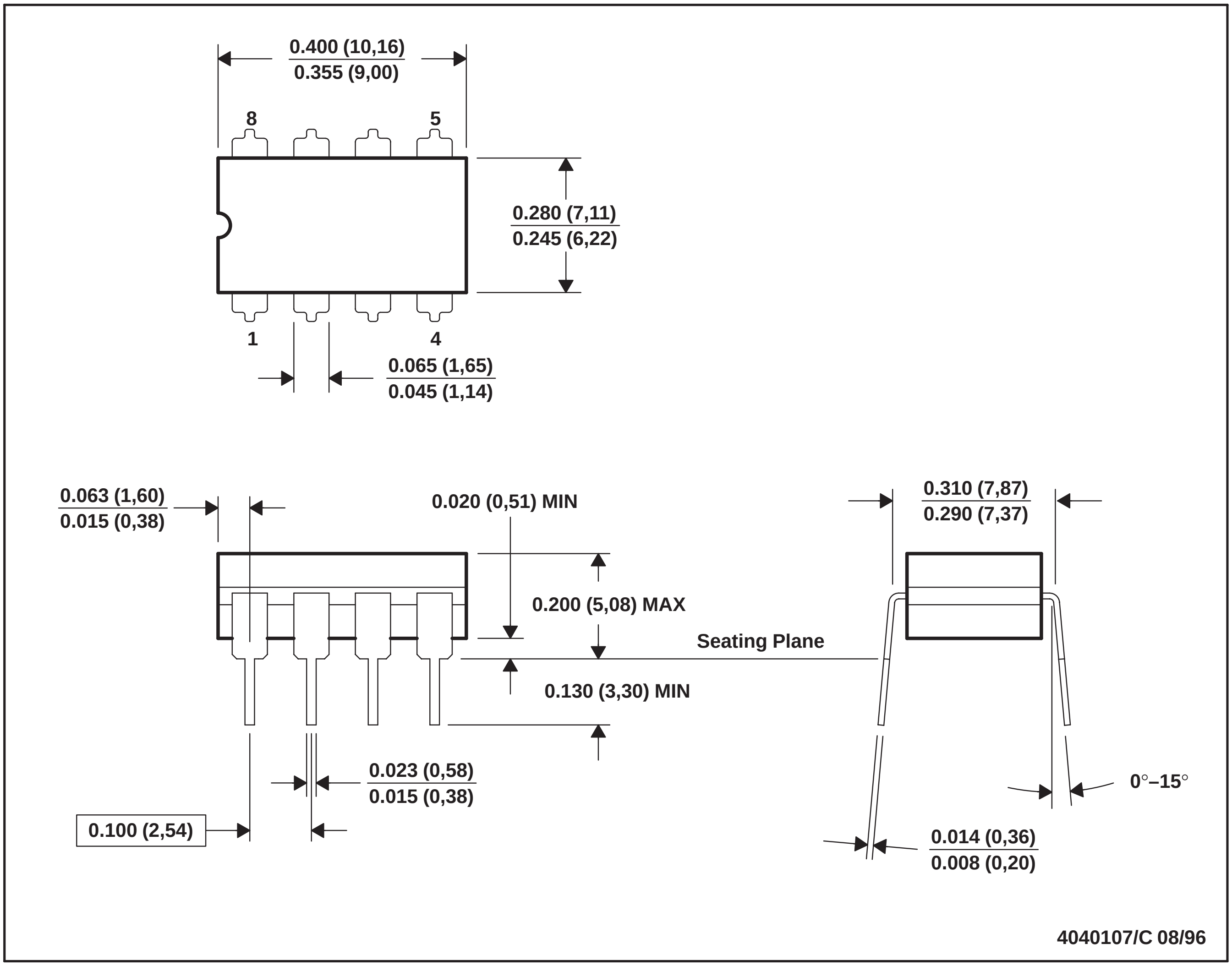
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLC272ACDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC272AIDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC272BCDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC272BIDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC272CDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC272CPSR	SO	PS	8	2000	367.0	367.0	38.0
TLC272CPWR	TSSOP	PW	8	2000	367.0	367.0	35.0
TLC272IDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC277CDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC277CPSR	SO	PS	8	2000	367.0	367.0	38.0
TLC277IDR	SOIC	D	8	2500	340.5	338.1	20.6

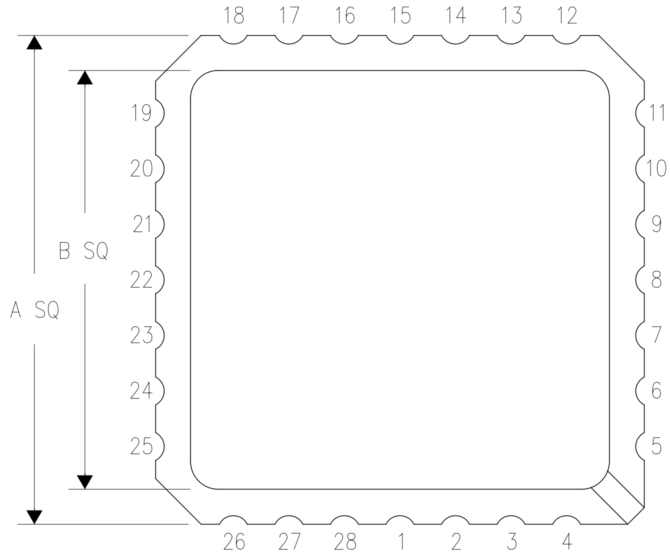
JG (R-GDIP-T8) **CERAMIC DUAL-IN-LINE**



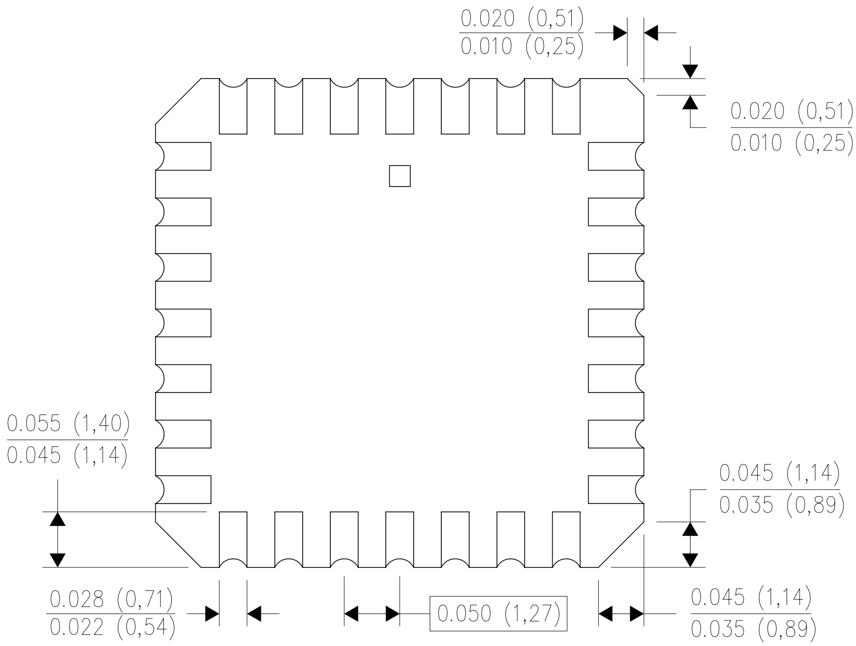
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification.
- E. Falls within MIL STD 1835 GDIP1-T8

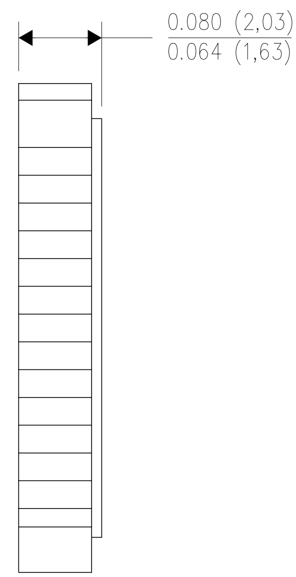
FK (S-CQCC-N**) LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



NO. OF TERMINALS **	A		B	
	MIN	MAX	MIN	MAX
20	0.342 (8,69)	0.358 (9,09)	0.307 (7,80)	0.358 (9,09)
28	0.442 (11,23)	0.458 (11,63)	0.406 (10,31)	0.458 (11,63)
44	0.640 (16,26)	0.660 (16,76)	0.495 (12,58)	0.560 (14,22)
52	0.740 (18,78)	0.761 (19,32)	0.495 (12,58)	0.560 (14,22)
68	0.938 (23,83)	0.962 (24,43)	0.850 (21,6)	0.858 (21,8)
84	1.141 (28,99)	1.165 (29,59)	1.047 (26,6)	1.063 (27,0)

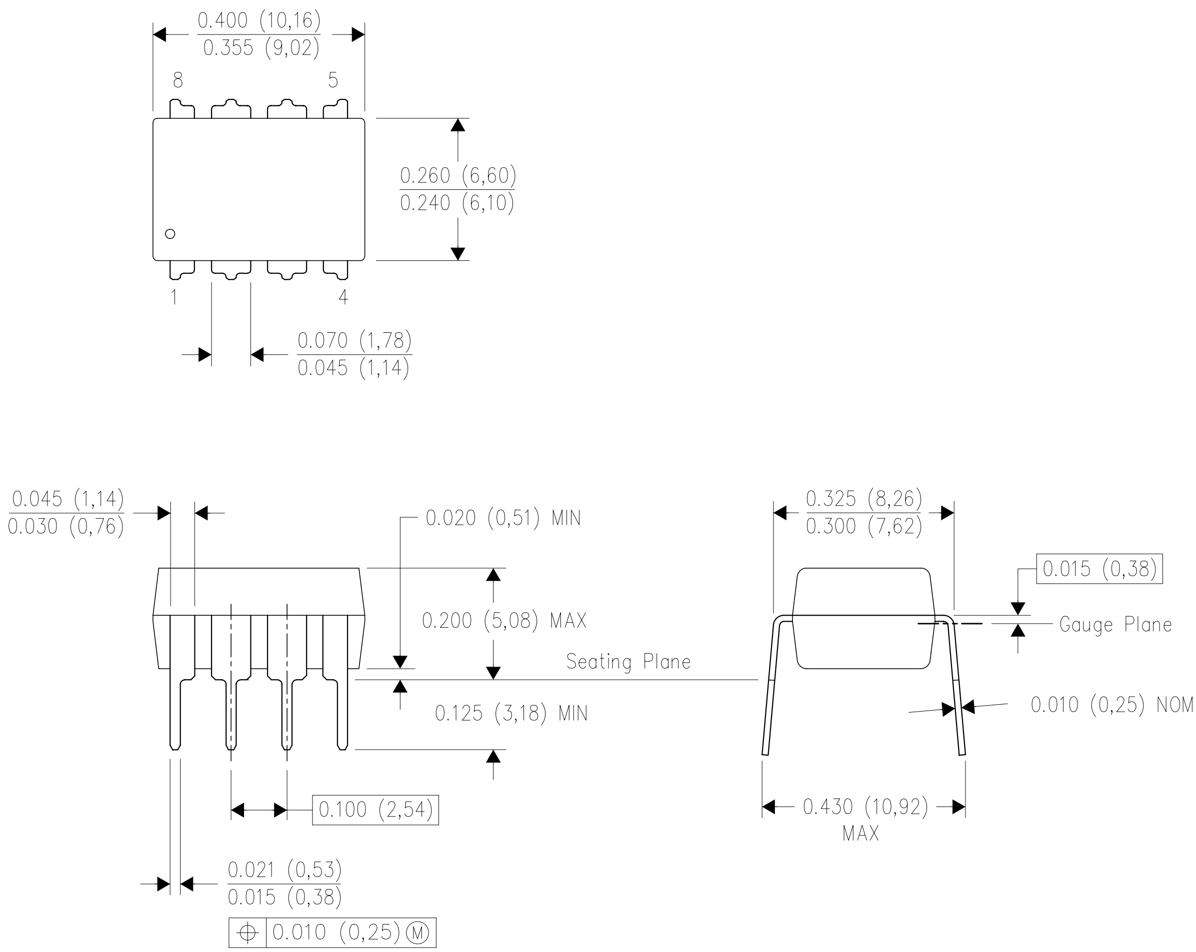




4040140/D 01/11

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a metal lid.
D. Falls within JEDEC MS-004

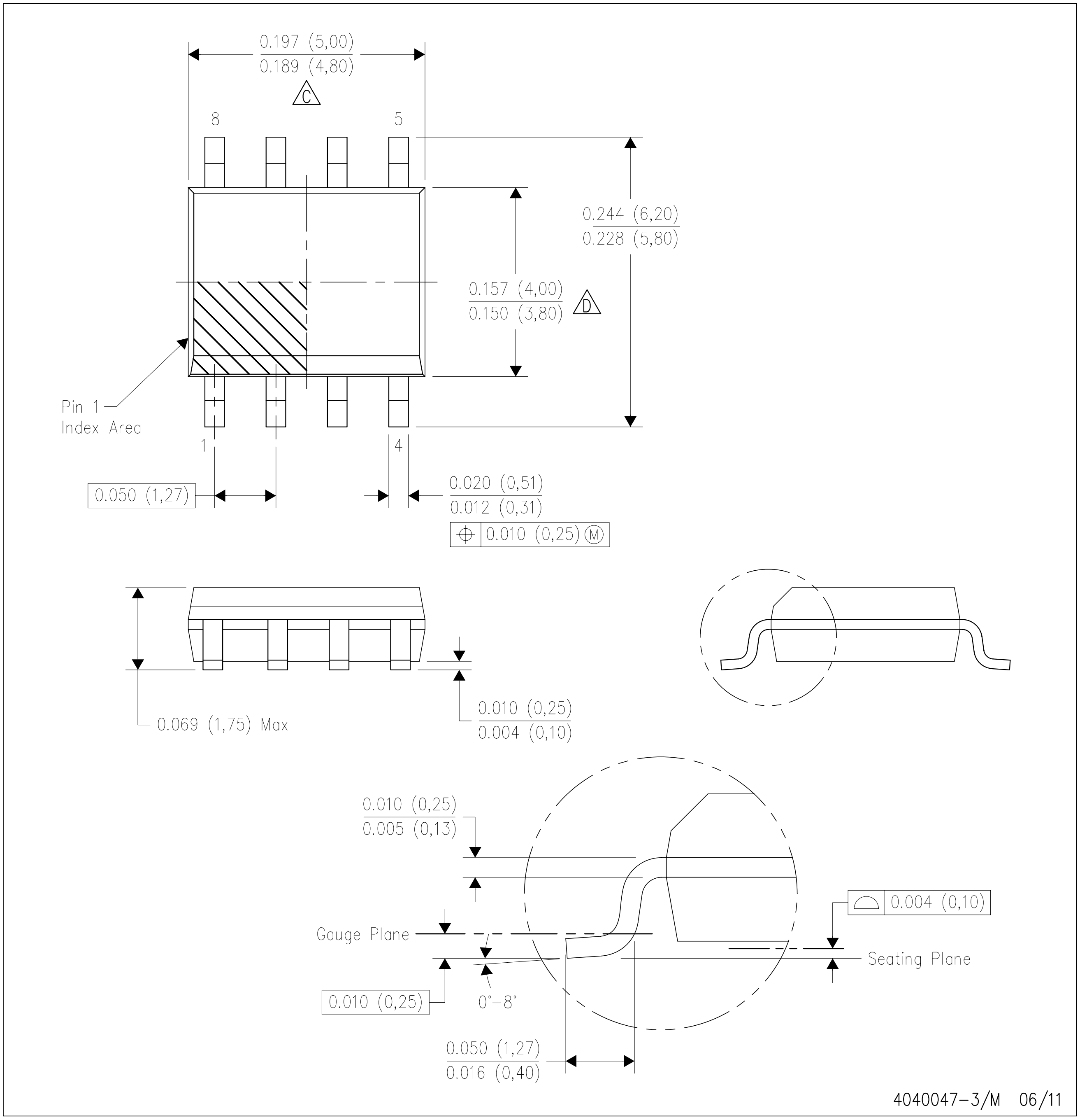
P (R-PDIP-T8) PLASTIC DUAL-IN-LINE PACKAGE



4040082/E 04/2010

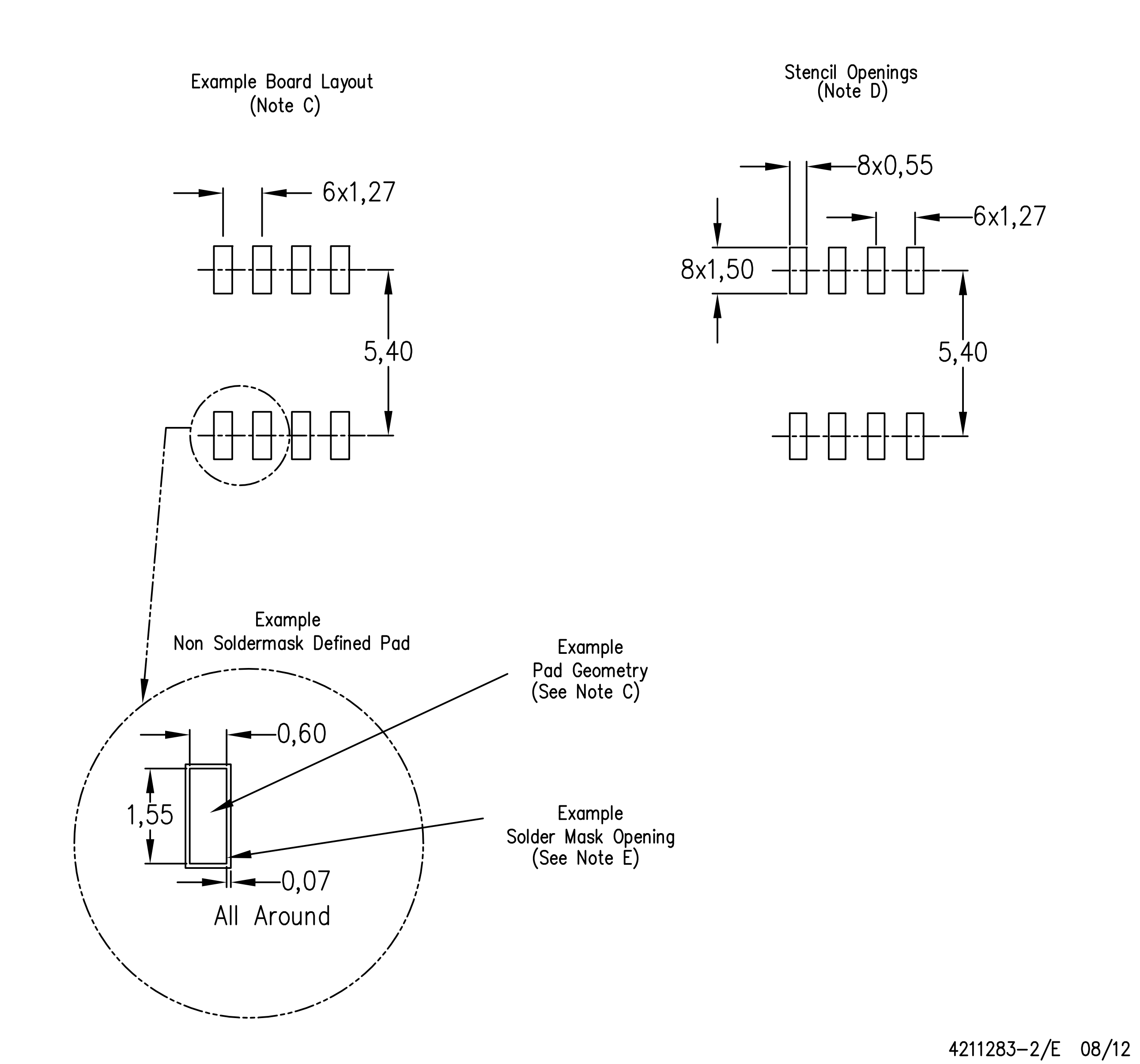
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001 variation BA.

D (R-PDSO-G8) PLASTIC SMALL OUTLINE



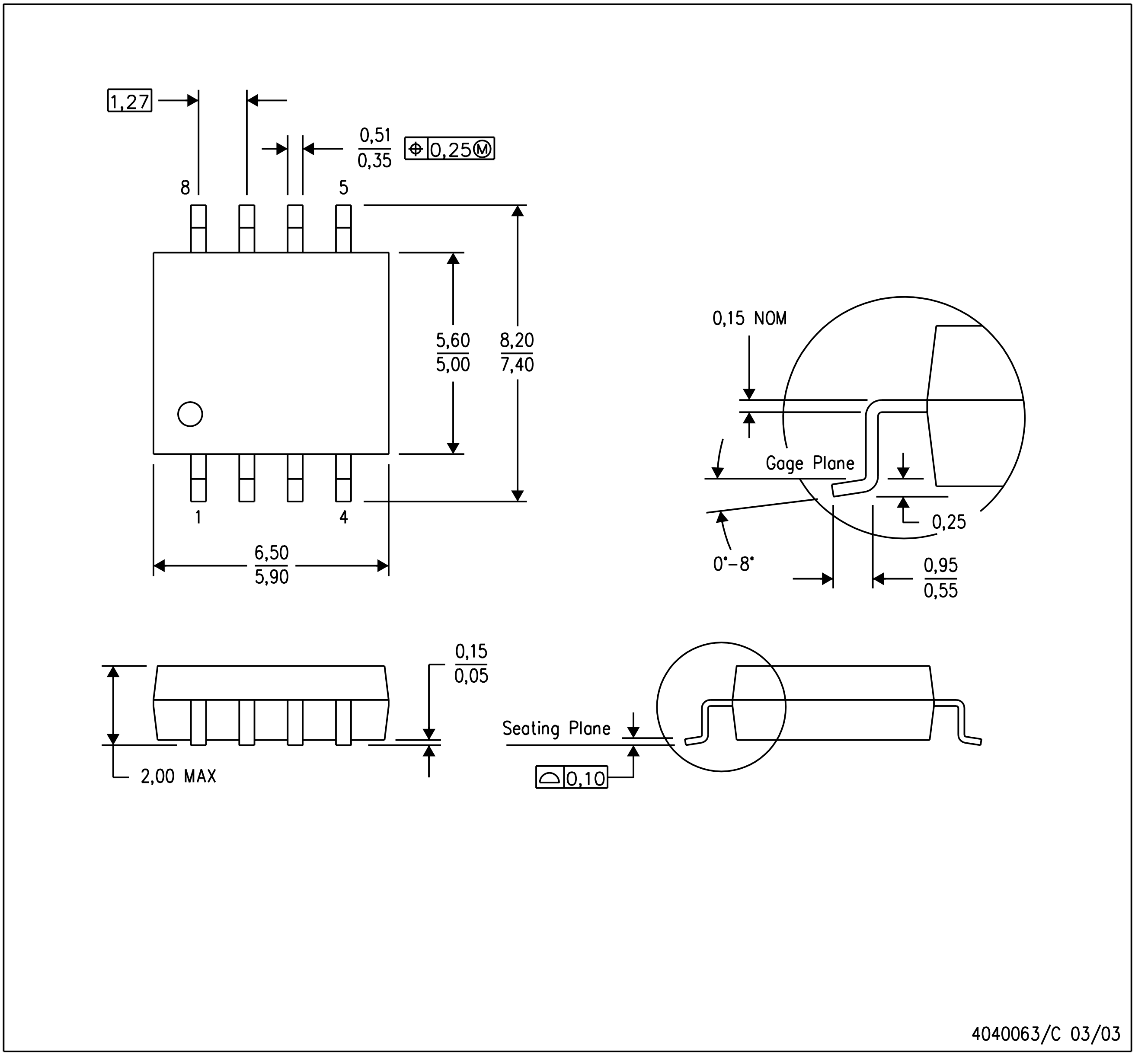
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include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

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



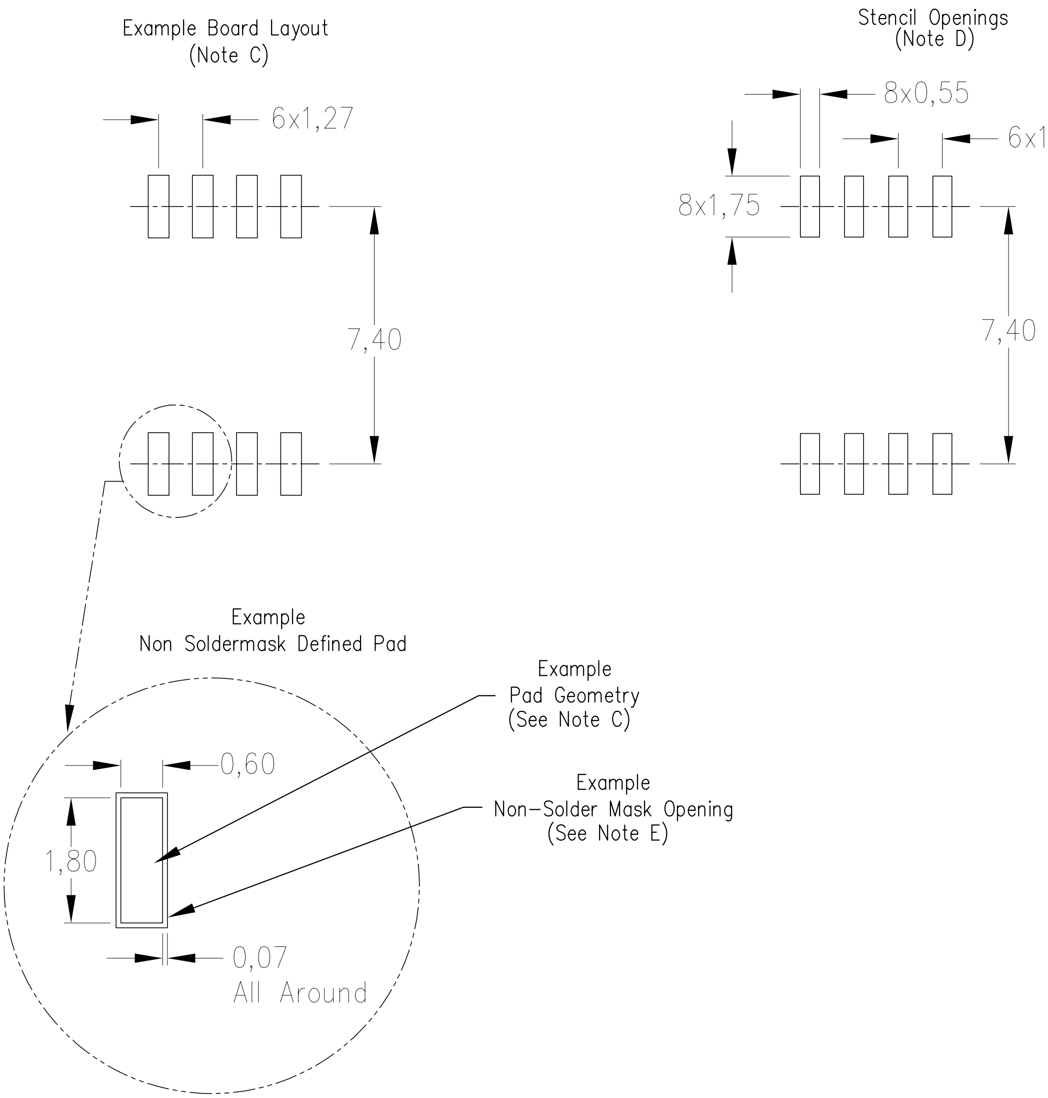
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact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

PS (R-PDSO-G8) **PLASTIC SMALL-OUTLINE PACKAGE**



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

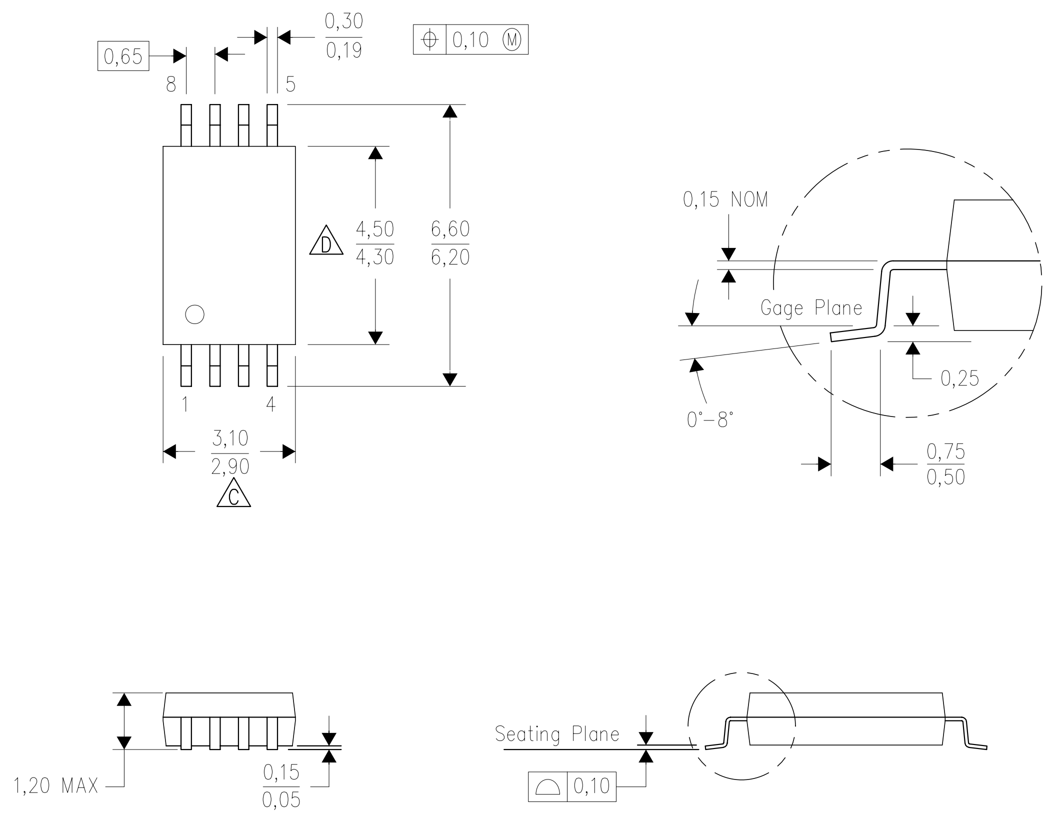
PS (R-PDSO-G8) PLASTIC SMALL OUTLINE



4212188/A 09/11

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

PW (R–PDSO–G8) PLASTIC SMALL OUTLINE



4040064–2/G 02/11

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