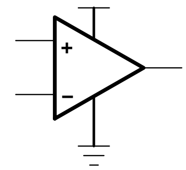
- **Qualified for Automotive Applications**
- **Rail-To-Rail Output**
- **Wide Bandwidth . . . 3 MHz**
- **High Slew Rate . . . 2 .4 V/μs**
- **Supply Voltage Range . . . 2.7 V to 16 V**
- **Supply Current . . . 550 μA/Channel**
- **Input Noise Voltage . . . 39 nV/√Hz**
- **Input Bias Current . . . 1 pA**
- **Specified Temperature Range**
  –40°C to 125°C . . . Automotive Grade
- **Ultrasmall Packaging**
  – 5-Pin SOT-23 (TLV271)
- **Ideal Upgrade for TLC27x Family**

Operational Amplifier



description

The TLV27x takes the minimum operating supply voltage down to 2.7 V over the extended automotive temperature range while adding the rail-to-rail output swing feature. This makes it an ideal alternative to the TLC27x family for applications where rail-to-rail output swings are essential. The TLV27x also provides 3-MHz bandwidth from only 550 μA.

Like the TLC27x, the TLV27x is fully specified for 5-V and ±5-V supplies. The maximum recommended supply voltage is 16 V, which allows the devices to be operated from a variety of rechargeable cells (±8 V supplies down to ±1.35 V).

The CMOS inputs enable use in high-impedance sensor interfaces, with the lower voltage operation making an attractive alternative for the TLC27x in battery-powered applications.

The 2.7-V operation makes it compatible with Li-Ion powered systems and the operating supply voltage range of many micropower microcontrollers available today including Texas Instruments MSP430.

SELECTION OF SIGNAL AMPLIFIER PRODUCTS†

DEVICE	V_{DD} (V)	V_{IO} (μV)	Iq/Ch (μA)	I_{IB} (pA)	GBW (MHz)	SR (V/μs)	SHUTDOWN	RAIL-TO-RAIL	SINGLES/DUALS/QUADS
TLV27x	2.7–16	500	550	1	3	2.4	—	O	S/D/Q
TLC27x	3–16	1100	675	1	1.7	3.6	—	—	S/D/Q
TLV237x	2.7–16	500	550	1	3	2.4	Yes	I/O	S/D/Q
TLC227x	4–16	300	1100	1	2.2	3.6	—	O	D/Q
TLV246x	2.7–6	150	550	1300	6.4	1.6	Yes	I/O	S/D/Q
TLV247x	2.7–6	250	600	2	2.8	1.5	Yes	I/O	S/D/Q
TLV244x	2.7–10	300	725	1	1.8	1.4	—	O	D/Q

† Typical values measured at 5 V, 25°C

FAMILY PACKAGE TABLE†

DEVICE	NUMBER OF CHANNELS	PACKAGE TYPES‡				UNIVERSAL EVM BOARD
		SOIC	SOT-23	TSSOP	MSOP§	
TLV271	1	8	5	—	—	See the EVM Selection Guide (SLOU060)
TLV272	2	8	—	—	8	
TLV274	4	14	—	14	—	

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at http://www.ti.com.
‡ Package drawings, thermal data, and symbolization are available at http://www.ti.com/packaging.
§ Product Preview

TLV271 AVAILABLE OPTIONS

T_A	V_{IO}MAX AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE (D)	SOT-23	
			(DBV)	SYMBOL
−40°C to 125°C	5 mV	TLV271QDRQ1	TLV271QDBVRQ1	271Q

TLV272 AVAILABLE OPTIONS

T_A	V_{IO}MAX AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE (D)	MSOP	
			(DGK)	SYMBOL
−40°C to 125°C	5 mV	TLV272QDRQ1	TLV272QDGKRQ1†	

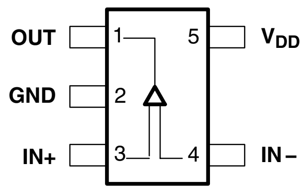
† Product Preview

TLV274 AVAILABLE OPTIONS

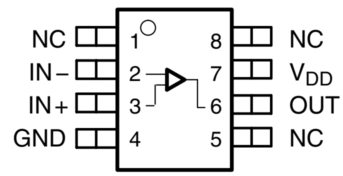
T_A	V_{IO}MAX AT 25°C	PACKAGED DEVICES	
		SMALL OUTLINE (D)	TSSOP (PW)
−40°C to 125°C	5 mV	TLV274QDRQ1	TLV274QPWRQ1

TLV27x PACKAGE PINOUTS(1)

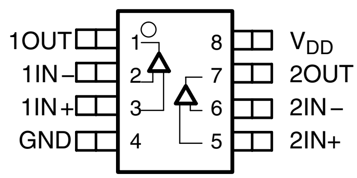
TLV271
DBV PACKAGE
(TOP VIEW)



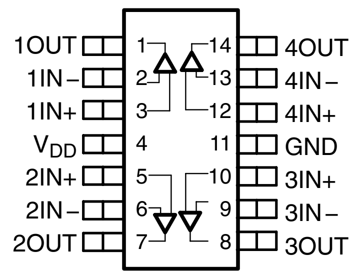
TLV271
D PACKAGE
(TOP VIEW)



TLV272
D OR DGK PACKAGE
(TOP VIEW)

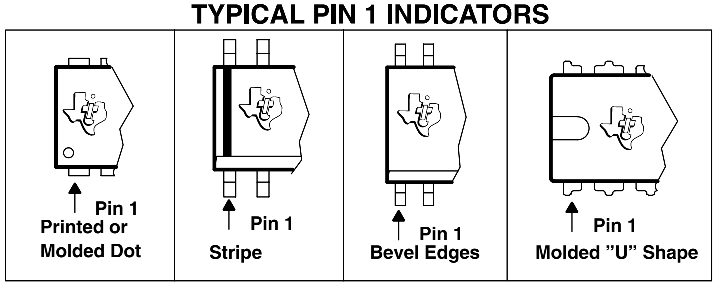


TLV274
D OR PW PACKAGE
(TOP VIEW)



NC – No internal connection
(1) SOT−23 may or may not be indicated

TYPICAL PIN 1 INDICATORS



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

Supply voltage, V_{DD} (see Note 1) . . . . . 16.5 V
Differential input voltage, V_{ID} . . . . . $\pm V_{DD}$
Input voltage range, V_I (see Note 1) . . . . . –0.2 V to V_{DD} + 0.2 V
Input current range, I_I . . . . . ±10 mA
Output current range, I_O . . . . . ±100 mA
Continuous total power dissipation . . . . . See Dissipation Rating Table
Operating free-air temperature range, T_A . . . . . −40°C to 125°C
Maximum junction temperature, T_J . . . . . 150°C
Storage temperature range, T_{stg} . . . . . −65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 260°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.

NOTE 1: All voltage values, except differential voltages, are with respect to GND.

DISSIPATION RATING TABLE

PACKAGE	θ_{JC} (°C/W)	θ_{JA} (°C/W)	$T_A \le 25°C$ POWER RATING	$T_A = 25°C$ POWER RATING
D (8)	38.3	176	710 mW	396 mW
D (14)	26.9	122.3	1022 mW	531 mW
DBV (5)	55	324.1	385 mW	201 mW
DGK (8)	54.23	259.96	481 mW	250 mW
PW (14)	29.3	173.6	720 mW	374 mW

recommended operating conditions

		MIN	MAX	UNIT
Supply voltage, V_{DD}	Single supply	2.7	16	V
	Split supply	±1.35	±8	
Common-mode input voltage range, V_{ICR}		0	V_{DD}–1.35	V
Operating free-air temperature, T_A	Q-suffix	–40	125	°C

electrical characteristics at specified free-air temperature, V_{DD} = 2.7 V, 5 V, and 15 V (unless otherwise noted)

dc performance

PARAMETER		TEST CONDITIONS		T_A†	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	$V_{IC} = V_{DD}/2$, R_L = 10 kΩ,	$V_O = V_{DD}/2$, R_S = 50 Ω	25°C		0.5	5	mV
				Full range			7	
α_{VIO}	Offset voltage drift			25°C		2		μV/°C
CMRR	Common-mode rejection ratio	V_{IC} = 0 to V_{DD}–1.35V, R_S = 50 Ω	V_{DD} = 2.7 V	25°C	53	70		dB
				Full range	54			
		V_{IC} = 0 to V_{DD}–1.35V, R_S = 50 Ω	V_{DD} = 5 V	25°C	58	80		
				Full range	57			
		V_{IC} = 0 to V_{DD}–1.35V, R_S = 50 Ω	V_{DD} = 15 V	25°C	67	85		
				Full range	66			
A_{VD}	Large-signal differential voltage amplification	$V_{O(PP)} = V_{DD}/2$, R_L = 10 kΩ	V_{DD} = 2.7 V	25°C	95	106		dB
				Full range	76			
			V_{DD} = 5 V	25°C	80	110		
				Full range	82			
			V_{DD} = 15 V	25°C	77	115		
				Full range	79			

† Full range is –40°C to 125°C. If not specified, full range is –40°C to 125°C.

input characteristics

PARAMETER		TEST CONDITIONS	T_A	MIN	TYP	MAX	UNIT
I_{IO}	Input offset current	V_{DD} = 15 V, $V_{IC} = V_{DD}/2$, $V_O = V_{DD}/2$, R_S = 50 Ω	25°C		1	60	pA
			125°C			1000	
I_{IB}	Input bias current		25°C		1	60	pA
			125°C			1000	
$r_{i(d)}$	Differential input resistance		25°C		1000		GΩ
C_{IC}	Common-mode input capacitance	f = 21 kHz	25°C		8		pF

electrical characteristics at specified free-air temperature, V_{DD} = 2.7 V, 5 V, and 15 V (unless otherwise noted)

output characteristics

PARAMETER	TEST CONDITIONS		T_A†	MIN	TYP	MAX	UNIT
V_{OH} High-level output voltage	$V_{IC} = V_{DD}/2$, I_{OH} = –1 mA	V_{DD} = 2.7 V	25°C	2.55	2.58		V
			Full range	2.48			
		V_{DD} = 5 V	25°C	4.9	4.93		
			Full range	4.85			
		V_{DD} = 15 V	25°C	14.92	14.96		
			Full range	14.9			
	$V_{IC} = V_{DD}/2$, I_{OH} = –5 mA	V_{DD} = 2.7 V	25°C	1.88	2.1		
			Full range	1.42			
		V_{DD} = 5 V	25°C	4.58	4.68		
			Full range	4.44			
		V_{DD} = 15 V	25°C	14.7	14.8		
			Full range	14.6			
V_{OL} Low-level output voltage	$V_{IC} = V_{DD}/2$, I_{OL} = 1 mA	V_{DD} = 2.7 V	25°C		0.1	0.15	V
			Full range			0.22	
		V_{DD} = 5 V	25°C		0.05	0.1	
			Full range			0.15	
		V_{DD} = 15 V	25°C		0.05	0.08	
			Full range			0.1	
	$V_{IC} = V_{DD}/2$, I_{OL} = 5 mA	V_{DD} = 2.7 V	25°C		0.5	0.7	
			Full range			1.15	
		V_{DD} = 5 V	25°C		0.28	0.4	
			Full range			0.54	
		V_{DD} = 15 V	25°C		0.19	0.3	
			Full range			0.35	
I_O Output current	V_O = 0.5 V from rail, V_{DD} = 2.7 V	Positive rail	25°C		4		mA
		Negative rail	25°C		5		
	V_O = 0.5 V from rail, V_{DD} = 5 V	Positive rail	25°C		7		
		Negative rail	25°C		8		
	V_O = 0.5 V from rail, V_{DD} = 15 V	Positive rail	25°C		13		
		Negative rail	25°C		12		

† Full range is –40°C to 125°C. If not specified, full range is –40°C to 125°C.
‡ Depending on package dissipation rating

electrical characteristics at specified free-air temperature, V_{DD} = 2.7 V, 5 V, and 15 V (unless otherwise noted) (continued)

power supply

PARAMETER		TEST CONDITIONS		T_A†	MIN	TYP	MAX	UNIT
I_{DD}	Supply current (per channel)	$V_O = V_{DD}/2$	V_{DD} = 2.7 V	25°C		470	560	μA
			V_{DD} = 5 V	25°C		550	660	
			V_{DD} = 15 V	25°C		750	900	
				Full range			1200	
PSRR	Supply voltage rejection ratio (ΔV_{DD} /ΔV_{IO})	V_{DD} = 2.7 V to 15 V, No load	$V_{IC} = V_{DD}/2$,	25°C	70	80		dB
				Full range	65			

† Full range is –40°C to 125°C. If not specified, full range is –40°C to 125°C.

dynamic performance

PARAMETER		TEST CONDITIONS		T_A†	MIN	TYP	MAX	UNIT
UGBW	Unity gain bandwidth	R_L = 2 kΩ, C_L = 10 pF	V_{DD} = 2.7 V	25°C		2.4		MHz
			V_{DD} = 5 V to 15 V	25°C		3		
SR	Slew rate at unity gain	$V_{O(PP)} = V_{DD}/2$, C_L = 50 pF, R_L = 10 kΩ,	V_{DD} = 2.7 V	25°C	1.4	2.1		V/μs
				Full range	1			
			V_{DD} = 5 V	25°C	1.4	2.4		V/μs
				Full range	1.2			
			V_{DD} = 15 V	25°C	1.9	2.1		V/μs
				Full range	1.4			
ϕ_m	Phase margin	R_L = 2 kΩ	C_L = 10 pF	25°C		65		°
	Gain margin	R_L = 2 kΩ	C_L = 10 pF	25°C		18		dB
t_s	Settling time	V_{DD} = 2.7 V, $V_{(STEP)PP}$ = 1 V, A_V = –1, C_L = 10 pF, R_L = 2 kΩ	0.1%	25°C		2.9		μs
		V_{DD} = 5 V, 15 V, $V_{(STEP)PP}$ = 1 V, A_V = –1, C_L = 47 pF, R_L = 2 kΩ	0.1%			2		

† Full range is –40°C to 125°C. If not specified, full range is –40°C to 125°C.

noise/distortion performance

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP	MAX	UNIT
THD + N	Total harmonic distortion plus noise	V_{DD} = 2.7 V, $V_{O(PP)} = V_{DD}/2$ V, R_L = 2 kΩ, f = 10 kHz	A_V = 1	25°C		0.02%		
			A_V = 10			0.05%		
			A_V = 100			0.18%		
		V_{DD} = 5 V, ±5 V, $V_{O(PP)} = V_{DD}/2$ V, R_L = 2 kΩ, f = 10K	A_V = 1	25°C		0.02%		
			A_V = 10			0.09%		
			A_V = 100			0.5%		
V_n	Equivalent input noise voltage	f = 1 kHz		25°C		39		nV/√Hz
		f = 10 kHz				35		
I_n	Equivalent input noise current	f = 1 kHz		25°C		0.6		fA/√Hz

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
CMRR	Common-mode rejection ratio	vs Frequency	1
	Input bias and offset current	vs Free-air temperature	2
V_{OL}	Low-level output voltage	vs Low-level output current	3, 5, 7
V_{OH}	High-level output voltage	vs High-level output current	4, 6, 8
$V_{O(PP)}$	Peak-to-peak output voltage	vs Frequency	9
I_{DD}	Supply current	vs Supply voltage	10
PSRR	Power supply rejection ratio	vs Frequency	11
A_{VD}	Differential voltage gain & phase	vs Frequency	12
	Gain-bandwidth product	vs Free-air temperature	13
SR	Slew rate	vs Supply voltage	14
		vs Free-air temperature	15
ϕ_m	Phase margin	vs Capacitive load	16
V_n	Equivalent input noise voltage	vs Frequency	17
	Voltage-follower large-signal pulse response		18, 19
	Voltage-follower small-signal pulse response		20
	Inverting large-signal response		21, 22
	Inverting small-signal response		23
	Crosstalk	vs Frequency	24

TYPICAL CHARACTERISTICS

COMMON-MODE REJECTION RATIO vs FREQUENCY

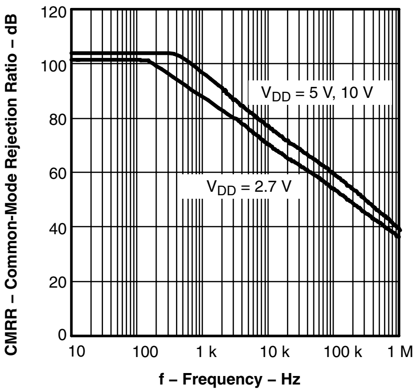


Figure 1

INPUT BIAS AND OFFSET CURRENT vs FREE-AIR TEMPERATURE

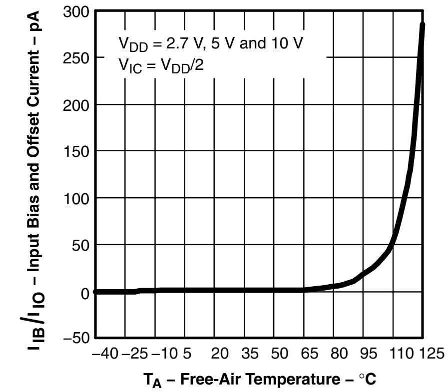


Figure 2

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

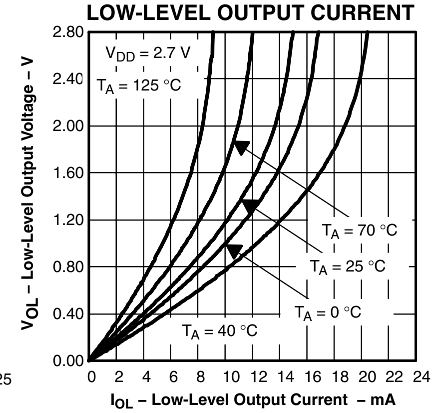


Figure 3

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

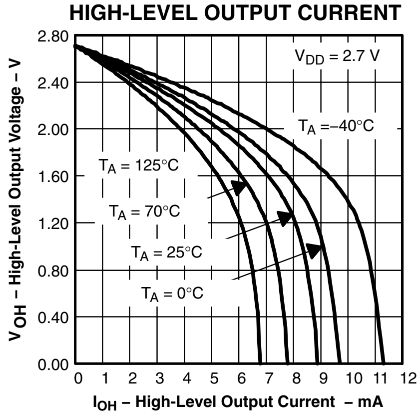


Figure 4

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

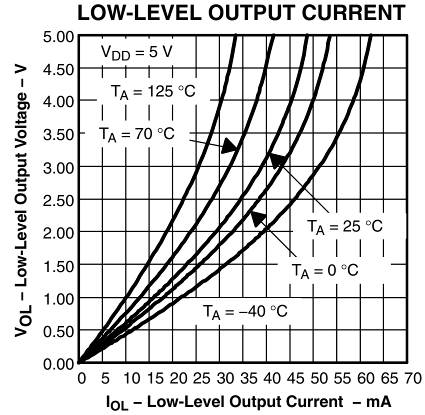


Figure 5

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

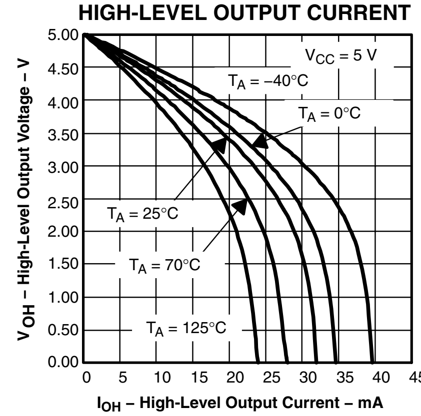


Figure 6

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

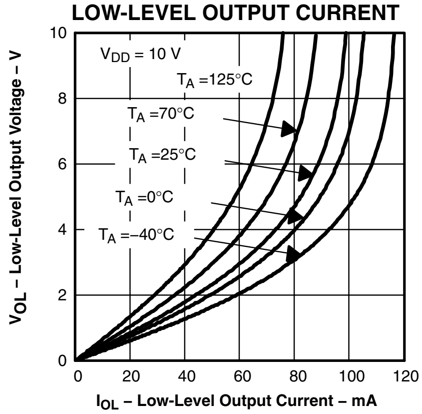


Figure 7

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

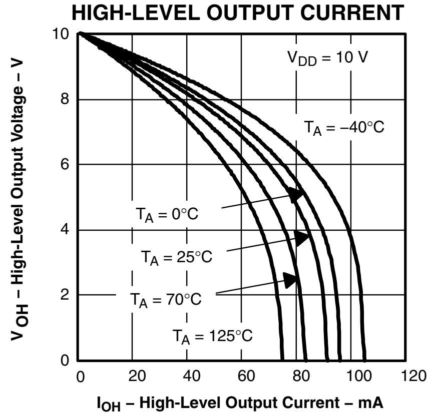


Figure 8

PEAK-TO-PEAK OUTPUT VOLTAGE vs FREQUENCY

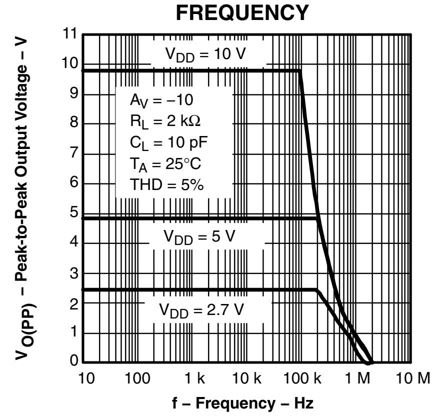


Figure 9

TYPICAL CHARACTERISTICS

SUPPLY CURRENT vs SUPPLY VOLTAGE

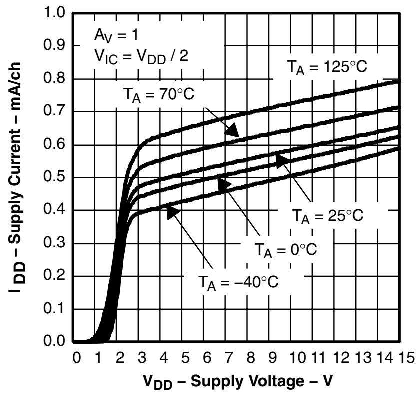


Figure 10

POWER SUPPLY REJECTION RATIO vs FREQUENCY

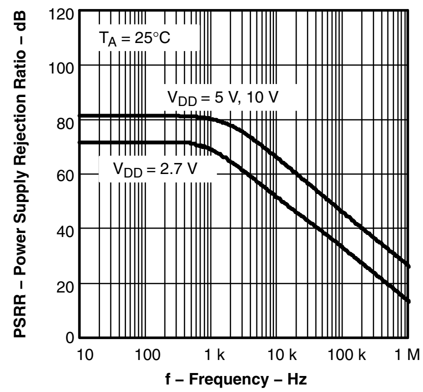


Figure 11

DIFFERENTIAL VOLTAGE GAIN AND PHASE vs FREQUENCY

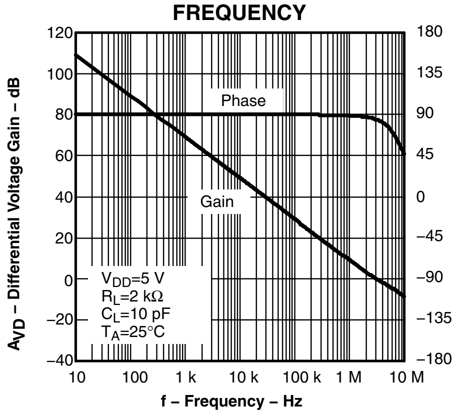


Figure 12

GAIN BANDWIDTH PRODUCT vs FREE-AIR TEMPERATURE

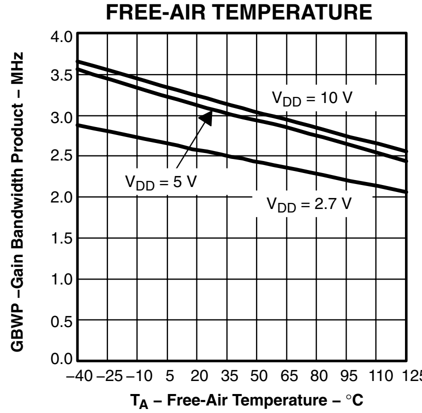


Figure 13

SLEW RATE vs SUPPLY VOLTAGE

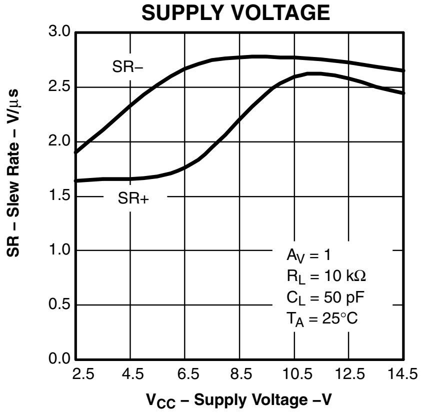


Figure 14

SLEW RATE vs FREE-AIR TEMPERATURE

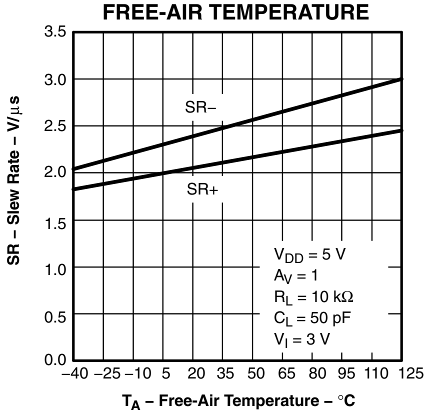


Figure 15

PHASE MARGIN vs CAPACITIVE LOAD

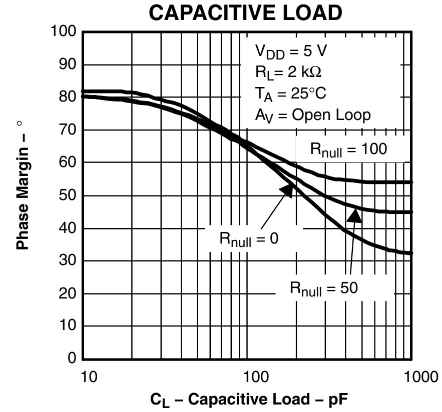


Figure 16

TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

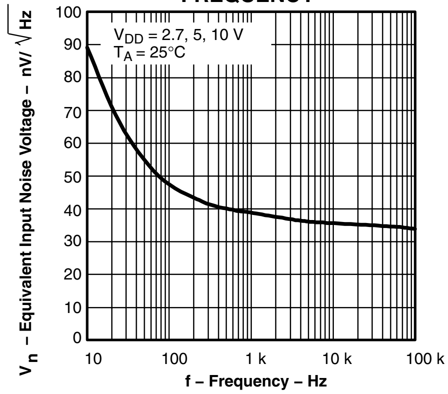


Figure 17

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

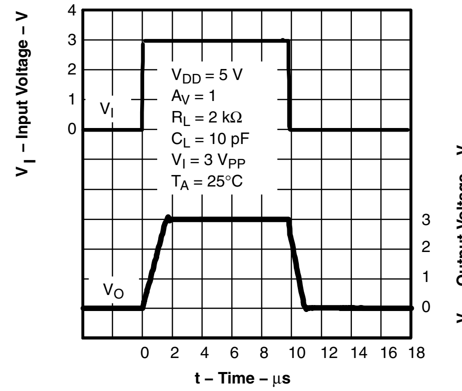


Figure 18

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

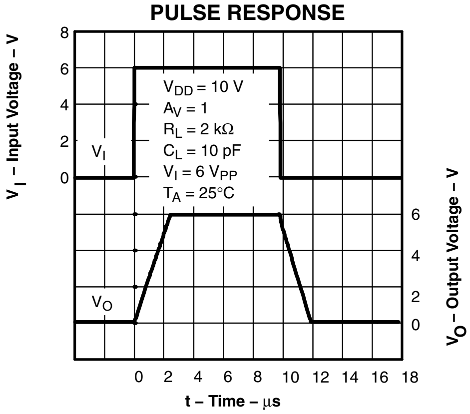


Figure 19

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE

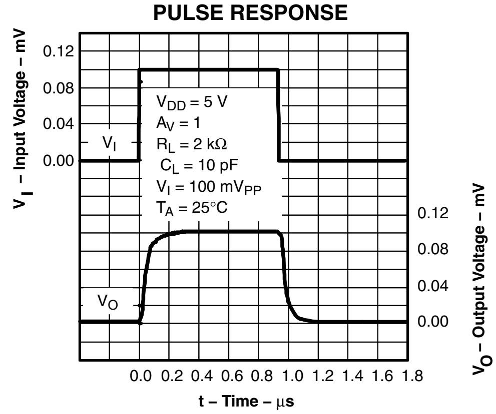


Figure 20

INVERTING LARGE-SIGNAL RESPONSE

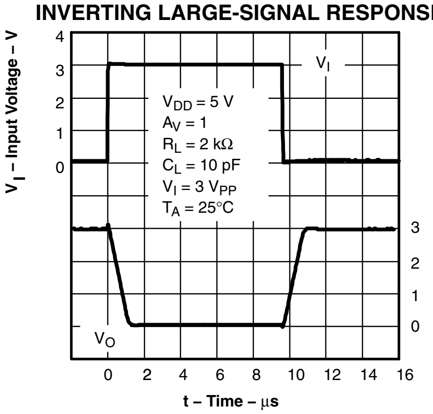


Figure 21

INVERTING LARGE-SIGNAL RESPONSE

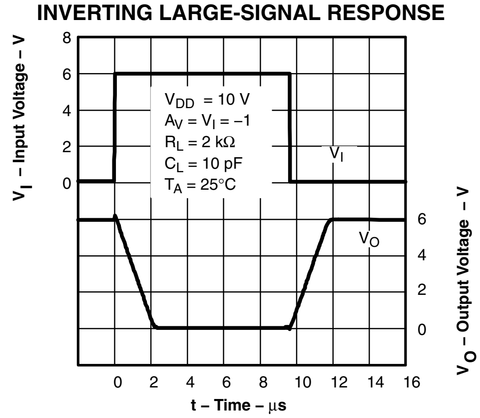


Figure 22

TYPICAL CHARACTERISTICS

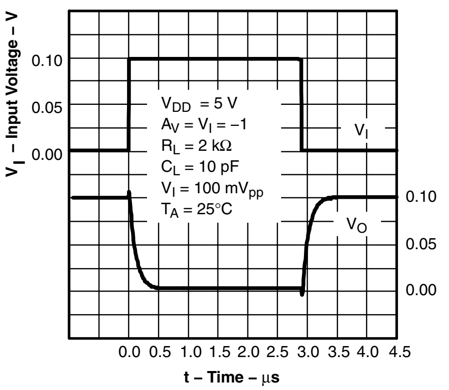


Figure 23

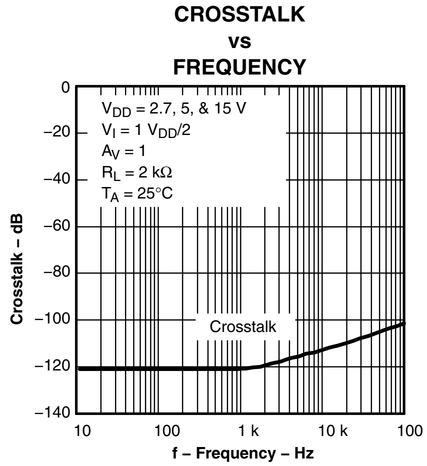


Figure 24

APPLICATION INFORMATION

driving a capacitive load

When the amplifier is configured in this manner, capacitive loading directly on the output decreases the device's phase margin leading to high frequency ringing or oscillations. Therefore, for capacitive loads of greater than 10 pF, it is recommended that a resistor be placed in series (R_{NULL}) with the output of the amplifier, as shown in Figure 25. A minimum value of 20 Ω should work well for most applications.

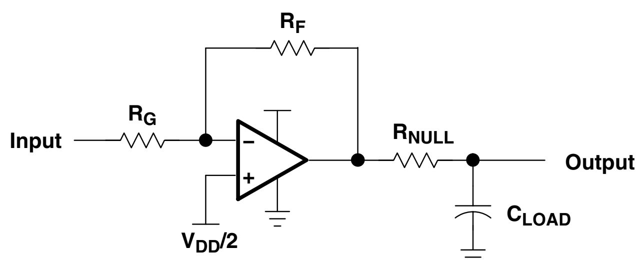
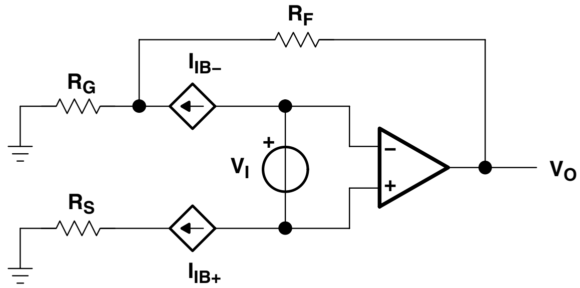


Figure 25. Driving a Capacitive Load

APPLICATION INFORMATION

offset voltage

The output offset voltage (V_{OO}) is the sum of the input offset voltage (V_{IO}) and both input bias currents (I_{IB}) times the corresponding gains. The following schematic and formula can be used to calculate the output offset voltage:

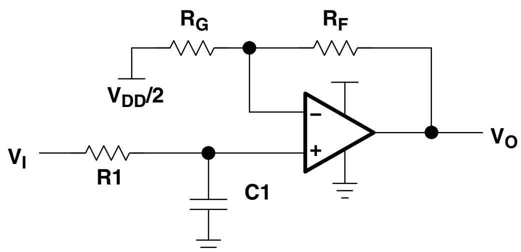


$$V_{OO} = V_{IO}\left(1 + \left(\frac{R_F}{R_G}\right)\right) \pm I_{IB+}\,R_S\left(1 + \left(\frac{R_F}{R_G}\right)\right) \pm I_{IB-}\,R_F$$

Figure 26. Output Offset Voltage Model

general configurations

When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. The simplest way to accomplish this is to place an RC filter at the noninverting terminal of the amplifier (see Figure 27).

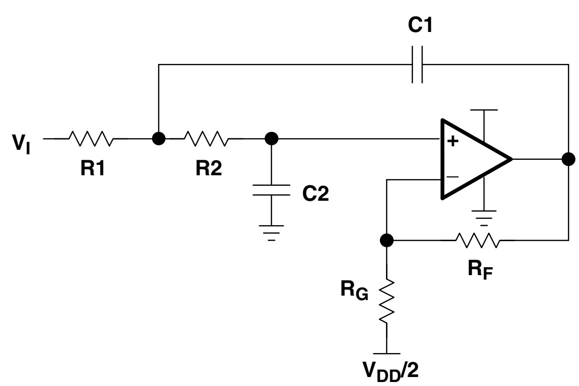


$$\frac{V_O}{V_I} = \left(1 + \frac{R_F}{R_G}\right)\left(\frac{1}{1 + sR1C1}\right)$$

$$f_{-3dB} = \frac{1}{2\pi R1C1}$$

Figure 27. Single-Pole Low-Pass Filter

If even more attenuation is needed, a multiple pole filter is required. The Sallen-Key filter can be used for this task. For the best results, the amplifier should have a bandwidth that is 8 to 10 times the filter frequency bandwidth. Failure to do this can result in phase shift of the amplifier.



R1 = R2 = R
C1 = C2 = C
Q = Peaking Factor
(Butterworth Q = 0.707)

$$f_{-3dB} = \frac{1}{2\pi RC}$$

$$R_G = \frac{R_F}{\left(2 - \frac{1}{Q}\right)}$$

Figure 28. 2-Pole Low-Pass Sallen-Key Filter

APPLICATION INFORMATION

circuit layout considerations

To achieve the levels of high performance of the TLV27x, follow proper printed-circuit board design techniques. A general set of guidelines is given in the following.

- Ground planes—It is highly recommended that a ground plane be used on the board to provide all components with a low inductive ground connection. However, in the areas of the amplifier inputs and output, the ground plane can be removed to minimize the stray capacitance.
- Proper power supply decoupling—Use a 6.8-μF tantalum capacitor in parallel with a 0.1-μF ceramic capacitor on each supply terminal. It may be possible to share the tantalum among several amplifiers depending on the application, but a 0.1-μF ceramic capacitor should always be used on the supply terminal of every amplifier. In addition, the 0.1-μF capacitor should be placed as close as possible to the supply terminal. As this distance increases, the inductance in the connecting trace makes the capacitor less effective. The designer should strive for distances of less than 0.1 inches between the device power terminals and the ceramic capacitors.
- Sockets—Sockets can be used but are not recommended. The additional lead inductance in the socket pins will often lead to stability problems. Surface-mount packages soldered directly to the printed-circuit board is the best implementation.
- Short trace runs/compact part placements—Optimum high performance is achieved when stray series inductance has been minimized. To realize this, the circuit layout should be made as compact as possible, thereby minimizing the length of all trace runs. Particular attention should be paid to the inverting input of the amplifier. Its length should be kept as short as possible. This helps to minimize stray capacitance at the input of the amplifier.
- Surface-mount passive components—Using surface-mount passive components is recommended for high performance amplifier circuits for several reasons. First, because of the extremely low lead inductance of surface-mount components, the problem with stray series inductance is greatly reduced. Second, the small size of surface-mount components naturally leads to a more compact layout thereby minimizing both stray inductance and capacitance. If leaded components are used, it is recommended that the lead lengths be kept as short as possible.

APPLICATION INFORMATION

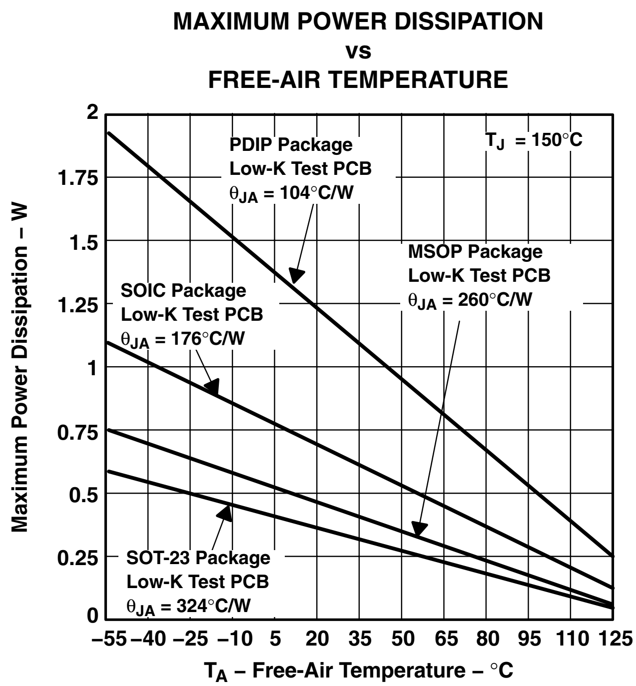
general power dissipation considerations

For a given θ_{JA}, the maximum power dissipation is shown in Figure 29 and is calculated by the following formula:

$$P_D = \left(\frac{T_{MAX} - T_A}{\theta_{JA}}\right)$$

Where:

P_D = Maximum power dissipation of TLV27x IC (watts)
T_{MAX} = Absolute maximum junction temperature (150°C)
T_A = Free-ambient air temperature (°C)
θ_{JA} = $\theta_{JC} + \theta_{CA}$
θ_{JC} = Thermal coefficient from junction to case
θ_{CA} = Thermal coefficient from case to ambient air (°C/W)



NOTE A: Results are with no air flow and using JEDEC Standard Low-K test PCB.

Figure 29. Maximum Power Dissipation vs Free-Air Temperature

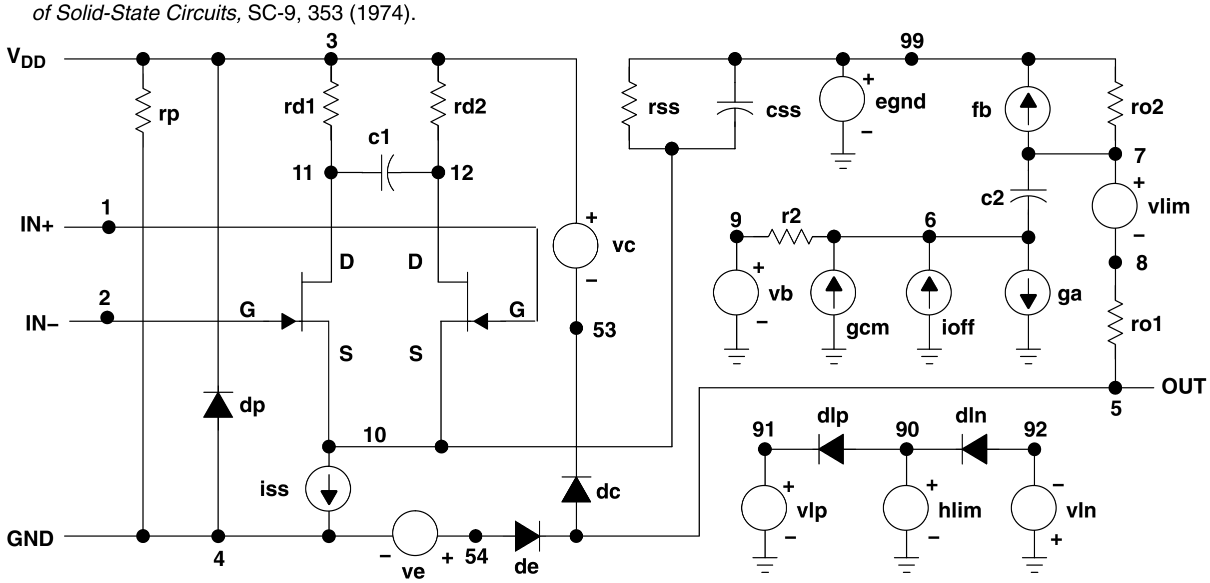
APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using Microsim *Parts*™ Release 9.1, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 2) and subcircuit in Figure 30 are generated using TLV27x typical electrical and operating characteristics at T_A = 25°C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Unity-gain frequency
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

NOTE 2: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, “Macromodeling of Integrated Circuit Operational Amplifiers,” *IEEE Journal of Solid-State Circuits,* SC-9, 353 (1974).




```
*DEVICE=amp_tlv27x_highVdd,OP AMP,NJF,INT
* amp_tlv_27x_highVdd operational amplifier ”macromodel”
* subcircuit updated using Model Editor release 9.1 on 05/15/00
* at 14:40 Model Editor is an OrCAD product.
*
* connections:                non-inverting input
*                             | inverting input
*                             | | positive power supply
*                             | | | negative power supply
*                             | | | | output
*                             | | | | |
.subckt amp_tlv27x_highVdd    1 2 3 4 5
*
        c1      11    12    457.48E−15
        c2      6     7     5.0000E−12
        css     10    99    1.1431E−12
        dc      5     53    dy
        de      54    5     dy
        dlp     90    91    dx
        dln     92    90    dx
        dp      4     3     dx
        egnd    99    0     poly(2) (3,0) (4,0) 0 .5 .5
        fb      7     99    poly(5) vb vc ve vlp vln 0
                            176.02E6 −1E3 1E3 180E6
                            −180E6
ga      6     0     11 12 16.272E−6
gcm     0     6     10 99 6.8698E−9
iss     10    4     dc 1.3371E−6
hlim    90    0     vlim 1K
j1      11    2     10 jx1
J2      12    1     10 jx2
r2      6     9     100.00E3
rd1     3     11    61.456E3
rd2     3     12    61.456E3
ro1     8     5     10
ro2     7     99    10
rp      3     4     150.51E3
rss     10    99    149.58E6
vb      9     0     dc 0
vc      3     53    dc .78905
ve      54    4     dc .78905
vlim    7     8     dc 0
vlp     91    0     dc 14.200
vln     0     92    dc 14.200
.model  dx    D(Is=800.00E−18)
.model  dy    D(Is=800.00E−18 Rs=1m Cjo=10p)
.model  jx1   NJF(Is=500.00E−15 Beta=198.03E−6 Vto=−1)
.model  jx2   NJF(Is=500.00E−15 Beta=198.03E−6 Vto=−1)
.ends
```

Figure 30. Boyle Macromodel and Subcircuit

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PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
TLV271QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV271QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV271QDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV272QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV272QDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV274QDRG4Q1	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV274QDRQ1	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV274QPWRG4Q1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV274QPWRQ1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR

[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.

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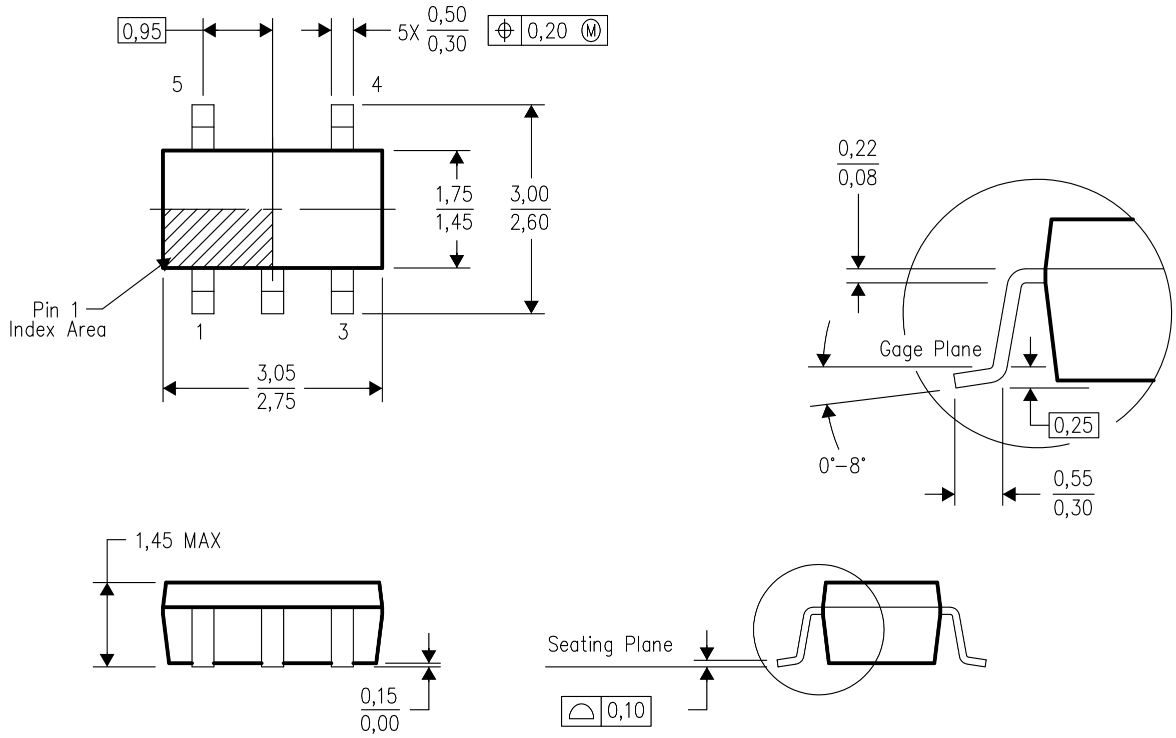
- Catalog: TLV271, TLV272, TLV274

NOTE: Qualified Version Definitions:

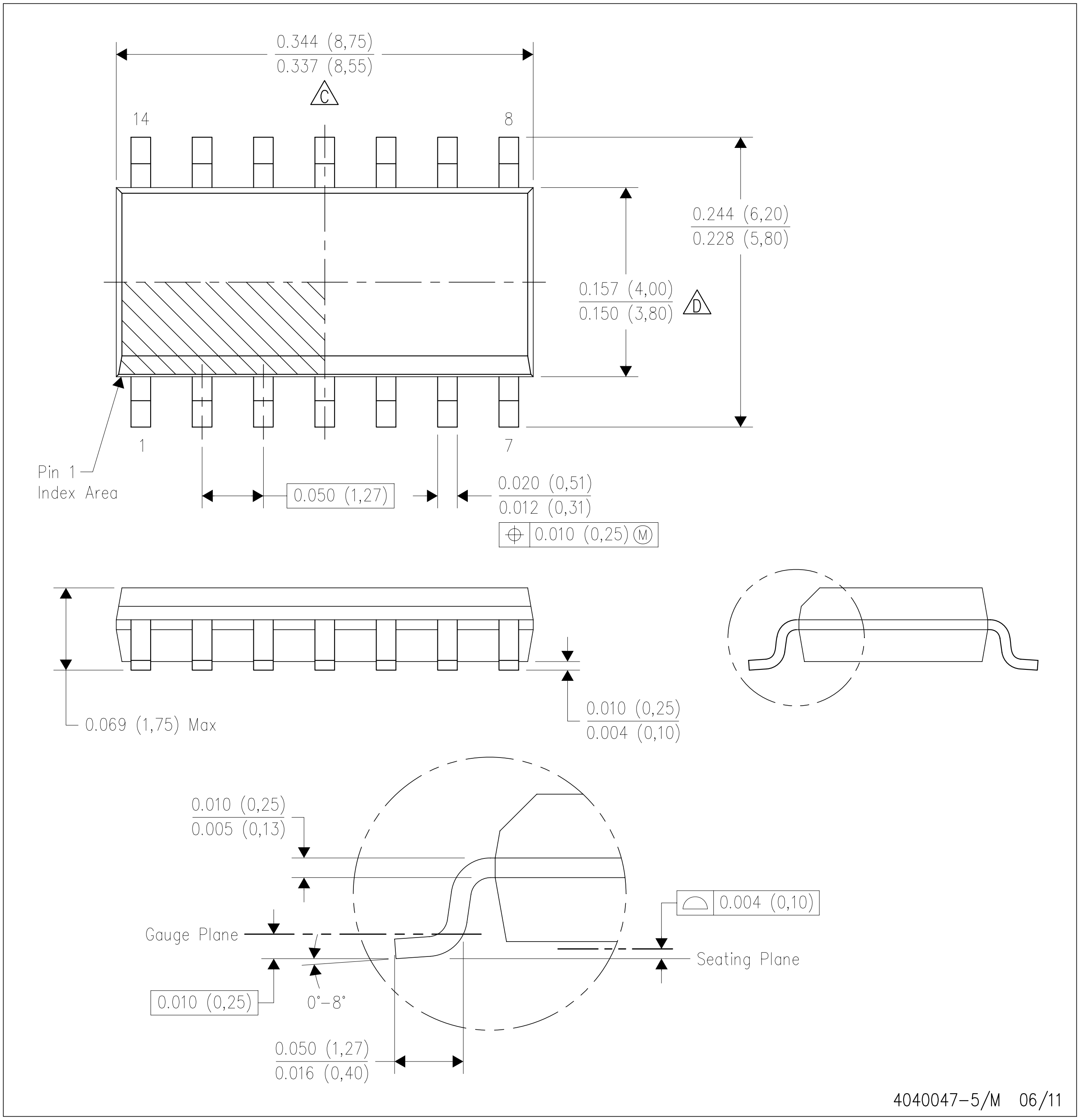
- Catalog - TI's standard catalog product

DBV (R-PDSO-G5) PLASTIC SMALL-OUTLINE PACKAGE



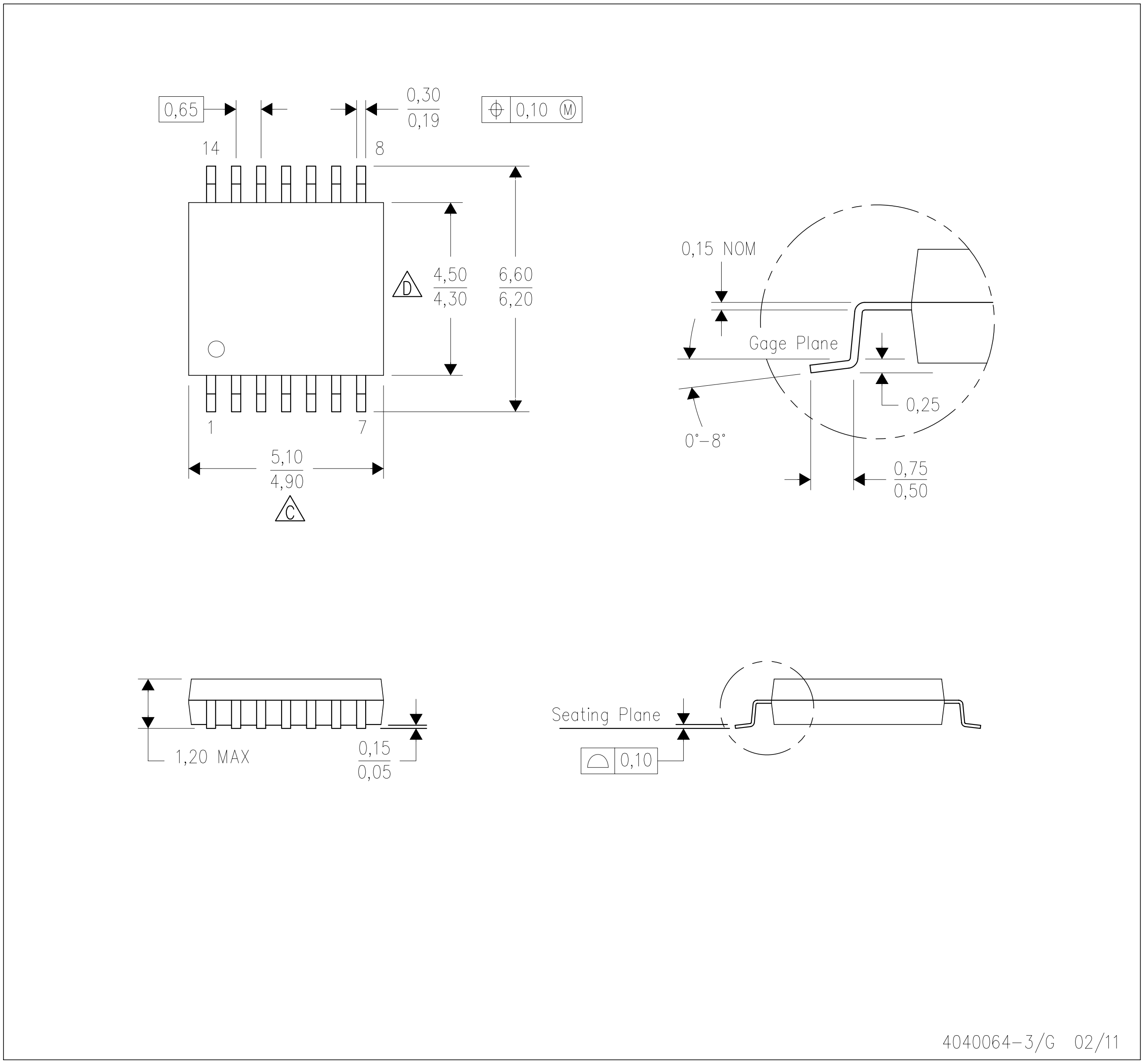
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO-178 Variation AA.

D (R–PDSO–G14) 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 AB.

PW (R-PDSO-G14) PLASTIC SMALL OUTLINE



NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
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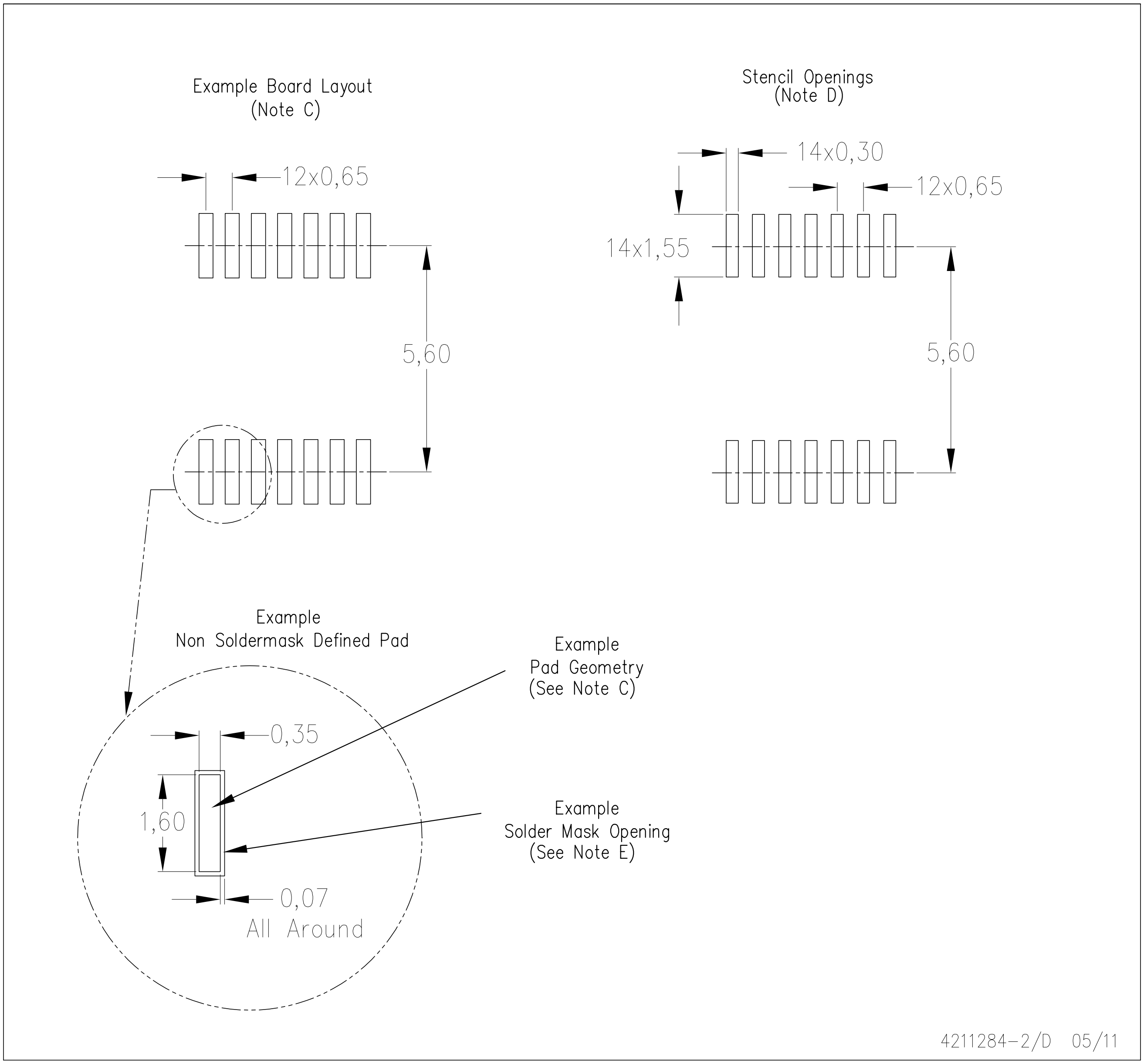
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
- E. Falls within JEDEC MO–153

PW (R-PDSO-G14) PLASTIC SMALL OUTLINE



NOTES:
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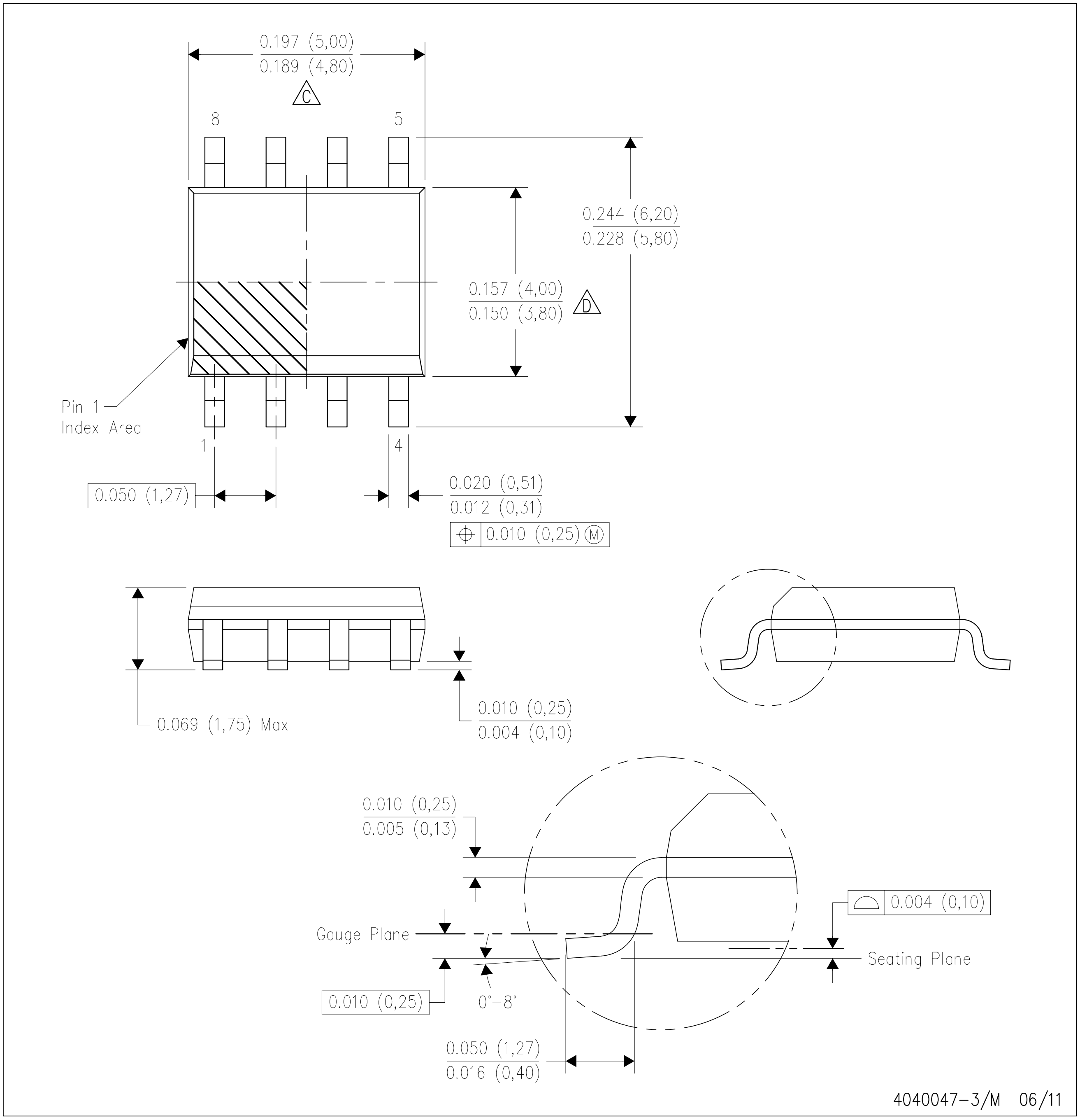
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. 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.

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
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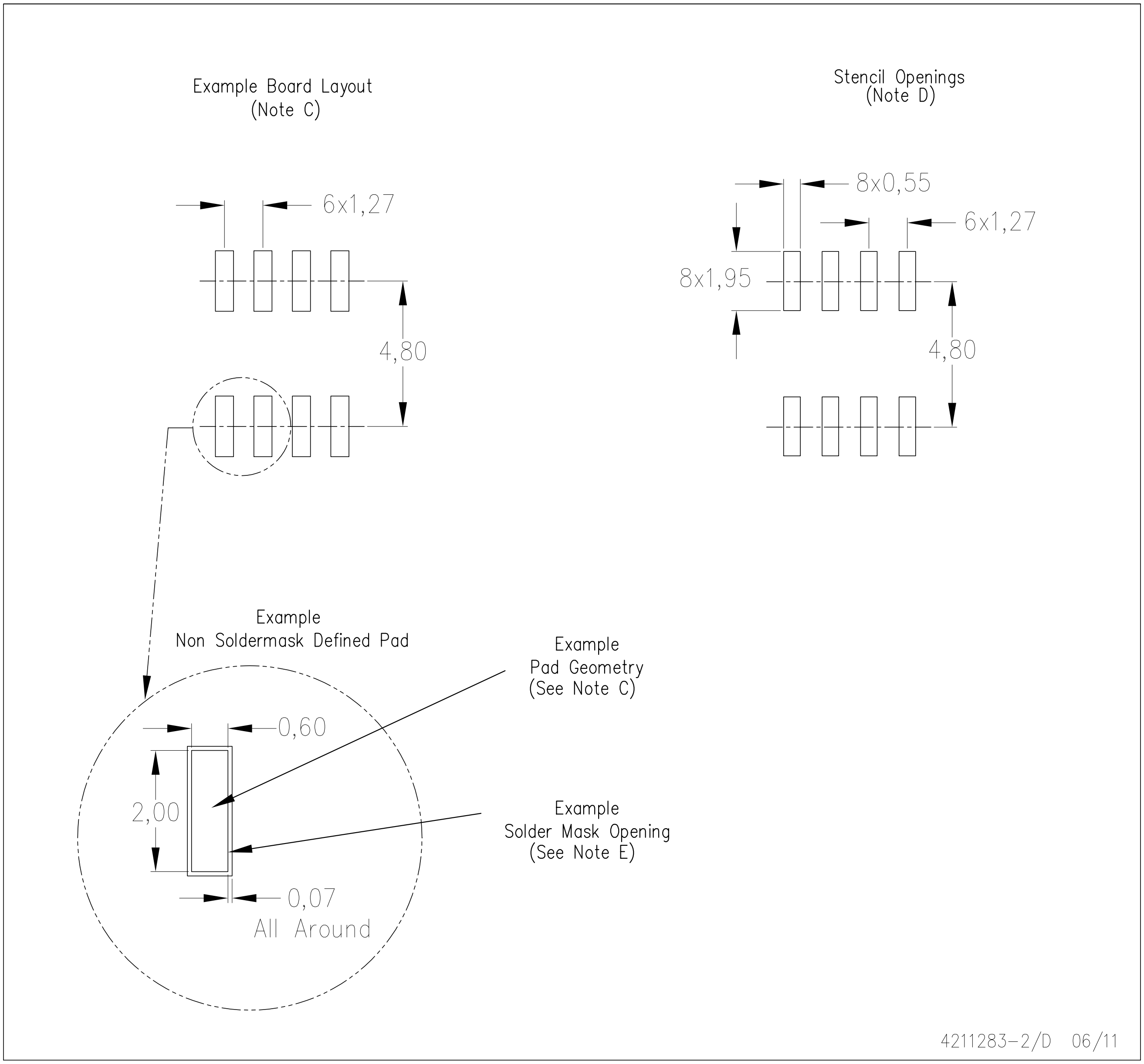
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) 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.
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