

FAMILY OF 600 μ A/Ch 2.8MHz RAIL-TO-RAIL INPUT/OUTPUT HIGH-DRIVE OPERATIONAL AMPLIFIERS WITH SHUTDOWN

FEATURES

- **CMOS Rail-To-Rail Input/Output**
- **Input Bias Current: 2.5pA**
- **Low Supply Current: 600 μ A/Channel**
- **Ultra-Low Power Shutdown Mode**
 $I_{DD(SHDN)}$: 350nA/ch at 3V
 $I_{DD(SHDN)}$: 1000nA/ch at 5V
- **Gain-Bandwidth Product: 2.8MHz**
- **High Output Drive Capability**
 - ± 10 mA at 180mV
 - ± 35 mA at 500mV
- **Input Offset Voltage: 250 μ V (typ)**
- **Supply Voltage Range: 2.7V to 6V**
- **Ultra-Small Packaging**
 - SOT23-5 or -6 (TLV2470/1)
 - MSOP-8 or -10 (TLV2472/3)

DESCRIPTION

The TLV247x is a family of CMOS rail-to-rail input/output operational amplifiers that establishes a new performance point for supply current versus ac performance. These devices consume just 600 μ A/channel while offering 2.8MHz of gain-bandwidth product. Along with increased ac performance, the amplifier provides high output drive capability, solving a major shortcoming of older micropower operational amplifiers. The TLV247x can swing to within 180mV of each supply rail while driving a 10mA load. For non-RRO applications, the TLV247x can supply ± 35 mA at 500mV off the rail. Both the inputs and outputs swing rail-to-rail for increased dynamic range in low-voltage applications. This performance makes the TLV247x family ideal for sensor interface, portable medical equipment, and other data acquisition circuits.

FAMILY PACKAGE TABLE

DEVICE	NUMBER OF CHANNELS	PACKAGE TYPES					SHUTDOWN	UNIVERSAL EVM BOARD
		PDIP	SOIC	SOT23	TSSOP	MSOP		
TLV2470	1	8	8	6	—	—	Yes	Refer to the EVM Selection Guide (SLOU060)
TLV2471	1	8	8	5	—	—	—	
TLV2472	2	8	8	—	—	8	—	
TLV2473	2	14	14	—	—	10	Yes	
TLV2474	4	14	14	—	14	—	—	
TLV2475	4	16	16	—	16	—	Yes	

A SELECTION OF SINGLE-SUPPLY OPERATIONAL AMPLIFIER PRODUCTS⁽¹⁾

DEVICE	V _{DD} (V)	V _{IO} (μ V)	BW (MHz)	SLEW RATE (V/ μ s)	I _{DD} (per channel) (μ A)	OUTPUT DRIVE	RAIL-TO-RAIL
TLV247X	2.7 – 6.0	250	2.8	1.5	600	± 35 mA	I/O
TLV245X	2.7 – 6.0	20	0.22	0.11	23	± 10 mA	I/O
TLV246X	2.7 – 6.0	150	6.4	1.6	550	± 90 mA	I/O
TLV277X	2.5 – 6.0	360	5.1	10.5	1000	± 10 mA	O

(1) All specifications measured at 5 V.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PowerPAD is a trademark of Texas Instruments.

Microsim PARTS is a trademark of MicroSim Corporation.

Microsim PSpice is a registered trademark of MicroSim Corporation.

All other trademarks are the property of their respective owners.



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

TLV2470 and TLV2471 AVAILABLE OPTIONS

T _A	PACKAGED DEVICES			
	SMALL OUTLINE (D) ⁽¹⁾	SOT23		PLASTIC DIP (P)
		(DBV) ⁽¹⁾	SYMBOL	
0°C to +70°C	TLV2470CD TLV2471CD	TLV2470CDBV TLV2471CDBV	VAUC VAVC	TLV2470CP TLV2471CP
-40°C to +125°C	TLV2470ID TLV2471ID	TLV2470IDBV TLV2471IDBV	VAUI VAVI	TLV2470IP TLV2471IP
	TLV2470AID TLV2471AID	—	—	TLV2470AIP TLV2471AIP

(1) This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2470CDR).

TLV2472 AND TLV2473 AVAILABLE OPTIONS

T _A	PACKAGED DEVICES						
	SMALL OUTLINE (D) ⁽¹⁾	MSOP		MSOP		PLASTIC DIP (N)	PLASTIC DIP (P)
		(DGN) ⁽¹⁾	SYMBOL ⁽²⁾	(DGQ) ⁽¹⁾	SYMBOL ⁽²⁾		
0°C to +70°C	TLV2472CD TLV2473CD	TLV2472CDGN —	xxTIABU —	— TLV2473CDGQ	— xxTIABW	— TLV2473CN	TLV2472CP —
-40°C to +125°C	TLV2472ID TLV2473ID	TLV2472IDGN —	xxTIABV —	— TLV2473IDGQ	— xxTIABX	— TLV2473IN	TLV2472IP —
	TLV2472AID TLV2473AID	—	—	—	—	— TLV2473AIN	TLV2472AIP —

(1) This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2472CDR).

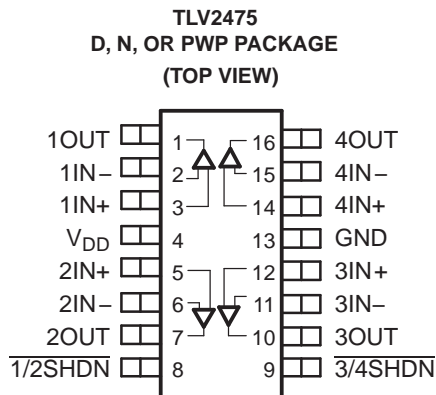
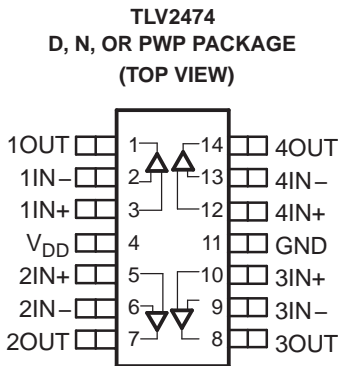
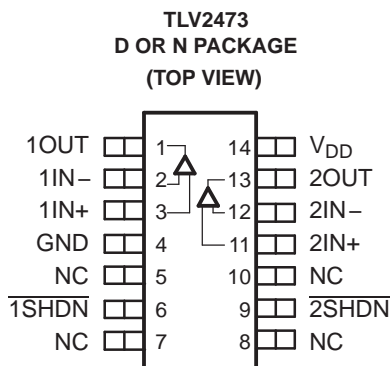
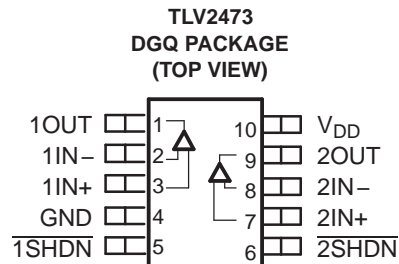
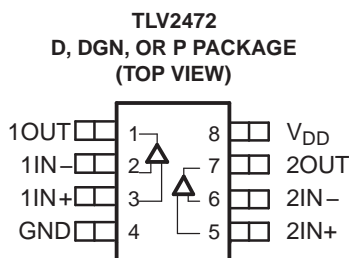
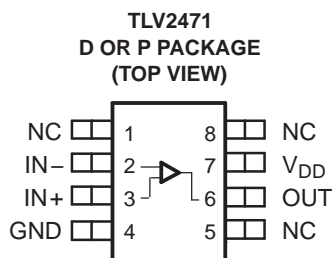
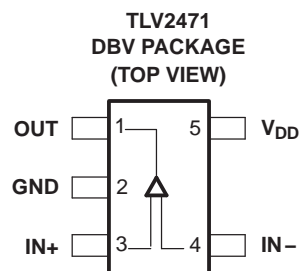
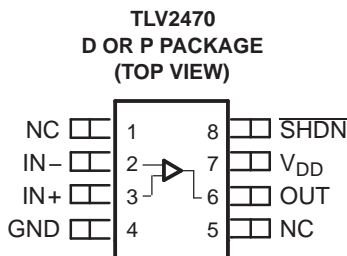
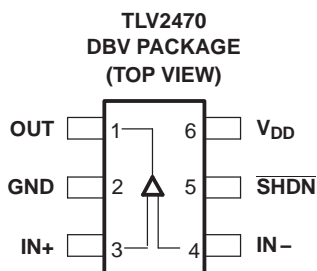
(2) xx represents the device date code.

TLV2474 and TLV2475 AVAILABLE OPTIONS

T _A	PACKAGED DEVICES		
	SMALL OUTLINE (D) ⁽¹⁾	PLASTIC DIP (N)	TSSOP (PWP) ⁽¹⁾
0°C to +70°C	TLV2474CD TLV2475CD	TLV2474CN TLV2475CN	TLV2474CPWP TLV2475CPWP
-40°C to +125°C	TLV2474ID TLV2475ID	TLV2474IN TLV2475IN	TLV2474IPWP TLV2475IPWP
	TLV2474AID TLV2475AID	TLV2474AIN TLV2475AIN	TLV2474AIPWP TLV2475AIPWP

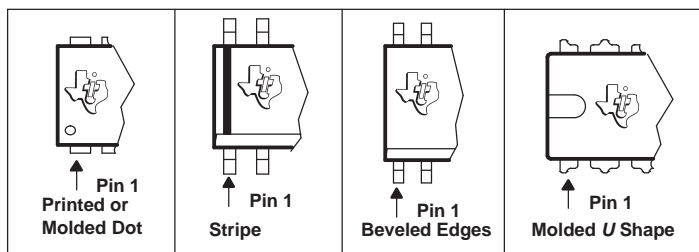
(1) This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2474CDR).

TLV247X PACKAGE PINOUTS



NC – No internal connection

TYPICAL PIN 1 INDICATORS



DESCRIPTION (CONTINUED)

Three members of the family (TLV2470/3/5) offer a shutdown terminal for conserving battery life in portable applications. During shutdown, the outputs are placed in a high-impedance state and the amplifier consumes only 350nA/channel. The family is fully specified at 3V and 5V across an expanded industrial temperature range (–40°C to +125°C). The singles and duals are available in the SOT23 and MSOP packages, while the quads are available in TSSOP. The TLV2470 offers an amplifier with shutdown functionality all in a SOT23-6 package, making it perfect for high-density power-sensitive circuits.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

over operating free-air temperature range (unless otherwise noted)

		UNIT
Supply voltage, V_{DD} ⁽²⁾		7 V
Differential input voltage, V_{ID}		$\pm V_{DD}$
Continuous total power dissipation		See Dissipation Rating table
Operating free-air temperature range, T_A	C suffix	0°C to +70°C
	I suffix	–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

- (1) 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.
- (2) All voltage values, except differential voltages, are with respect to GND.

DISSIPATION RATING TABLE

PACKAGE	θ_{JC} (°C/W)	θ_{JA} (°C/W)	$T_A \leq +25^\circ\text{C}$ POWER RATING
D (8)	38.3	176	710mW
D (14)	26.9	122.3	1022mW
D (16)	25.7	114.7	1090mW
DBV (5)	55	324.1	385mW
DBV (6)	55	294.3	425mW
DGN (8)	4.7	52.7	2.37W
DGQ (10)	4.7	52.3	2.39W
N (14, 16)	32	78	1600mW
P (8)	41	104	1200mW
PWP (14)	2.07	30.7	4.07W
PWP (16)	2.07	29.7	4.21W

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
Supply voltage, V_{DD}	Single supply	2.7	6	V
	Split supply	± 1.35	± 3	
Common-mode input voltage range, V_{ICR}		0	V_{DD}	V
Operating free-air temperature, T_A	C-suffix	0	+70	°C
	I-suffix	–40	+125	
Shutdown on/off voltage level ⁽¹⁾	V_{IH}	2		V
	V_{IL}		0.8	

- (1) Relative to GND

ELECTRICAL CHARACTERISTICS

At specified free-air temperature, $V_{DD} = 3V$, unless otherwise noted.

PARAMETER	TEST CONDITIONS	$T_A^{(1)}$	MIN	TYP	MAX	UNIT
V_{IO} Input offset voltage	TLV247x	25°C		250	2200	μV
		Full range			2400	
		25°C		250	1600	
		Full range			1800	
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = V_{DD}/2$, $V_O = V_{DD}/2$, $R_S = 50\Omega$			0.4		$\mu V/^\circ C$
I_{IO} Input offset current	TLV247xC TLV247xI	25°C		1.5	50	pA
		Full range			100	
		Full range			300	
I_{IB} Input bias current	TLV247xC TLV247xI	25°C		2	50	pA
		Full range			100	
		Full range			300	
V_{OH} High-level output voltage	$V_{IC} = V_{DD}/2$	$I_{OH} = -2.5mA$	25°C	2.85	2.94	V
			Full range	2.8		
		$I_{OH} = -10mA$	25°C	2.6	2.74	
			Full range	2.5		
V_{OL} Low-level output voltage	$V_{IC} = V_{DD}/2$	$I_{OL} = 2.5mA$	25°C	0.07	0.15	V
			Full range		0.2	
		$I_{OL} = 10mA$	25°C	0.2	0.35	
			Full range		0.5	
I_{OS} Short-circuit output current	Sourcing		25°C	30		mA
			Full range	20		
	Sourcing, Outside of rails ⁽²⁾	TLV247xC	25°C	62		
			Full range	60		
		TLV247xI	Full range	59		
			Full range	59		
	Sinking		25°C	30		
			Full range	20		
	Sinking, Outside of rails ⁽²⁾		25°C	62		
		TLV247xC	Full range	60		
		TLV247xI	Full range	59		
			Full range	59		
I_O Output current	$V_O = 0.5V$ from rail	25°C		± 22		mA
A_{VD} Large-signal differential voltage amplification	$V_{O(PP)} = 1V$, $R_L = 10k\Omega$	25°C		90	116	dB
		Full range		88		
$r_{i(d)}$ Differential input resistance		25°C		10^{12}		Ω
C_{IC} Common-mode input capacitance	$f = 10kHz$	25°C		19.3		pF
Z_o Closed-loop output impedance	$f = 10kHz$, $A_V = 10$	25°C		2		Ω
CMRR Common-mode rejection ratio	$V_{IC} = 0V$ to $3V$, $R_S = 50\Omega$		25°C	61	78	dB
		TLV247xC	Full range	59		
		TLV247xI	Full range	58		

(1) Full range is 0°C to +70°C for C-suffix and –40°C to +125°C for I-suffix. If not specified, full range is –40°C to +125°C.

(2) Depending on package dissipation rating.

ELECTRICAL CHARACTERISTICS (continued)

At specified free-air temperature, $V_{DD} = 3V$, unless otherwise noted.

PARAMETER	TEST CONDITIONS	$T_A^{(1)}$	MIN	TYP	MAX	UNIT
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 2.7V$ to $6V$, $V_{IC} = V_{DD}/2$, No load	25°C	74	90		dB
		Full range	66			
	$V_{DD} = 3V$ to $5V$, $V_{IC} = V_{DD}/2$, No load	25°C	77	92		
		Full range	68			
I_{DD} Supply current (per channel)	$V_O = 1.5V$, No load	25°C		550	750	μA
		Full range			800	
$I_{DD(SHDN)}$ Supply current in shutdown mode (TLV2470, TLV2473, TLV2475) (per channel)	$\overline{SHDN} = 0V$	25°C		350	1500	nA
		TLV247xC	Full range		2000	
		TLV247xI	Full range		4000	

(1) Full range is 0°C to +70°C for C-suffix and –40°C to +125°C for I-suffix. If not specified, full range is –40°C to +125°C.

OPERATING CHARACTERISTICS

At specified free-air temperature, $V_{DD} = 3V$, unless otherwise noted.

PARAMETER		TEST CONDITIONS		T _A ⁽¹⁾	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V _{O(PP)} = 0.8V, C _L = 150pF, R _L = 10kΩ		25°C	1.1	1.4		V/μs
				Full range	0.6			
V _n	Equivalent input noise voltage	f = 100Hz		25°C		28		nV/√Hz
		f = 1kHz		25°C		15		
I _n	Equivalent input noise current	f = 1kHz		25°C		0.405		pA/√Hz
THD+N	Total harmonic distortion plus noise	V _{O(PP)} = 2V, R _L = 10kΩ, f = 1kHz	A _V = 1	25°C		0.02%		
			A _V = 10			0.1%		
			A _V = 100			0.5%		
t _(on)	Amplifier turn-on time	R _L = OPEN ⁽²⁾		25°C		5		μs
t _(off)	Amplifier turn-off time			25°C		250		ns
	Gain-bandwidth product	f = 10kHz, R _L = 600Ω		25°C		2.8		MHz
t _s	Settling time	V _{(STEP)PP} = 2V, A _V = −1, C _L = 10pF, R _L = 10kΩ	0.1%	25°C		1.5		μs
			0.01%			3.9		
		V _{(STEP)PP} = 2V, A _V = −1, C _L = 56pF, R _L = 10kΩ	0.1%			1.6		
			0.01%			4		
φ _m	Phase margin	R _L = 10kΩ, C _L = 1000pF		25°C		61°		
	Gain margin	R _L = 10kΩ, C _L = 1000pF		25°C		15		dB

(1) Full range is 0°C to +70°C for C-suffix and –40°C to +125°C for I-suffix. If not specified, full range is –40°C to +125°C.

(2) Disable and enable time are defined as the interval between application of logic signal to \overline{SHDN} and the point at which the supply current has reached half its final value.

ELECTRICAL CHARACTERISTICS

At specified free-air temperature, $V_{DD} = 5V$, unless otherwise noted.

PARAMETER	TEST CONDITIONS	$T_A^{(1)}$	MIN	TYP	MAX	UNIT
V_{IO} Input offset voltage	TLV247x	25°C	250	2200		μV
		Full range		2400		
	TLV247xA	25°C	250	1600		μV
		Full range		2000		
α_{VIO} Temperature coefficient of input offset voltage	$V_{IC} = V_{DD}/2$, $V_O = V_{DD}/2$, $R_S = 50\Omega$			0.4		$\mu V/^{\circ}C$
I_{IO} Input offset current	TLV247xC	25°C	1.7	50		pA
		Full range		100		
I_{IB} Input bias current	TLV247xI	25°C	2.5	50		
		Full range		300		
V_{OH} High-level output voltage	$V_{IC} = V_{DD}/2$	TLV247xC	25°C	4.85	4.96	V
			Full range	4.8		
		TLV247xI	25°C	4.72	4.82	
			Full range	4.65		
V_{OL} Low-level output voltage	$V_{IC} = V_{DD}/2$	TLV247xC	25°C	0.07	0.15	V
			Full range	0.2		
		TLV247xI	25°C	0.178	0.28	
			Full range	0.35		
I_{OS} Short-circuit output current	Sourcing	25°C	110			mA
		Full range	60			
	Sourcing, Outside of rails ⁽²⁾	25°C	63			
		TLV247xC	Full range	61		
		TLV247xI	Full range	58		
		25°C	90			
	Sinking	Full range	60			
		25°C	63			
	Sinking, Outside of rails ⁽²⁾	TLV247xC	Full range	61		
		TLV247xI	Full range	58		
I_O Output current	$V_O = 0.5V$ from rail	25°C		± 35		mA
A_{VD} Large-signal differential voltage amplification	$V_{O(PP)} = 3V$, $R_L = 10k\Omega$	25°C	92	120		dB
		Full range	91			
$r_{i(d)}$ Differential input resistance		25°C		10^{12}		Ω
C_{IC} Common-mode input capacitance	$f = 10kHz$	25°C		18.9		pF
z_o Closed-loop output impedance	$f = 10kHz$, $A_V = 10$	25°C		1.8		Ω
CMRR Common-mode rejection ratio	$V_{IC} = 0V$ to $5V$, $R_S = 50\Omega$	25°C	64	84		dB
		TLV247xC	Full range	63		
		TLV247xI	Full range	58		
k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{DD} = 2.7V$ to $6V$, $V_{IC} = V_{DD}/2$, No load	25°C	74	90		dB
		Full range	66			
	$V_{DD} = 3V$ to $5V$, $V_{IC} = V_{DD}/2$, No load	25°C	77	92		
		Full range	66			
I_{DD} Supply current (per channel)	$V_O = 2.5V$, No load	25°C	600	900		μA
		Full range		1000		

(1) Full range is 0°C to +70°C for C-suffix and –40°C to +125°C for I-suffix. If not specified, full range is –40°C to +125°C.

(2) Depending on package dissipation rating

ELECTRICAL CHARACTERISTICS (continued)

At specified free-air temperature, $V_{DD} = 5V$, unless otherwise noted.

PARAMETER		TEST CONDITIONS	$T_A^{(1)}$	MIN	TYP	MAX	UNIT
$I_{DD(SHDN)}$	Supply current in shutdown mode (TLV2470, TLV2473, TLV2475) (per channel)	$\overline{SHDN} = 0V$	25°C	1000	2500		nA
			TLV247xC			3000	
			TLV247xI			6000	nA

(1) Full range is 0°C to +70°C for C-suffix and –40°C to +125°C for I-suffix. If not specified, full range is –40°C to +125°C.

OPERATING CHARACTERISTICS

At specified free-air temperature, $V_{DD} = 5V$, unless otherwise noted.

PARAMETER		TEST CONDITIONS		T _A ⁽¹⁾	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V _{O(PP)} = 2V, C _L = 150pF, R _L = 10kΩ		25°C	1.1	1.5		V/μs
				Full range	0.7			
V _n	Equivalent input noise voltage	f = 100Hz		25°C		28		nV/√Hz
		f = 1kHz		25°C		15		
I _n	Equivalent input noise current	f = 1kHz		25°C		0.39		pA/√Hz
THD + N	Total harmonic distortion plus noise	V _{O(PP)} = 4V, R _L = 10kΩ, f = 1kHz	A _V = 1	25°C		0.01%		
			A _V = 10			0.05%		
			A _V = 100			0.3%		
t _(on)	Amplifier turn-on time	R _L = OPEN ⁽²⁾		25°C		5		μs
t _(off)	Amplifier turn-off time			25°C		250		ns
	Gain-bandwidth product	f = 10kHz, R _L = 600Ω		25°C		2.8		MHz
t _s	Settling time	V _{(STEP)PP} = 2V, A _V = −1, C _L = 10pF, R _L = 10kΩ	0.1%	25°C		1.8		μs
			0.01%			3.3		
		V _{(STEP)PP} = 2V, A _V = −1, C _L = 56pF, R _L = 10kΩ	0.1%			1.7		
			0.01%			3		
φ _m	Phase margin	R _L = 10kΩ, C _L = 1000pF		25°C		68		°C
	Gain margin	R _L = 10kΩ, C _L = 1000pF		25°C		23		dB

(1) Full range is 0°C to +70°C for C suffix and –40°C to +125°C for I suffix. If not specified, full range is –40°C to +125°C.

(2) Disable and enable time are defined as the interval between application of logic signal to SHDN and the point at which the supply current has reached half its final value.

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	vs Common-mode input voltage	Figure 1, Figure 2
I_{IB}	Input bias current	vs Free-air temperature	Figure 3, Figure 4
I_{IO}	Input offset current		
V_{OH}	High-level output voltage	vs High-level output current	Figure 5, Figure 7
V_{OL}	Low-level output voltage	vs Low-level output current	Figure 6, Figure 8
Z_o	Output impedance	vs Frequency	Figure 9
I_{DD}	Supply current	vs Supply voltage	Figure 10
PSRR	Power-supply rejection ratio	vs Frequency	Figure 11
CMRR	Common-mode rejection ratio	vs Frequency	Figure 12
V_n	Equivalent input noise voltage	vs Frequency	Figure 13
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	Figure 14, Figure 15
A_{VD}	Differential voltage gain and phase	vs Frequency	Figure 16, Figure 17
ϕ_m	Phase margin	vs Load capacitance	Figure 18, Figure 19
	Gain margin	vs Load capacitance	Figure 20, Figure 21
	Gain-bandwidth product	vs Supply voltage	Figure 22
SR	Slew rate	vs Supply voltage	Figure 23
		vs Free-air temperature	Figure 24, Figure 25
	Crosstalk	vs Frequency	Figure 26
THD+N	Total harmonic distortion + noise	vs Frequency	Figure 27, Figure 28
V_O	Large and small signal follower	vs Time	Figure 29–Figure 32
	Shutdown pulse response	vs Time	Figure 33, Figure 34
	Shutdown forward and reverse isolation	vs Frequency	Figure 35, Figure 36
$I_{DD(SHDN)}$	Shutdown supply current	vs Supply voltage	Figure 37
$I_{DD(SHDN)}$	Shutdown supply current	vs Free-air temperature	Figure 38
$I_{DD(SHDN)}$	Shutdown pulse current	vs Time	Figure 39, Figure 40

TYPICAL CHARACTERISTICS

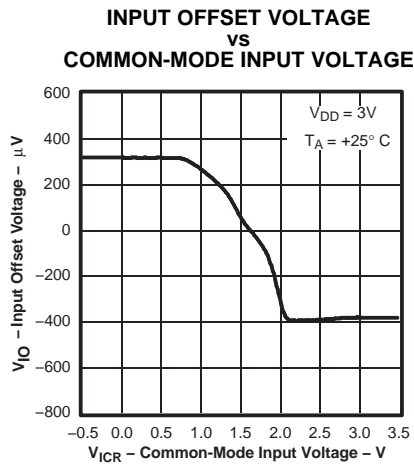


Figure 1.

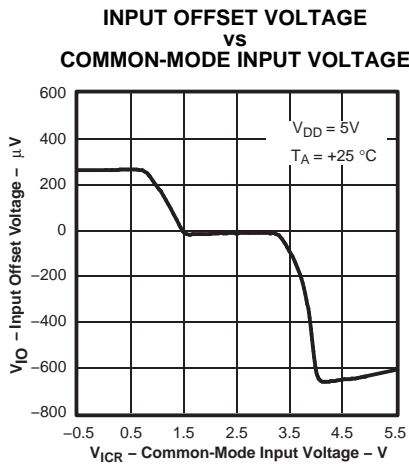


Figure 2.

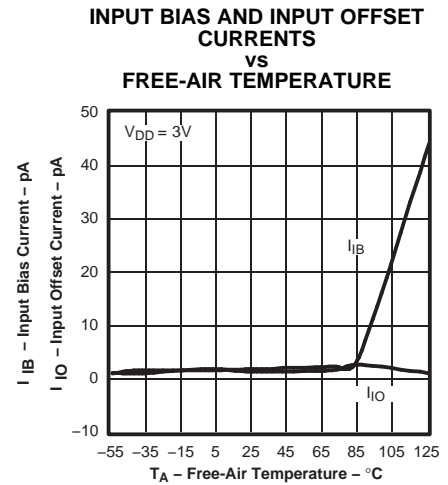


Figure 3.

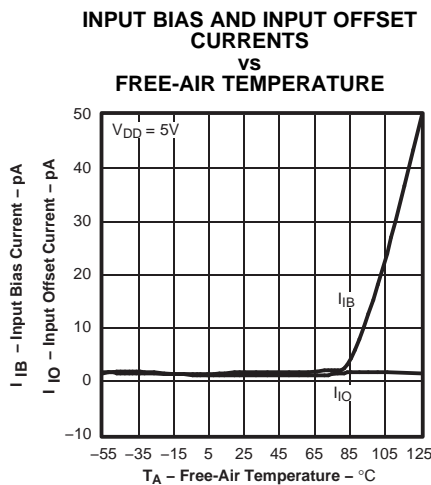


Figure 4.

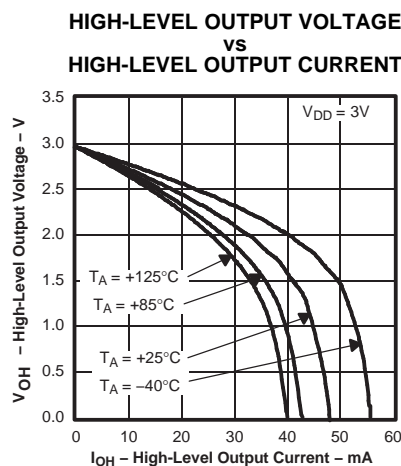


Figure 5.

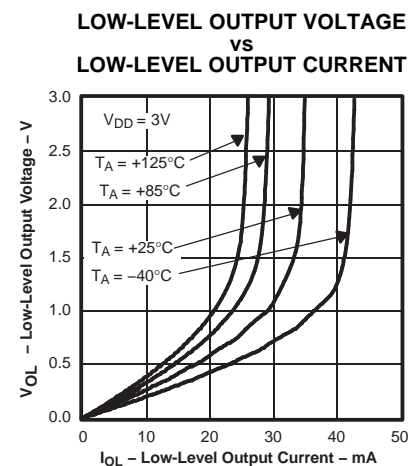


Figure 6.

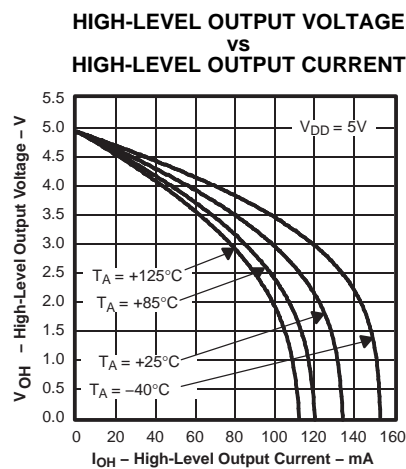


Figure 7.

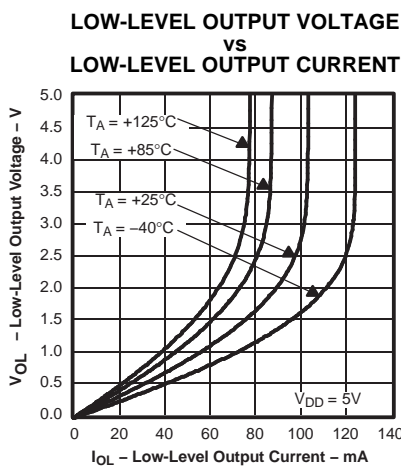


Figure 8.

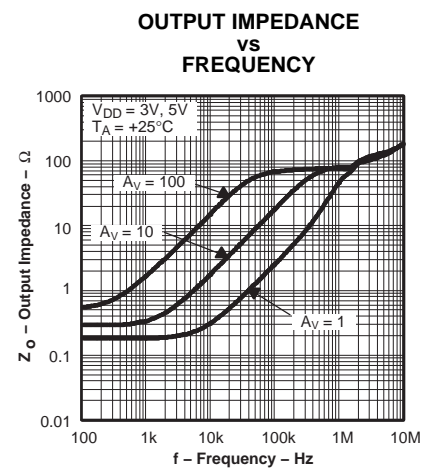


Figure 9.

TYPICAL CHARACTERISTICS (continued)

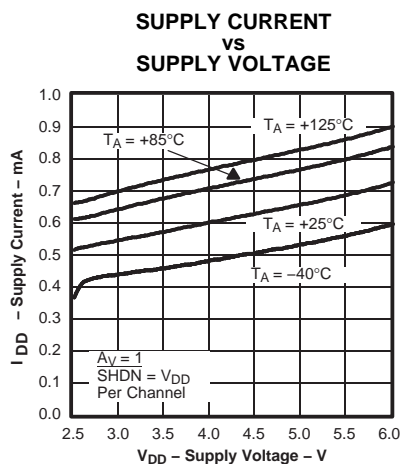


Figure 10.

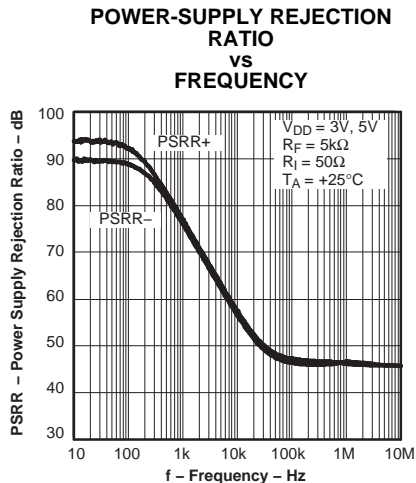


Figure 11.

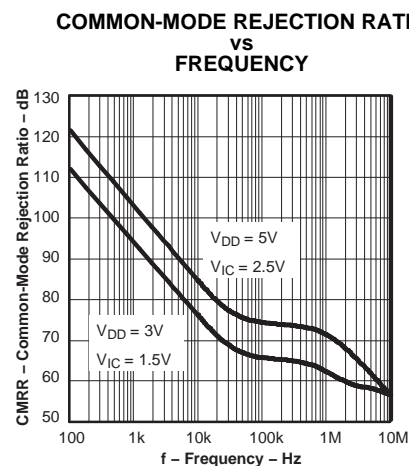


Figure 12.

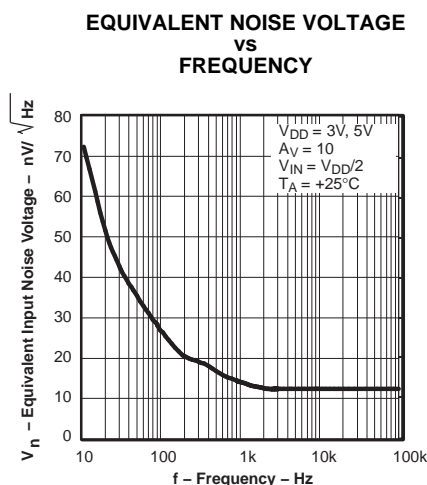


Figure 13.

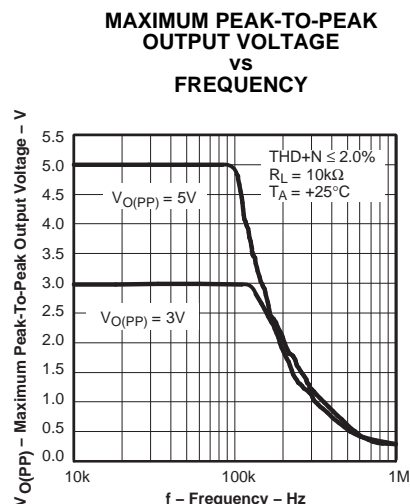


Figure 14.

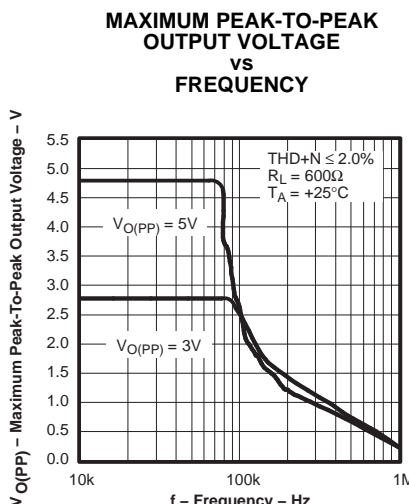


Figure 15.

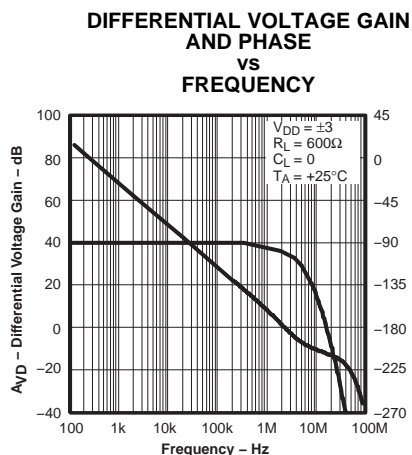


Figure 16.

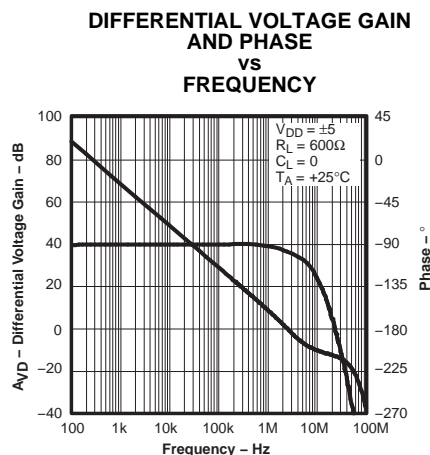


Figure 17.

TYPICAL CHARACTERISTICS (continued)

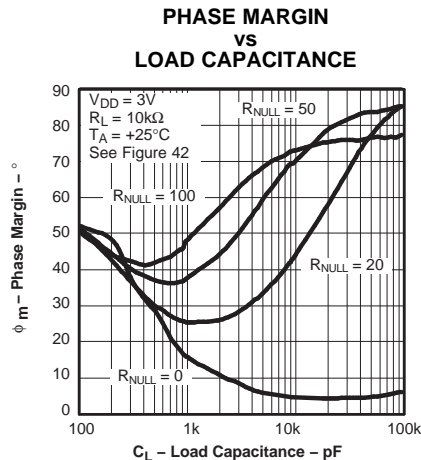


Figure 18.

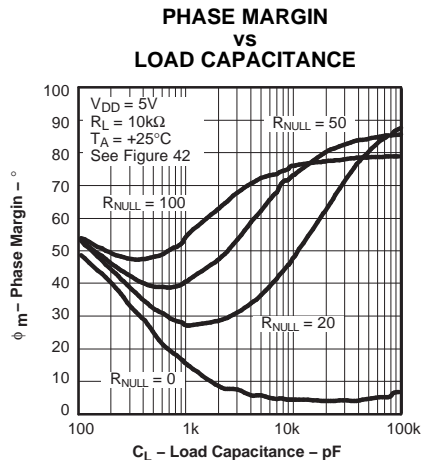


Figure 19.

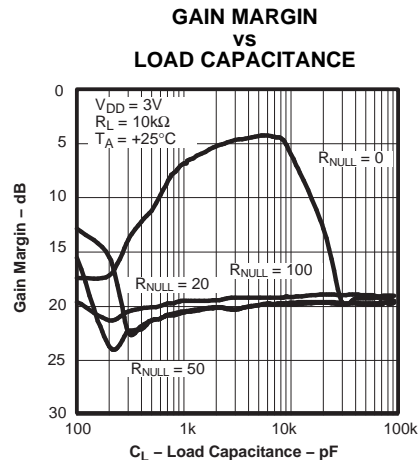


Figure 20.

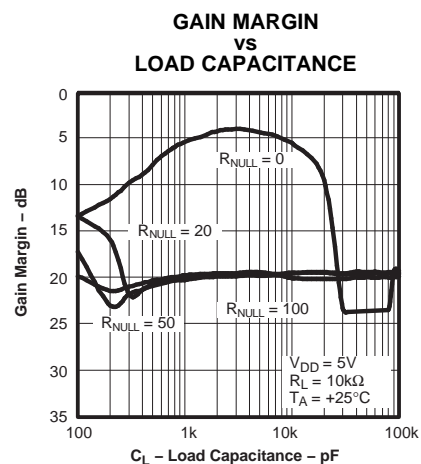


Figure 21.

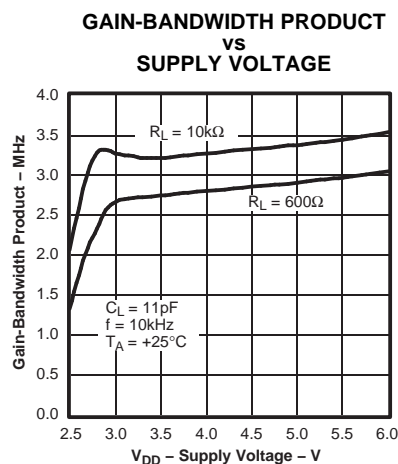


Figure 22.

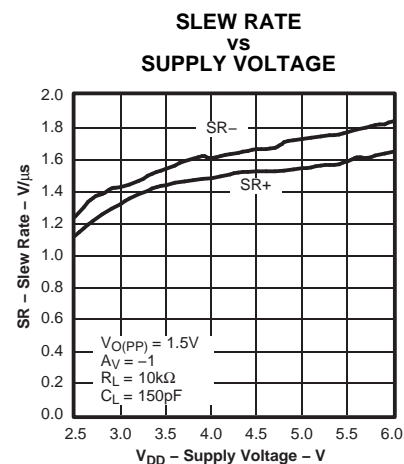


Figure 23.

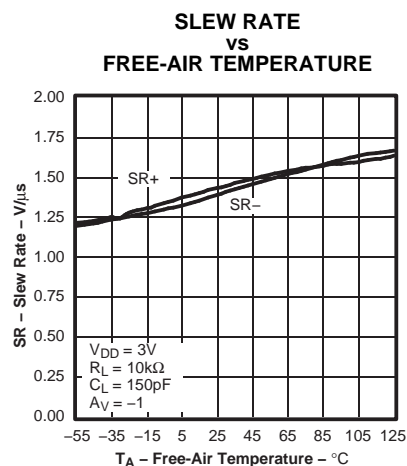


Figure 24.

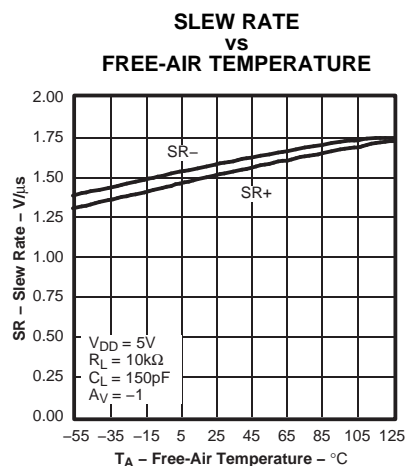


Figure 25.

TYPICAL CHARACTERISTICS (continued)

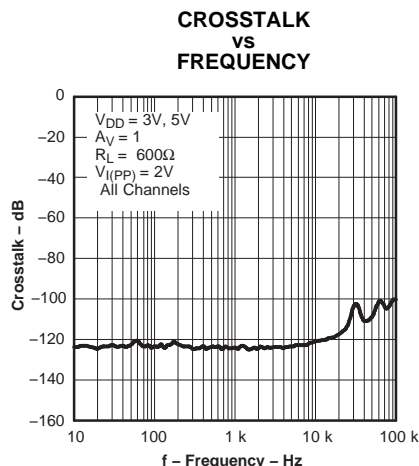


Figure 26.

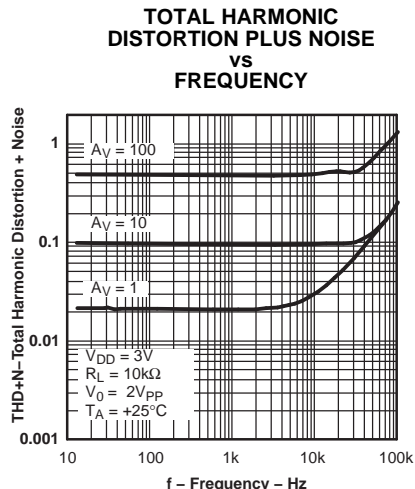


Figure 27.

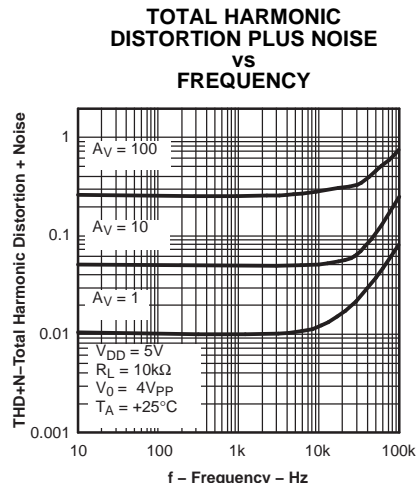


Figure 28.

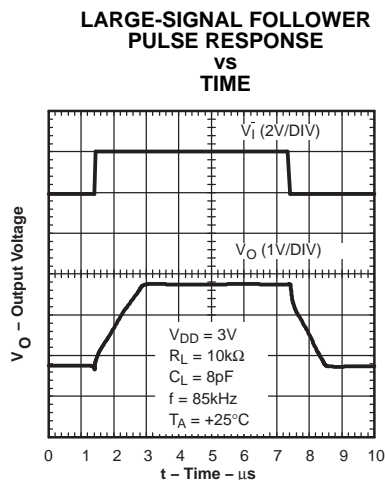


Figure 29.

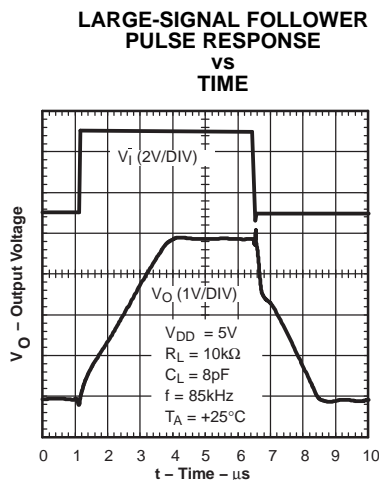


Figure 30.

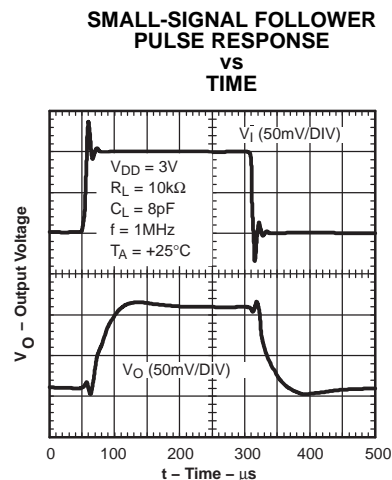


Figure 31.

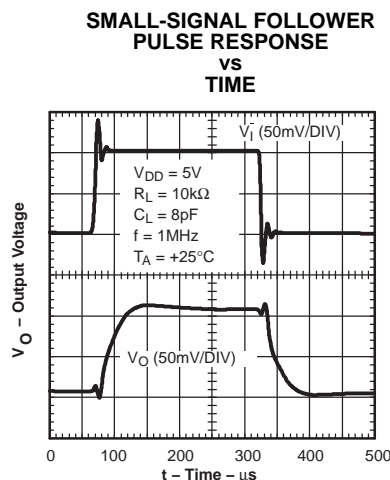


Figure 32.

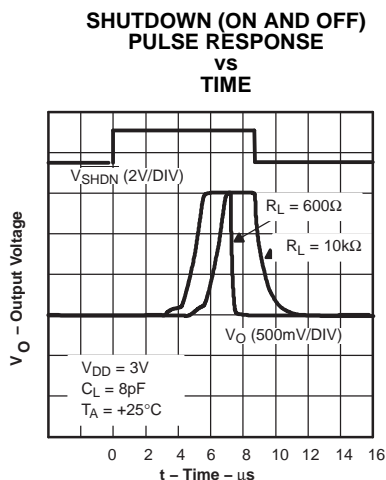


Figure 33.

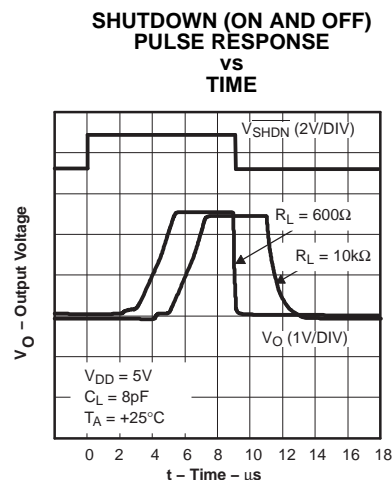


Figure 34.

TYPICAL CHARACTERISTICS (continued)

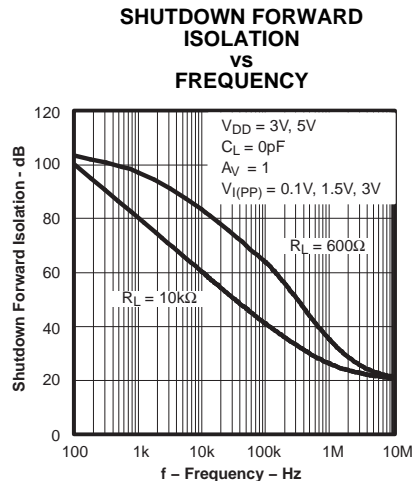


Figure 35.

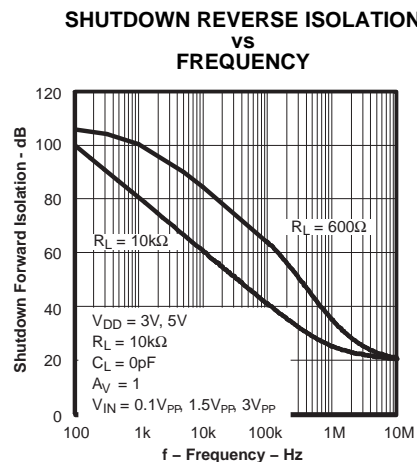


Figure 36.

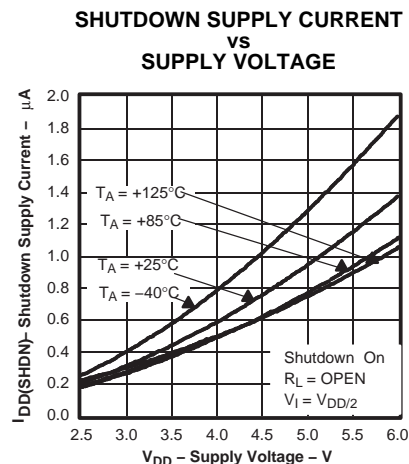


Figure 37.

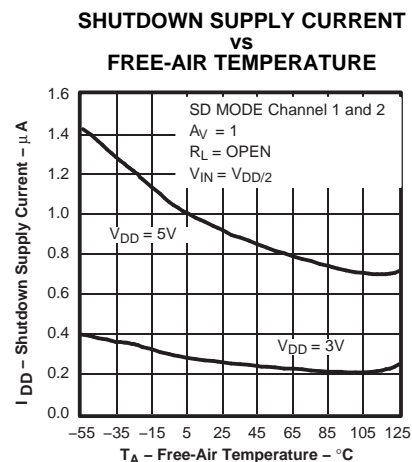


Figure 38.

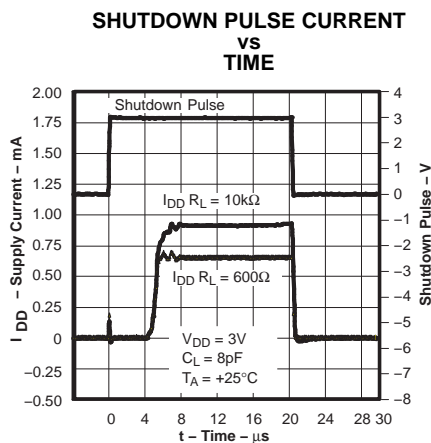


Figure 39.

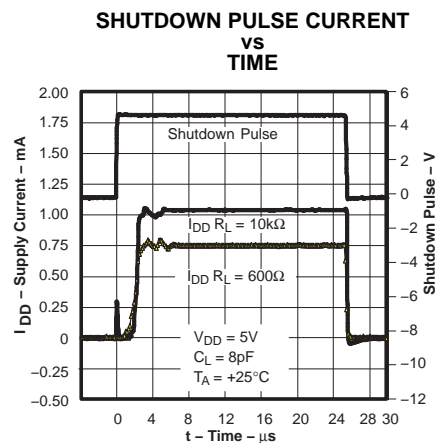


Figure 40.

PARAMETER MEASUREMENT INFORMATION

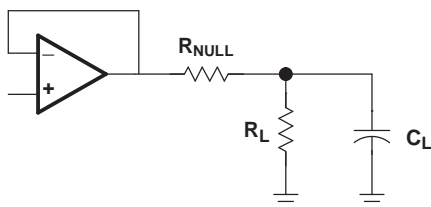


Figure 41.

APPLICATION INFORMATION

DRIVING A CAPACITIVE LOAD

When the amplifier is configured in this manner, capacitive loading directly on the output will decrease the device phase margin leading to high-frequency ringing or oscillations. Therefore, for capacitive loads of greater than 10pF, it is recommended that a resistor be placed in series (R_{NULL}) with the output of the amplifier, as shown in Figure 42. A minimum value of 20Ω should work well for most applications.

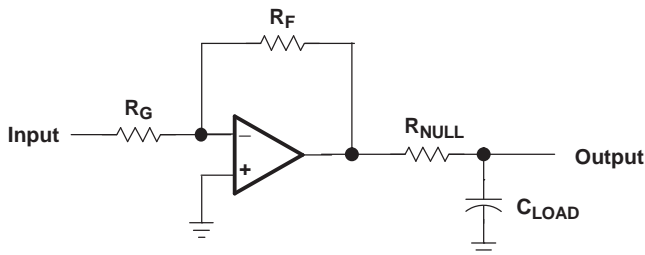


Figure 42. Driving a Capacitive Load

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:

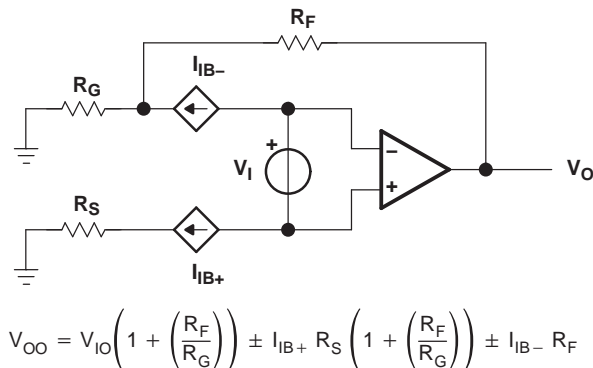


Figure 43. Output Offset Voltage Model

APPLICATION INFORMATION (continued)

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 44).

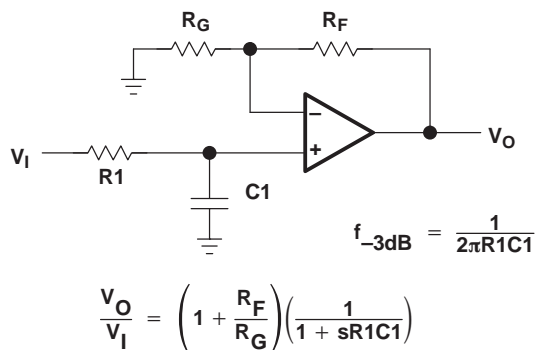


Figure 44. Single-Pole Low-Pass Filter

If even more attenuation is needed, a multiple pole filter is required. The Sallen-Key filter can be used for this task. For 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.

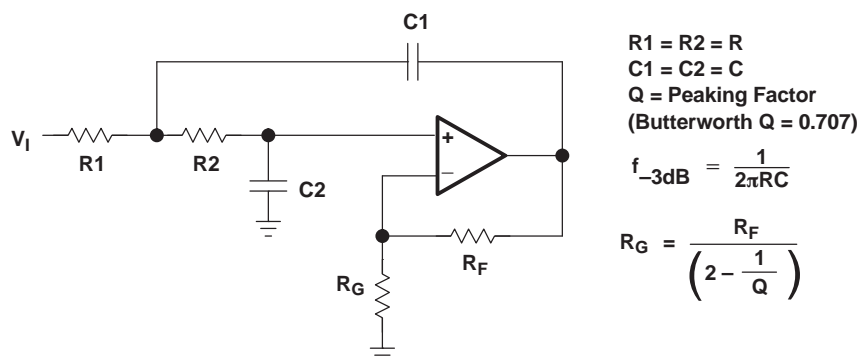


Figure 45. 2-Pole Low-Pass Sallen-Key Filter

SHUTDOWN FUNCTION

Three members of the TLV247x family (TLV2470/3/5) have a shutdown terminal for conserving battery life in portable applications. When the shutdown terminal is tied low, the supply current is reduced to 350nA/channel, the amplifier is disabled, and the outputs are placed in a high impedance mode. To enable the amplifier, the shutdown terminal can either be left floating or pulled high. When the shutdown terminal is left floating, care should be taken to ensure that parasitic leakage current at the shutdown terminal does not inadvertently place the operational amplifier into shutdown. The shutdown terminal threshold is always referenced to $V_{DD}/2$. Therefore, when operating the device with split supply voltages (e.g., $\pm 2.5V$), the shutdown terminal needs to be pulled to V_{DD-} (not GND) to disable the operational amplifier.

The amplifier's output with a shutdown pulse is shown in Figure 33 and Figure 34. The amplifier is powered with a single 5V supply and configured as a noninverting configuration with a gain of 5. The amplifier turn-on and turn-off times are measured from the 50% point of the shutdown pulse to the 50% point of the output waveform. The times for the single, dual, and quad versions are listed in the data tables.

APPLICATION INFORMATION (continued)

Figure 35 and Figure 36 show the amplifier's forward and reverse isolation in shutdown. The operational amplifier is powered by $\pm 1.35\text{V}$ supplies and configured as a voltage follower ($A_V = 1$). The isolation performance is plotted across frequency using 0.1V_{PP} , 1.5V_{PP} , and 2.5V_{PP} input signals. During normal operation, the amplifier would not be able to handle a 2.5V_{PP} input signal with a supply voltage of $\pm 1.35\text{V}$ since it exceeds the common-mode input voltage range (V_{ICR}). However, this curve illustrates that the amplifier remains in shutdown even under a worst case scenario.

CIRCUIT LAYOUT CONSIDERATIONS

To achieve the levels of high performance of the TLV247x, follow proper printed-circuit board (PCB) 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 $6.8\mu\text{F}$ tantalum capacitor in parallel with a $0.1\mu\text{F}$ ceramic capacitor on each supply terminal. It may be possible to share the tantalum among several amplifiers depending on the application, but a $0.1\mu\text{F}$ ceramic capacitor should always be used on the supply terminal of every amplifier. In addition, the $0.1\mu\text{F}$ 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 will help 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.

GENERAL PowerPAD™ DESIGN CONSIDERATIONS

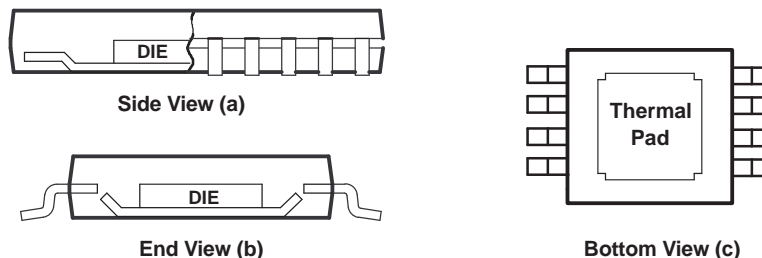
The TLV247x is available in a thermally-enhanced PowerPAD family of packages. These packages are constructed using a downset leadframe upon which the die is mounted (see Figure 46a and Figure 46b). This arrangement results in the lead frame being exposed as a thermal pad on the underside of the package (see Figure 46c). Because this thermal pad has direct thermal contact with the die, excellent thermal performance can be achieved by providing a good thermal path away from the thermal pad.

The PowerPAD package allows for both assembly and thermal management in one manufacturing operation. During the surface-mount solder operation (when the leads are being soldered), the thermal pad must be soldered to a copper area underneath the package. Through the use of thermal paths within this copper area, heat can be conducted away from the package into either a ground plane or other heat dissipating device.

Soldering the PowerPAD to the PCB is always recommended, even with applications that have low power dissipation. It provides the necessary mechanical and thermal connection between the lead frame die pad and the PCB.

The PowerPAD package represents a breakthrough in combining the small area and ease of assembly of surface mount with the, heretofore, awkward mechanical methods of heatsinking.

APPLICATION INFORMATION (continued)



The thermal pad is electrically isolated from all terminals in the package.

Figure 46. Views of Thermally Enhanced DGN Package

Although there are many ways to properly heatsink the PowerPAD package, the following steps illustrate the recommended approach.

1. The thermal pad must be connected to the most negative supply voltage on the device (GND pin).
2. Prepare the PCB with a top side etch pattern as illustrated in the thermal land pattern mechanical drawing at the end of this document. There should be etch for the leads as well as etch for the thermal pad.
3. Place holes in the area of the thermal pad as illustrated in the land pattern mechanical drawing at the end of this document. These holes should be 13mils in diameter. Keep them small so that solder wicking through the holes is not a problem during reflow.
4. Additional vias may be placed anywhere along the thermal plane outside of the thermal pad area. This helps dissipate the heat generated by the TLV247x IC. These additional vias may be larger than the 13mil diameter vias directly under the thermal pad. They can be larger because they are not in the thermal pad area to be soldered so that wicking is not a problem.
5. Connect all holes to the internal ground plane that is at the same voltage potential as the device GND pin.
6. When connecting these holes to the ground plane, **do not** use the typical web or spoke via connection methodology. Web connections have a high thermal resistance connection that is useful for slowing the heat transfer during soldering operations. This makes the soldering of vias that have plane connections easier. In this application, however, low thermal resistance is desired for the most efficient heat transfer. Therefore, the holes under the TLV247x PowerPAD package should make their connection to the internal ground plane with a complete connection around the entire circumference of the plated-through hole.
7. The top-side solder mask should leave the terminals of the package and the thermal pad area with its holes exposed. The bottom-side solder mask should cover the holes of the thermal pad area. This prevents solder from being pulled away from the thermal pad area during the reflow process.
8. Apply solder paste to the exposed thermal pad area and all of the IC terminals.
9. With these preparatory steps in place, the TLV247x IC is simply placed in position and run through the solder reflow operation as any standard surface-mount component. This results in a part that is properly installed.

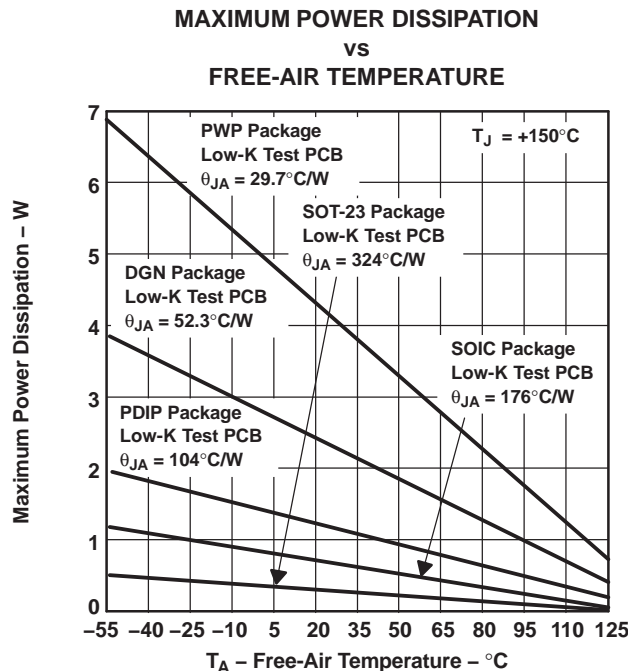
For a given θ_{JA} , the maximum power dissipation is shown in [Figure 47](#) and is calculated by [Equation 1](#):

$$P_D = \left(\frac{T_{MAX} - T_A}{\theta_{JA}} \right) \quad (1)$$

Where:

- P_D = Maximum power dissipation of TLV247x IC (watts)
- T_{MAX} = Absolute maximum junction temperature (+150°C)
- T_A = Free-ambient air temperature (°C)
- $\theta_{JA} = \theta_{JC} + \theta_{CA}$
 - θ_{JC} = Thermal coefficient from junction to case
 - θ_{CA} = Thermal coefficient from case to ambient air (°C/W)

APPLICATION INFORMATION (continued)

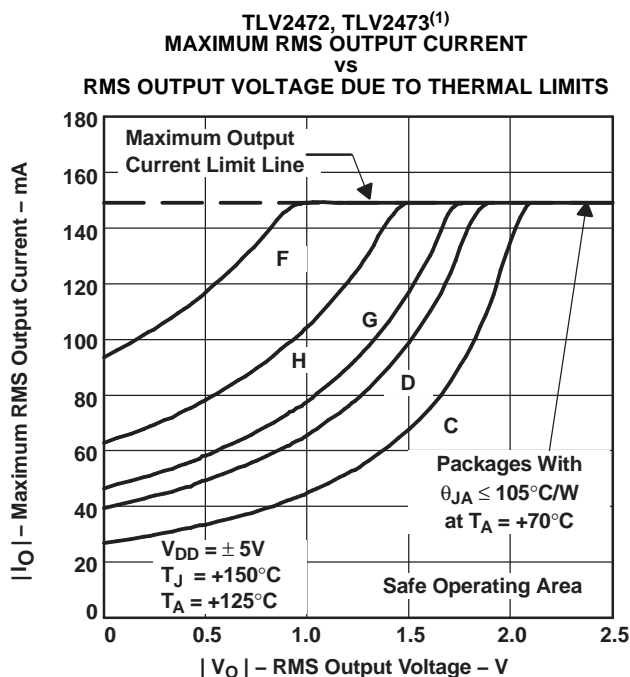
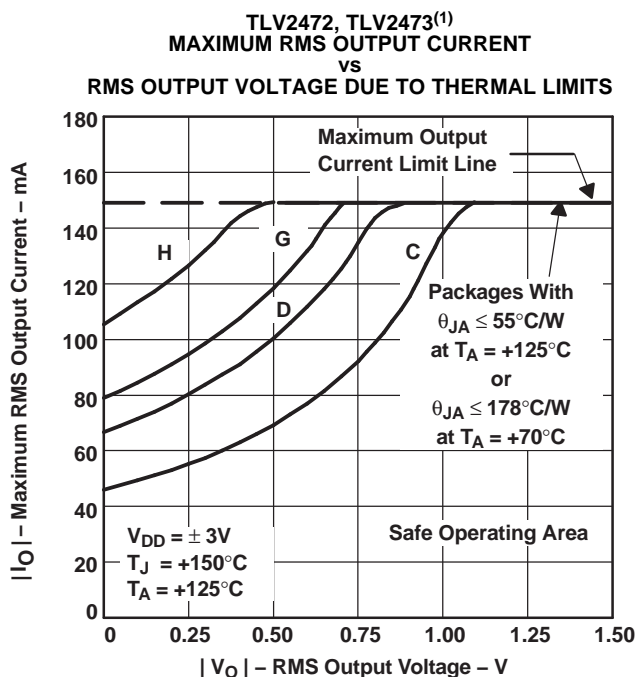
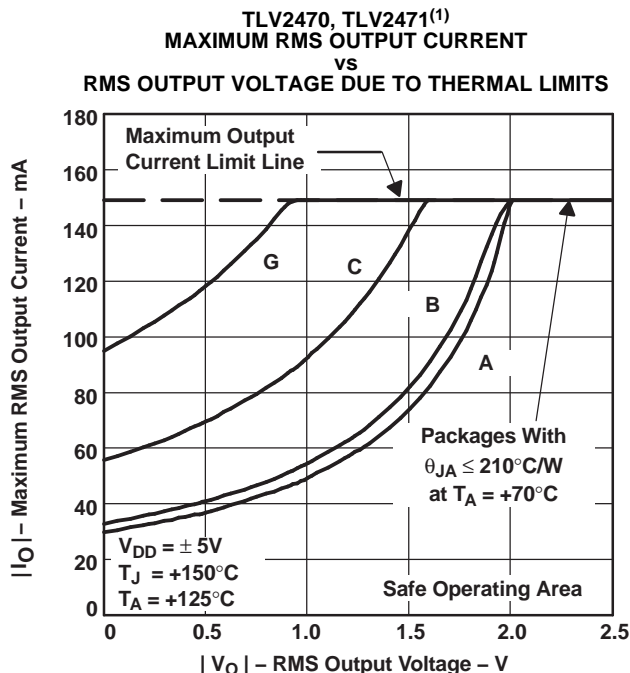
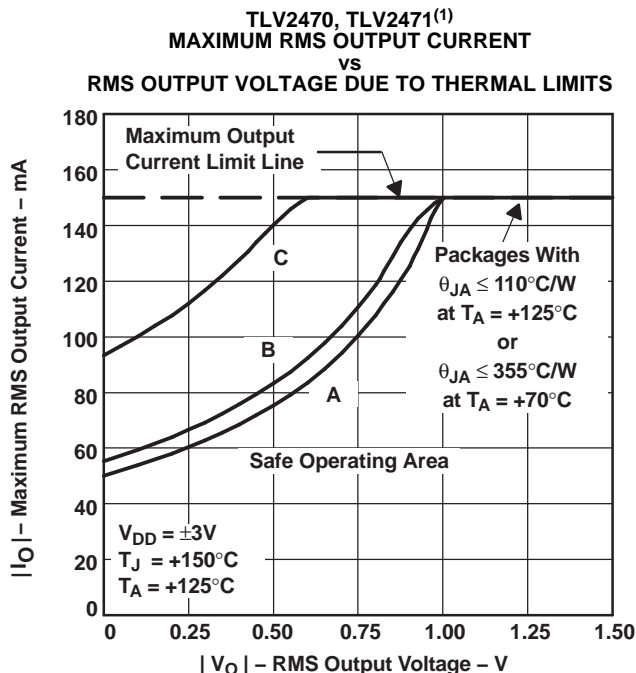


Results are with no air flow and using JEDEC Standard Low-K test PCB.

Figure 47. Maximum Power Dissipation vs Free-Air Temperature

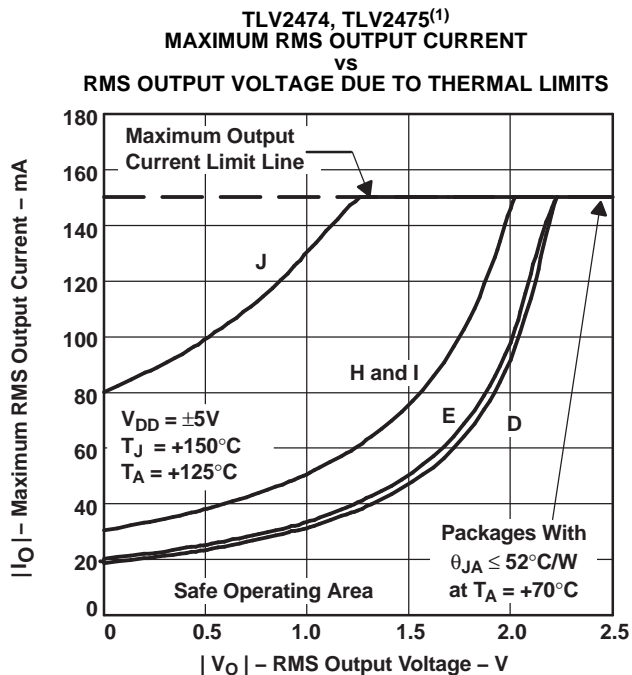
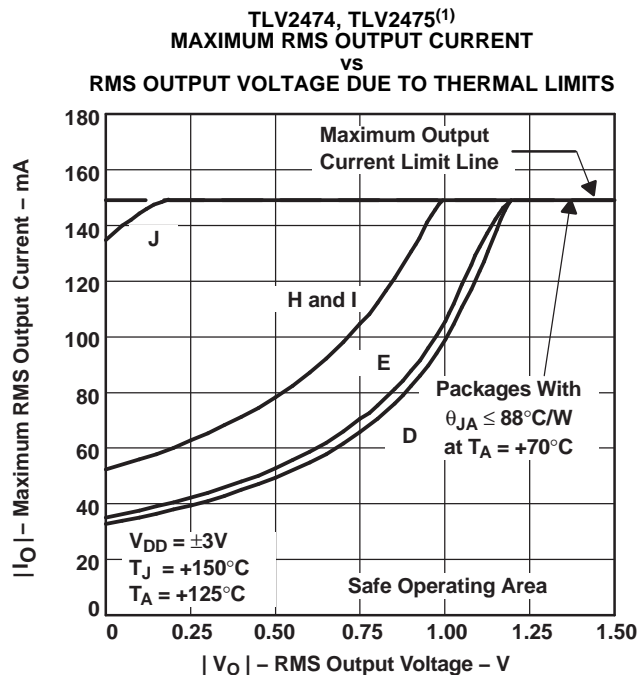
The next consideration is the package constraints. The two sources of heat within an amplifier are quiescent power and output power. The designer should never forget about the quiescent heat generated within the device, especially multi-amplifier devices. Because these devices have linear output stages (Class A-B), most of the heat dissipation is at low output voltages with high output currents. [Figure 48](#) to [Figure 53](#) show this effect, along with the quiescent heat, with an ambient air temperature of +70°C and +125°C. When using $V_{DD} = 3\text{V}$, there is generally not a heat problem with an ambient air temperature of +70°C. But, when using $V_{DD} = 5\text{V}$, the packages are severely limited in the amount of heat it can dissipate. The other key factor when looking at these graphs is how the devices are mounted on the PCB. The PowerPAD devices are extremely useful for heat dissipation. But, the device should always be soldered to a copper plane to fully use the heat dissipation properties of the PowerPAD. The SOIC package, on the other hand, is highly dependent on how it is mounted on the PCB. As more trace and copper area is placed around the device, θ_{JA} decreases and the heat dissipation capability increases. The currents and voltages shown in these graphs are for the total package. For the dual or quad amplifier packages, the sum of the RMS output currents and voltages should be used to choose the proper package.

APPLICATION INFORMATION (continued)



Note: (1) A - SOT23 (5); B - SOT23 (6); C - SOIC (8); D - SOIC (14); E - SOIC (16); F - MSOP PP (8); G - PDIP (8); H - PDIP (14); I - PDIP (16); J - TSSOP PP (14/16)

APPLICATION INFORMATION (continued)



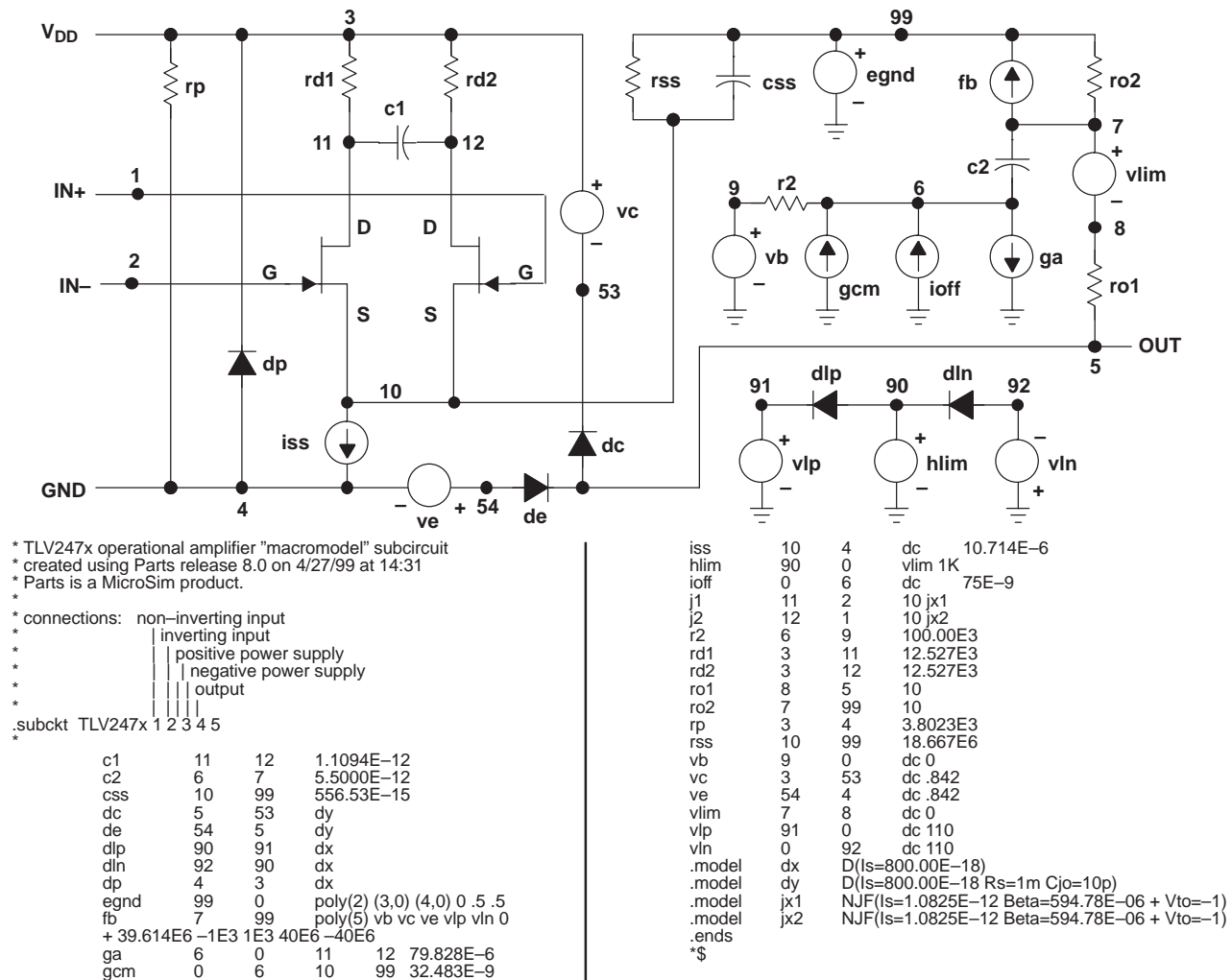
NOTE: (1) A - SOT23 (5); B - SOT23 (6); C - SOIC (8); D - SOIC (14); E - SOIC (16); F - MSOP PP (8); G - PDIP (8); H - PDIP (14); I - PDIP (16); J - TSSOP PP (14/16)

APPLICATION INFORMATION (continued)

MACROMODEL INFORMATION

Macromodel information provided was derived using Microsim PARTS™, the model generation software used with Microsim PSpice®. The [Boyle macromodel](#) and subcircuit in [Figure 54](#) are generated using the TLV247x typical electrical and operating characteristics at $T_A = 25^\circ\text{C}$. 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



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).

Figure 54. Boyle Macromodel and Subcircuit

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TLV2470AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470AIP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2470AIPe4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2470CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470CDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470CDBVRG4	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470CDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470CDBVTG4	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2470CPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2470ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470IDBVR	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470IDBVRG4	ACTIVE	SOT-23	DBV	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470IDBVT	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470IDBVTG4	ACTIVE	SOT-23	DBV	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2470IIP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TLV2470IPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2471AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471AIP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2471AIPe4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2471CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471CDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471CDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471CDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471CDBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2471CPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2471ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471IDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471IDBVRG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471IDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471IDBVTG4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2471IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TLV2471IPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2472AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472AIDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472AIDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472AIP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2472AIPe4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2472CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472CDGN	ACTIVE	MSOP-Power PAD	DGN	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472CDGNG4	ACTIVE	MSOP-Power PAD	DGN	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472CDGNR	ACTIVE	MSOP-Power PAD	DGN	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472CDGNRG4	ACTIVE	MSOP-Power PAD	DGN	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2472CPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2472ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472IDGN	ACTIVE	MSOP-Power PAD	DGN	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472IDGNG4	ACTIVE	MSOP-Power PAD	DGN	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472IDGNR	ACTIVE	MSOP-Power PAD	DGN	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472IDGNRG4	ACTIVE	MSOP-Power	DGN	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
PAD								
TLV2472IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2472IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2472IPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2473AID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473AIDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473AIDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473AIN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2473AINE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2473CD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473CDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473CDGQ	ACTIVE	MSOP-Power PAD	DGQ	10	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473CDGQG4	ACTIVE	MSOP-Power PAD	DGQ	10	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473CDGQR	ACTIVE	MSOP-Power PAD	DGQ	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473CDGQRG4	ACTIVE	MSOP-Power PAD	DGQ	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473CDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473CDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473ID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473IDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473IDGQ	ACTIVE	MSOP-Power PAD	DGQ	10	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473IDGQG4	ACTIVE	MSOP-Power PAD	DGQ	10	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473IDGQR	ACTIVE	MSOP-Power PAD	DGQ	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TLV2473IDGQRG4	ACTIVE	MSOP-Power PAD	DGQ	10	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2473IN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2473INE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2474AID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474AIDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474AIDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474AIDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474AIN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2474AINE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2474AIPWP	ACTIVE	HTSSOP	PWP	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474AIPWPG4	ACTIVE	HTSSOP	PWP	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474AIPWPR	ACTIVE	HTSSOP	PWP	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474AIPWPRG4	ACTIVE	HTSSOP	PWP	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474AIPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474AIPWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474CD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474CDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474CDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474CDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474CN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2474CNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2474CPWP	ACTIVE	HTSSOP	PWP	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474CPWPG4	ACTIVE	HTSSOP	PWP	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474CPWPR	ACTIVE	HTSSOP	PWP	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474CPWPRG4	ACTIVE	HTSSOP	PWP	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474ID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
no Sb/Br)								
TLV2474IDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474IDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474IDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2474IN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2474INE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2474IPWP	ACTIVE	HTSSOP	PWP	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474IPWPG4	ACTIVE	HTSSOP	PWP	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474IPWPR	ACTIVE	HTSSOP	PWP	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2474IPWPRG4	ACTIVE	HTSSOP	PWP	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2475AIDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2475AIDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2475AIN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2475AINE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2475AIPWP	ACTIVE	HTSSOP	PWP	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2475AIPWPG4	ACTIVE	HTSSOP	PWP	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2475AIPWPR	ACTIVE	HTSSOP	PWP	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2475AIPWPRG4	ACTIVE	HTSSOP	PWP	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2475CD	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2475CDG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2475CDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2475CDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2475CN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2475CNE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2475CPWPR	ACTIVE	HTSSOP	PWP	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2475CPWPRG4	ACTIVE	HTSSOP	PWP	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
TLV2475IDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2475IDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2475IN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2475INE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLV2475IPWPR	ACTIVE	HTSSOP	PWP	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
TLV2475IPWPRG4	ACTIVE	HTSSOP	PWP	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

⁽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.

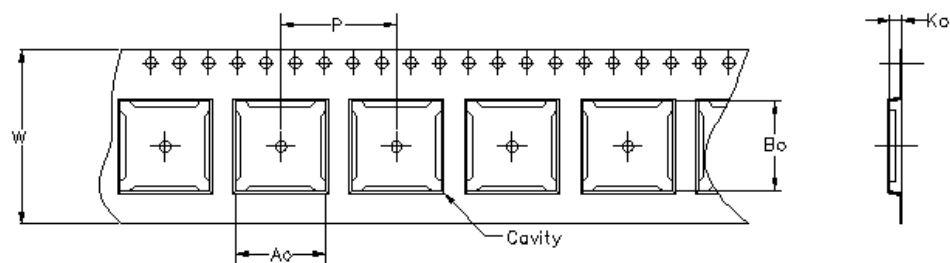
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

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.

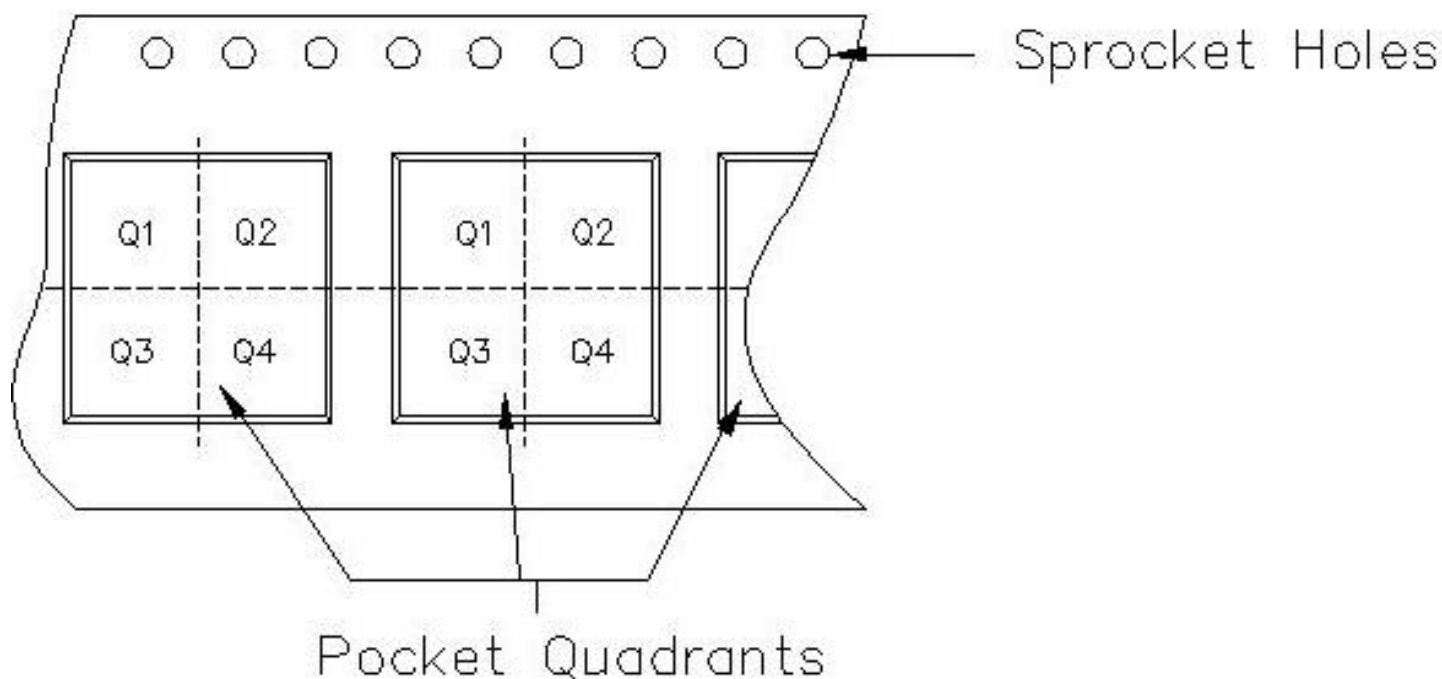
Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. 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.



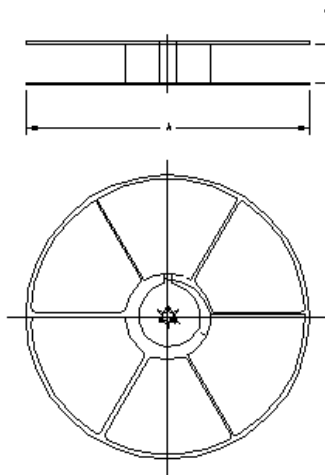
Carrier tape design is defined largely by the component length, width, and thickness.

A_0 = Dimension designed to accommodate the component width.
B_0 = Dimension designed to accommodate the component length.
K_0 = Dimension designed to accommodate the component thickness.
W = Overall width of the carrier tape.
P = Pitch between successive cavity centers.



TAPE AND REEL INFORMATION

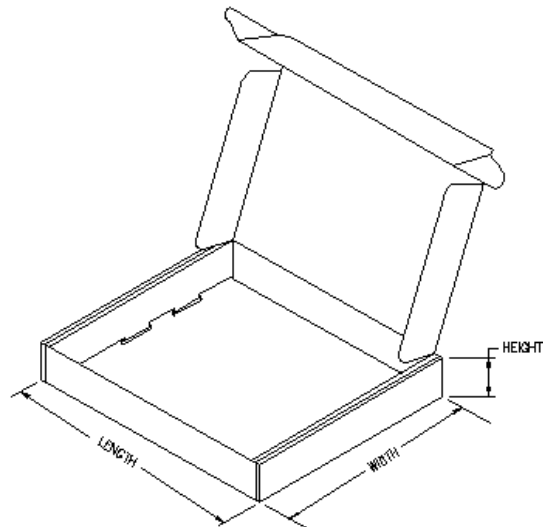
Device	Package	Pins	Site	Reel Diameter (mm)	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLV2470AIDR	D	8	TAI	330	12	6.4	5.2	2.1	8	12	Q1
TLV2470CDBVR	DBV	6	LEN	180	9	3.15	3.2	1.4	4	8	NONE
TLV2470CDBVT	DBV	6	LEN	180	9	3.15	3.2	1.4	4	8	NONE
TLV2470CDR	D	8	TAI	330	12	6.4	5.2	2.1	8	12	Q1
TLV2470IDBVR	DBV	6	LEN	180	9	3.15	3.2	1.4	4	8	NONE
TLV2470IDBVT	DBV	6	LEN	180	9	3.15	3.2	1.4	4	8	NONE
TLV2470IDR	D	8	TAI	330	12	6.4	5.2	2.1	8	12	Q1
TLV2471AIDR	D	8	TAI	330	12	6.4	5.2	2.1	8	12	Q1
TLV2471CDBVR	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	NONE
TLV2471CDBVT	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	NONE
TLV2471CDR	D	8	TAI	330	12	6.4	5.2	2.1	8	12	Q1
TLV2471IDBVR	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	NONE
TLV2471IDBVT	DBV	5	LEN	180	9	3.15	3.2	1.4	4	8	NONE
TLV2471IDR	D	8	TAI	330	12	6.4	5.2	2.1	8	12	Q1
TLV2472AIDR	D	8	TAI	330	12	6.4	5.2	2.1	8	12	Q1
TLV2472CDGNR	DGN	8	HNT	330	8	5.3	3.4	1.4	8	12	NONE
TLV2472CDR	D	8	TAI	330	12	6.4	5.2	2.1	8	12	Q1
TLV2472IDGNR	DGN	8	HNT	330	8	5.3	3.4	1.4	8	12	NONE
TLV2472IDR	D	8	TAI	330	12	6.4	5.2	2.1	8	12	Q1
TLV2473CDGQR	DGQ	10	HNT	330	8	5.3	3.4	1.4	8	12	NONE
TLV2473IDGQR	DGQ	10	HNT	330	8	5.3	3.4	1.4	8	12	NONE
TLV2474AIPWPR	PWP	14	TAI	330	12	6.67	5.4	1.6	8	12	Q1
TLV2474AIPWR	PW	14	MLA	330	12	7.0	5.6	1.6	8	12	Q1
TLV2474CPWPR	PWP	14	TAI	330	12	6.67	5.4	1.6	8	12	Q1
TLV2474IPWPR	PWP	14	TAI	330	12	6.67	5.4	1.6	8	12	Q1
TLV2475AIPWPR	PWP	16	TAI	330	12	6.67	5.4	1.6	8	12	Q1
TLV2475CPWPR	PWP	16	TAI	330	12	6.67	5.4	1.6	8	12	Q1
TLV2475IPWPR	PWP	16	TAI	330	12	6.67	5.4	1.6	8	12	Q1



TAPE AND REEL BOX INFORMATION

Device	Package	Pins	Site	Length (mm)	Width (mm)	Height (mm)
TLV2470AIDR	D	8	TAI	346.0	346.0	61.0
TLV2470CDBVR	DBV	6	LEN	182.4	182.4	17.3
TLV2470CDBVT	DBV	6	LEN	182.4	182.4	17.3
TLV2470CDR	D	8	TAI	346.0	346.0	61.0
TLV2470IDBVR	DBV	6	LEN	182.4	182.4	17.3
TLV2470IDBVT	DBV	6	LEN	182.4	182.4	17.3
TLV2470IDR	D	8	TAI	346.0	346.0	61.0
TLV2471AIDR	D	8	TAI	346.0	346.0	61.0
TLV2471CDBVR	DBV	5	LEN	182.4	182.4	17.3
TLV2471CDBVT	DBV	5	LEN	182.4	182.4	17.3
TLV2471CDR	D	8	TAI	346.0	346.0	61.0
TLV2471IDBVR	DBV	5	LEN	182.4	182.4	17.3
TLV2471IDBVT	DBV	5	LEN	182.4	182.4	17.3
TLV2471IDR	D	8	TAI	346.0	346.0	61.0
TLV2472AIDR	D	8	TAI	346.0	346.0	61.0
TLV2472CDGNR	DGN	8	HNT	358.0	335.0	35.0
TLV2472CDR	D	8	TAI	346.0	346.0	61.0
TLV2472IDGNR	DGN	8	HNT	358.0	335.0	35.0
TLV2472IDR	D	8	TAI	346.0	346.0	61.0
TLV2473CDGQR	DGQ	10	HNT	358.0	335.0	35.0
TLV2473IDGQR	DGQ	10	HNT	358.0	335.0	35.0
TLV2474AIPWPR	PWP	14	TAI	346.0	346.0	61.0
TLV2474AIPWR	PW	14	MLA	342.9	336.6	20.6
TLV2474CPWPR	PWP	14	TAI	346.0	346.0	61.0
TLV2474IPWPR	PWP	14	TAI	346.0	346.0	61.0

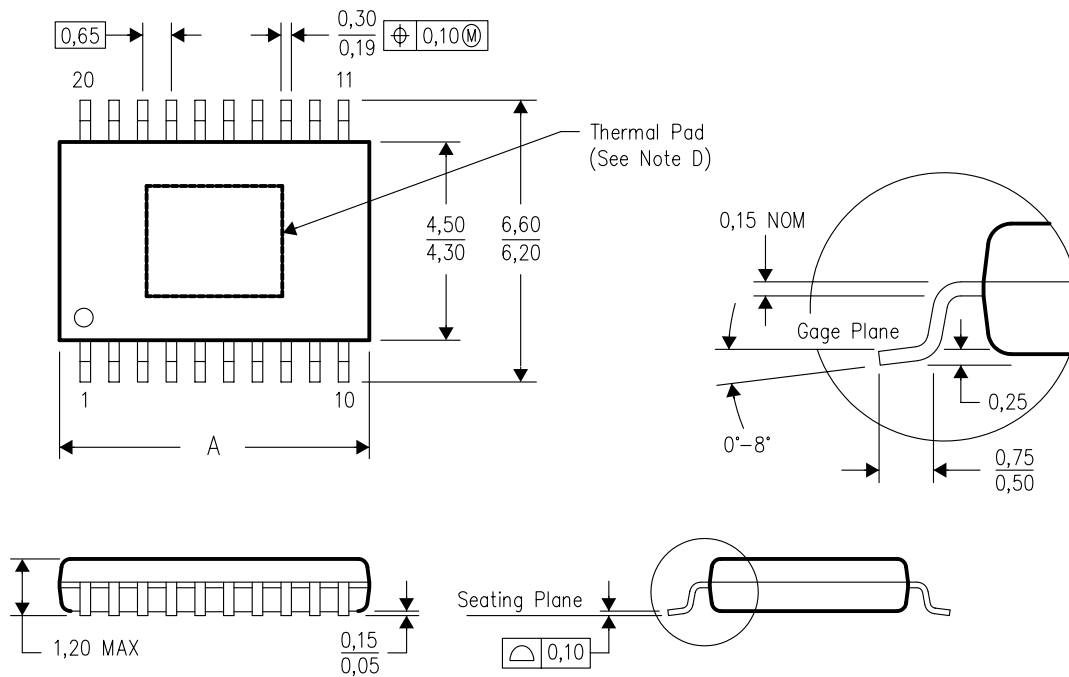
Device	Package	Pins	Site	Length (mm)	Width (mm)	Height (mm)
TLV2475AIPWPR	PWP	16	TAI	346.0	346.0	61.0
TLV2475CPWPR	PWP	16	TAI	346.0	346.0	61.0
TLV2475IPWPR	PWP	16	TAI	346.0	346.0	61.0



PWP (R-PDSO-G**)

PowerPAD™ PLASTIC SMALL-OUTLINE PACKAGE

20 PIN SHOWN



PINS ** DIM	14	16	20	24	28
A MAX	5,10	5,10	6,60	7,90	9,80
A MIN	4,90	4,90	6,40	7,70	9,60

4073225/H 12/05

- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusions. Mold flash and protrusion shall not exceed 0.15 per side.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <<http://www.ti.com>>.
 - Falls within JEDEC MO-153

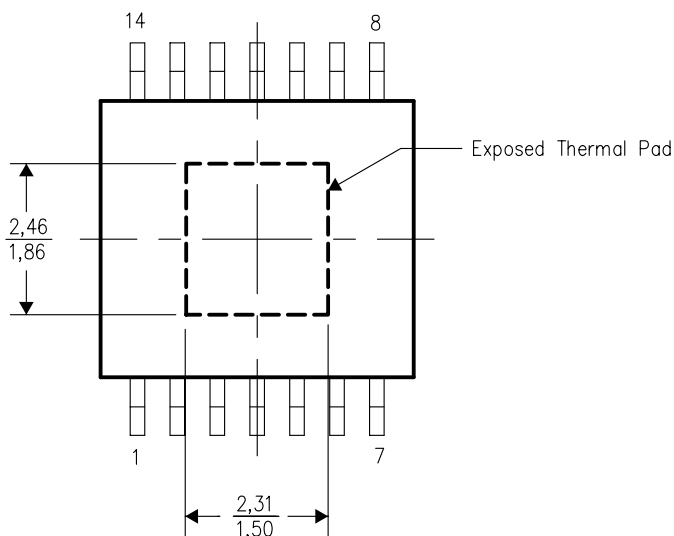
PowerPAD is a trademark of Texas Instruments.

THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. When the thermal pad is soldered directly to the printed circuit board (PCB), the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to a ground plane or special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

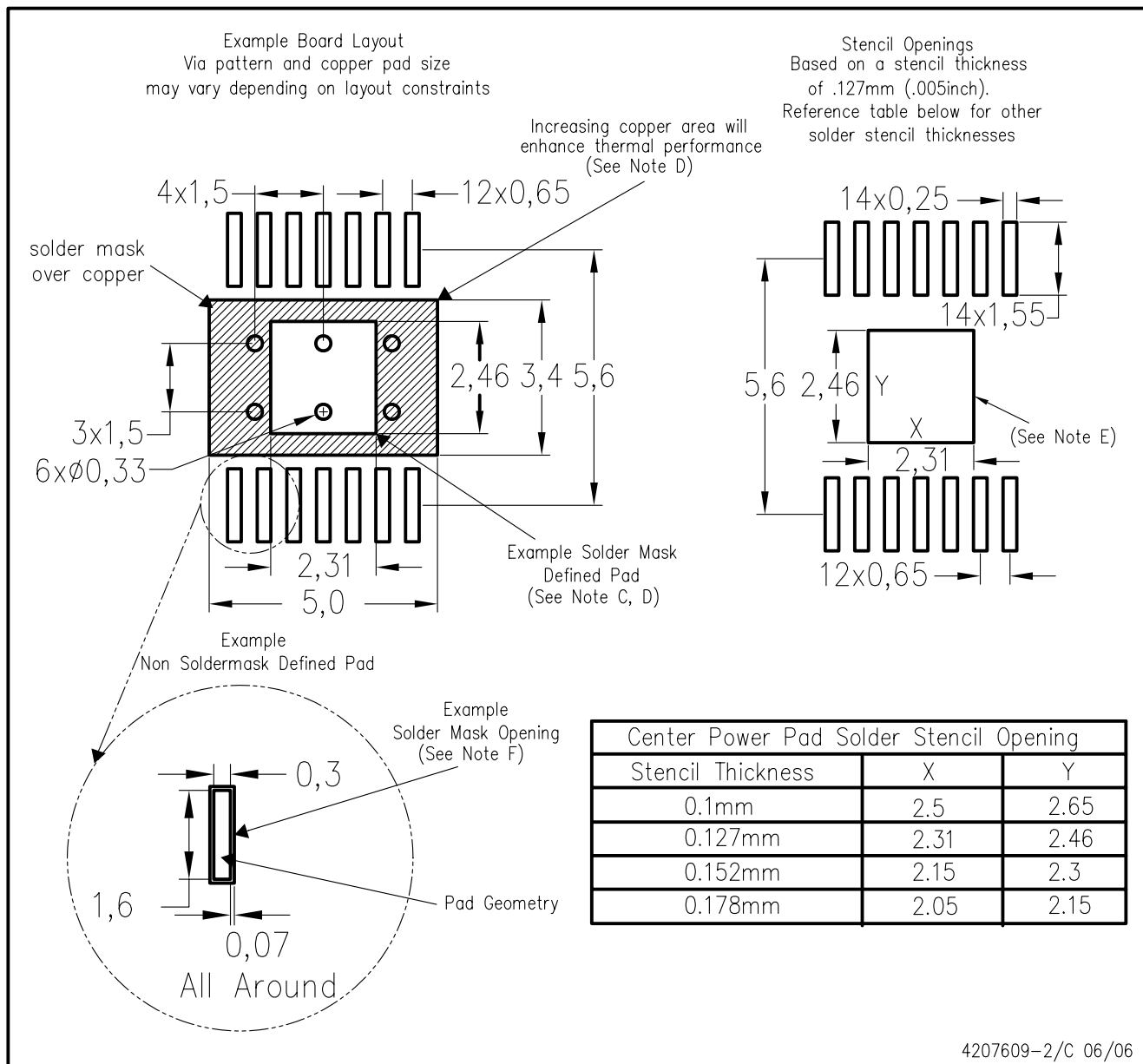


Top View

NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions

PWP (R-PDSO-G14) PowerPAD™



4207609-2/C 06/06

- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002, SLMA004, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>. Publication IPC-7351 is recommended for alternate designs.
 - 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

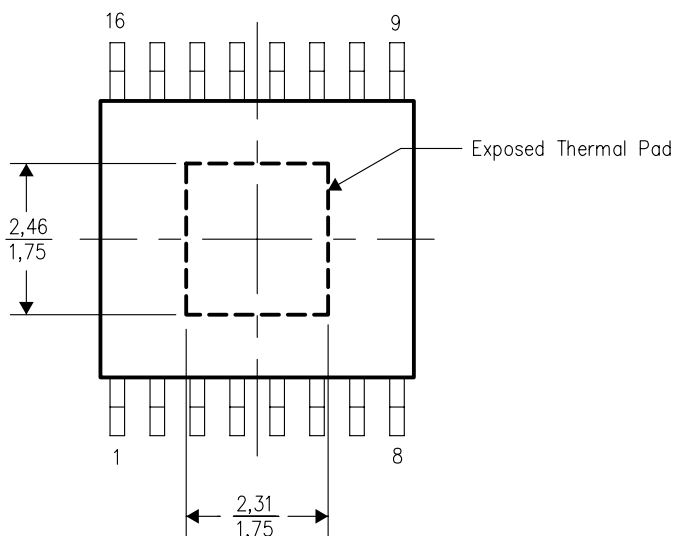
PowerPAD is a trademark of Texas Instruments.

THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. When the thermal pad is soldered directly to the printed circuit board (PCB), the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to a ground plane or special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

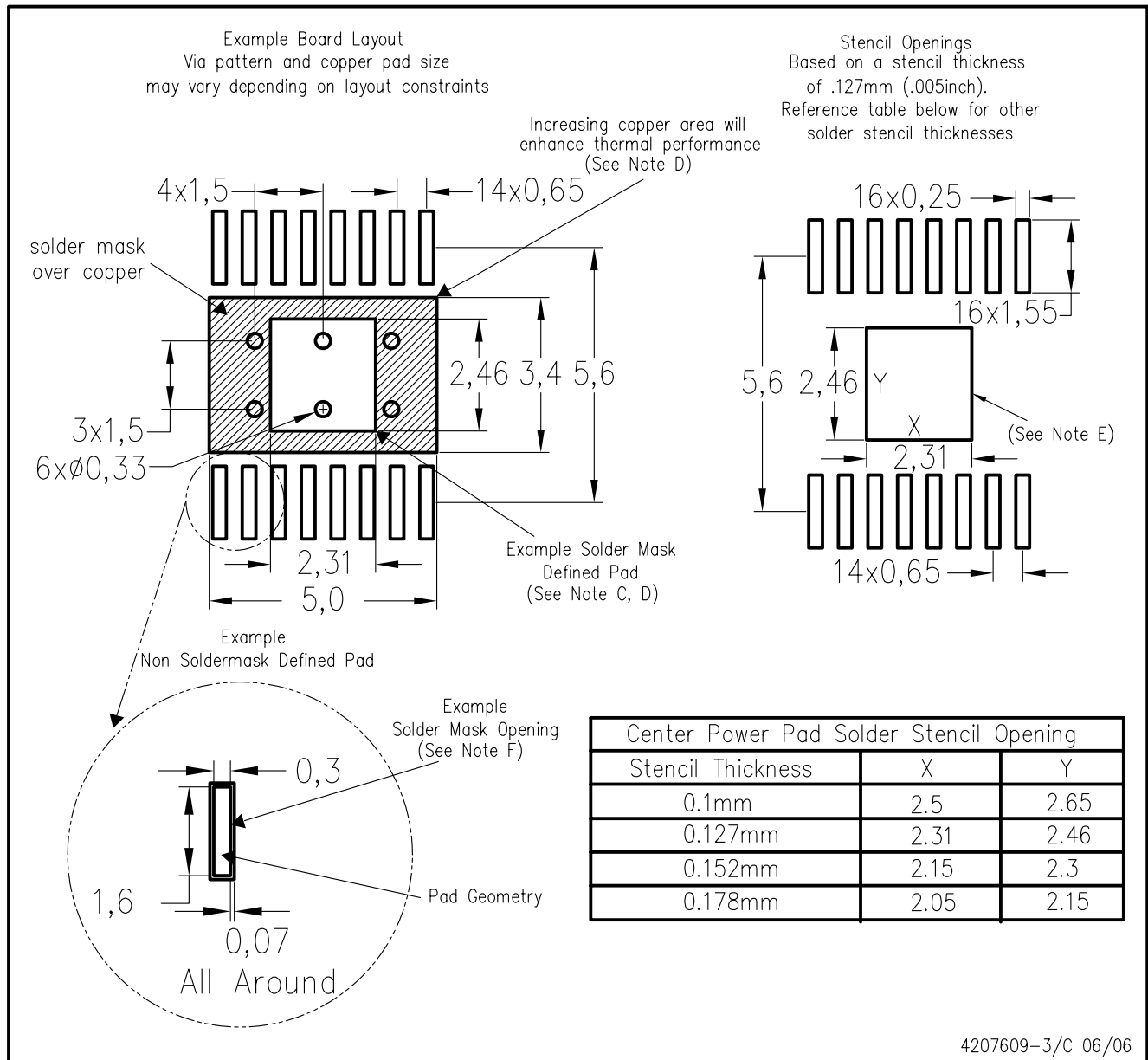


Top View

NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions

PWP (R-PDSO-G16) PowerPAD™



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002, SLMA004, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>. Publication IPC-7351 is recommended for alternate designs.
 - 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PowerPAD is a trademark of Texas Instruments.

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE



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

For the latest package information, go to http://www.ti.com/sc/docs/package/pkg_info.htm

N (R-PDIP-T**)

16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE



PINS **	14	16	18	20
DIM				
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS-001 VARIATION	AA	BB	AC	AD



4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
 - The 20 pin end lead shoulder width is a vendor option, either half or full width.

DBV (R-PDSO-G5)

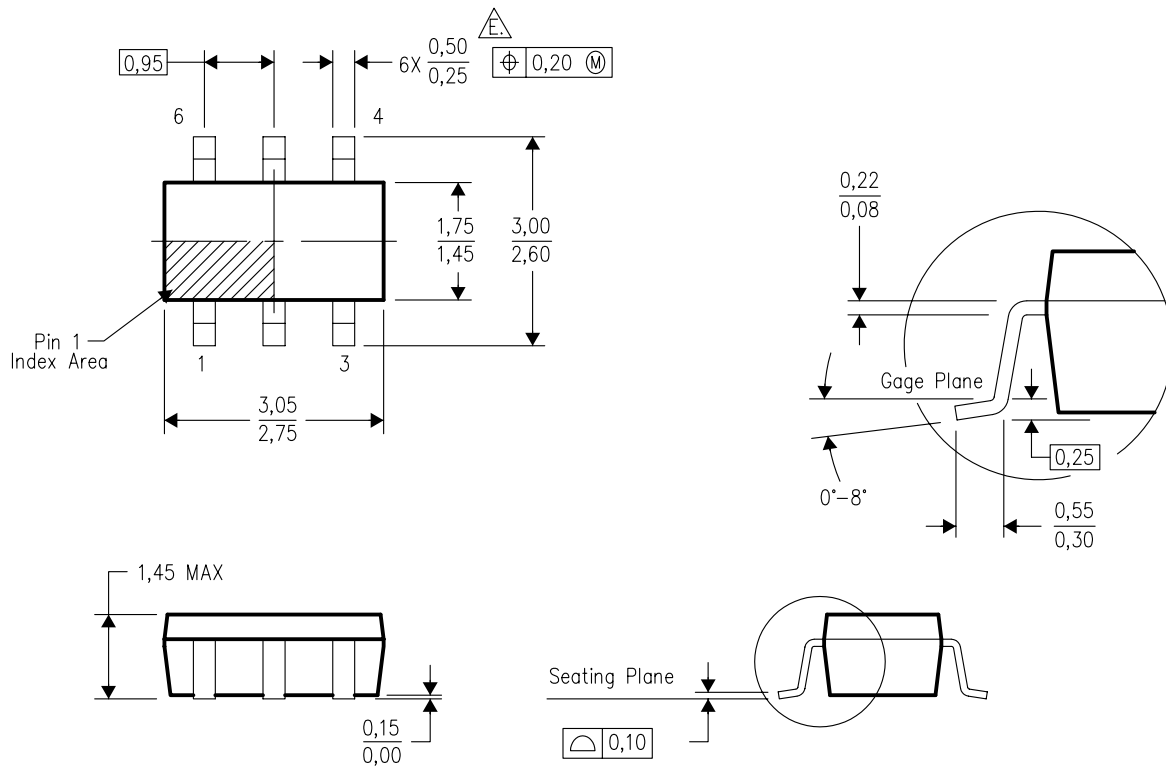
PLASTIC SMALL-OUTLINE PACKAGE



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

DBV (R-PDSO-G6)

PLASTIC SMALL-OUTLINE PACKAGE

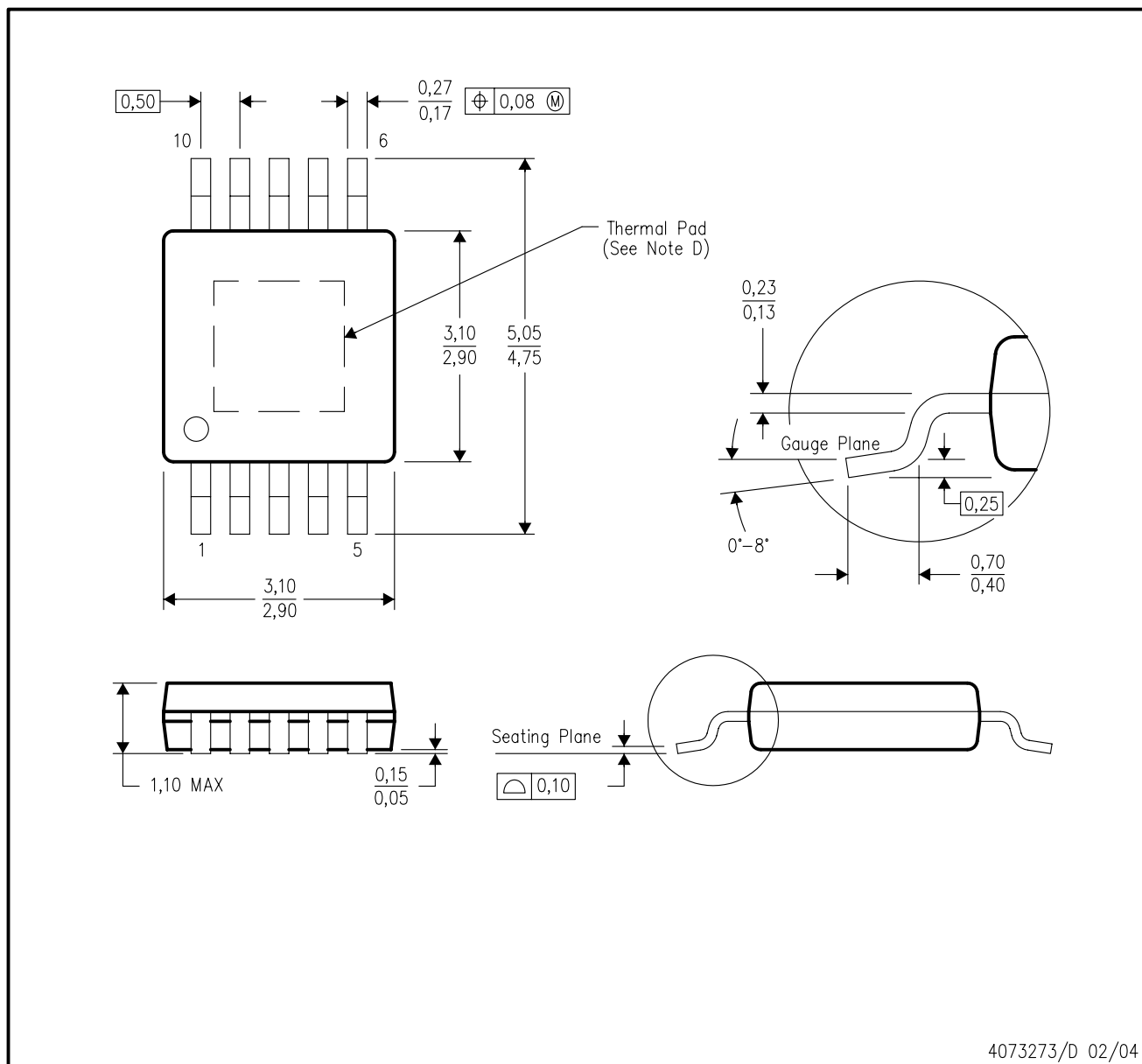


4073253-5/K 03/2006

- 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. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- \triangle Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DGQ (S-PDSO-G10)

PowerPAD™ PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <<http://www.ti.com>>.
 - Falls within JEDEC MO-187 variation BA-T.

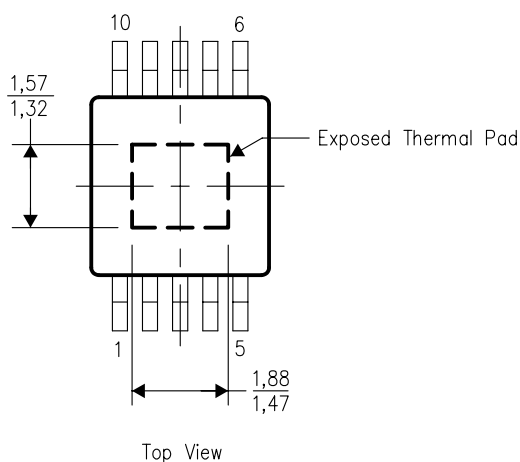
PowerPAD is a trademark of Texas Instruments.

THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. When the thermal pad is soldered directly to the printed circuit board (PCB), the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to a ground or power plane (whichever is applicable), or alternatively, a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

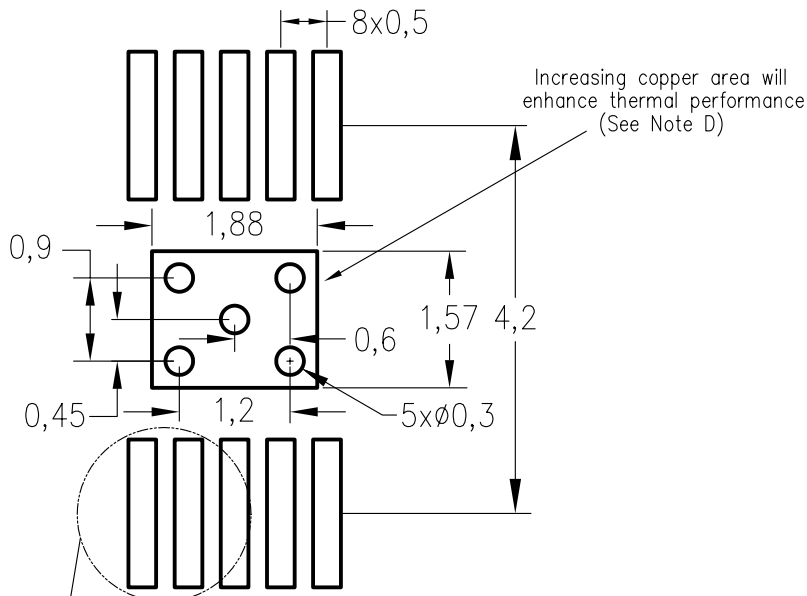


NOTE: All linear dimensions are in millimeters

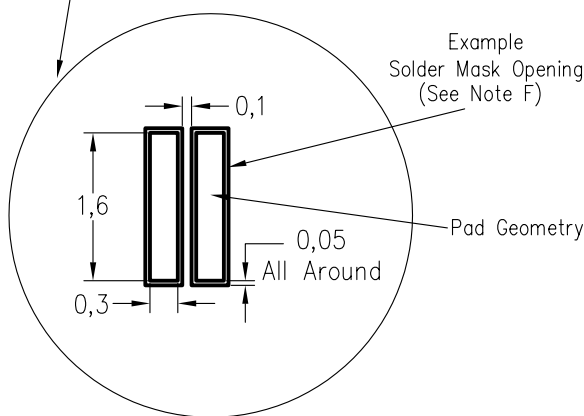
Exposed Thermal Pad Dimensions

DGQ (R-PDSO-G10) PowerPAD™

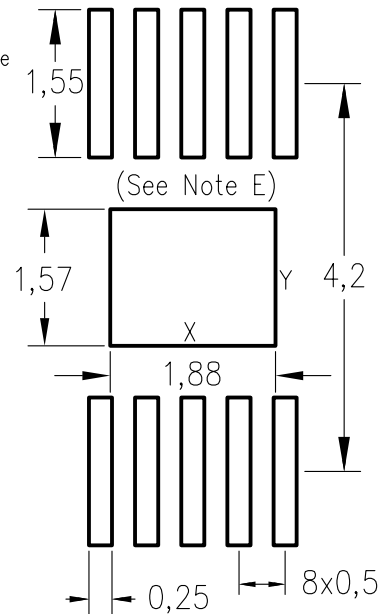
Example Board Layout
Via pattern and copper pad size
may vary depending on layout constraints



Example
Non Soldermask Defined Pad



Stencil Openings
Based on a stencil thickness
of .127mm (.005inch).
Reference table below for other
solder stencil thicknesses



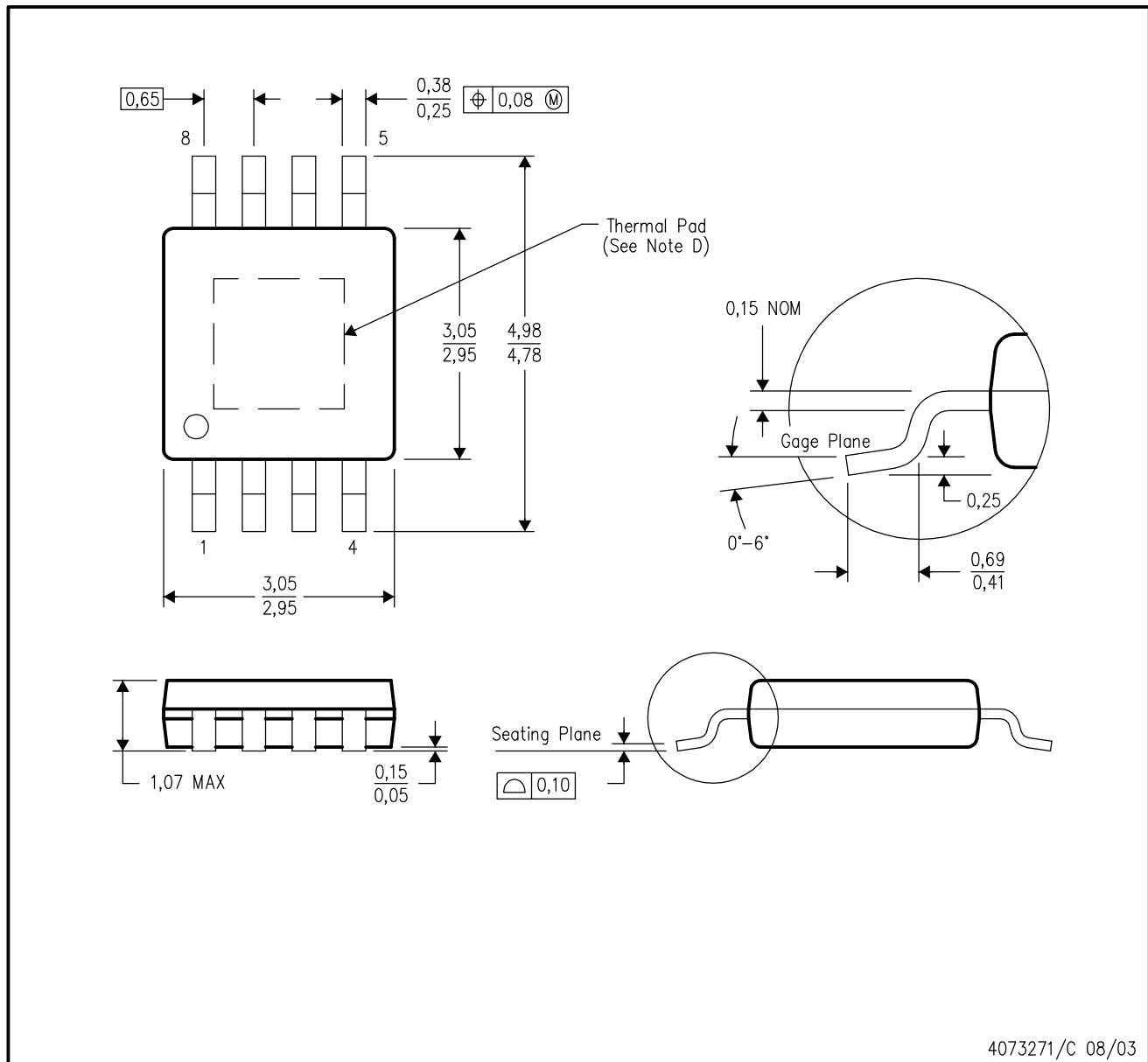
Center Power Pad Solder Stencil Opening		
Stencil Thickness	X	Y
0.1mm	2.0	1.7
0.127mm	1.88	1.57
0.152mm	1.75	1.45
0.178mm	1.65	1.35

4207733/A 02/06

- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002, SLMA004, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>. Publication IPC-7351 is recommended for alternate designs.
 - 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

DGN (S-PDSO-G8)

PowerPAD™ PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <<http://www.ti.com>>.
 - Falls within JEDEC MO-187

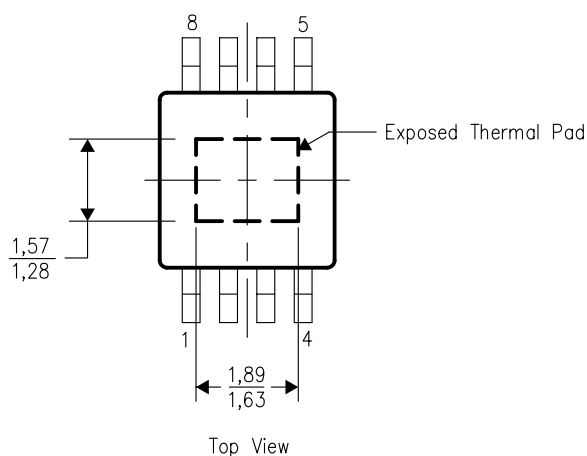
PowerPAD is a trademark of Texas Instruments.

THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. When the thermal pad is soldered directly to the printed circuit board (PCB), the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to a ground or power plane (whichever is applicable), or alternatively, a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at www.ti.com.

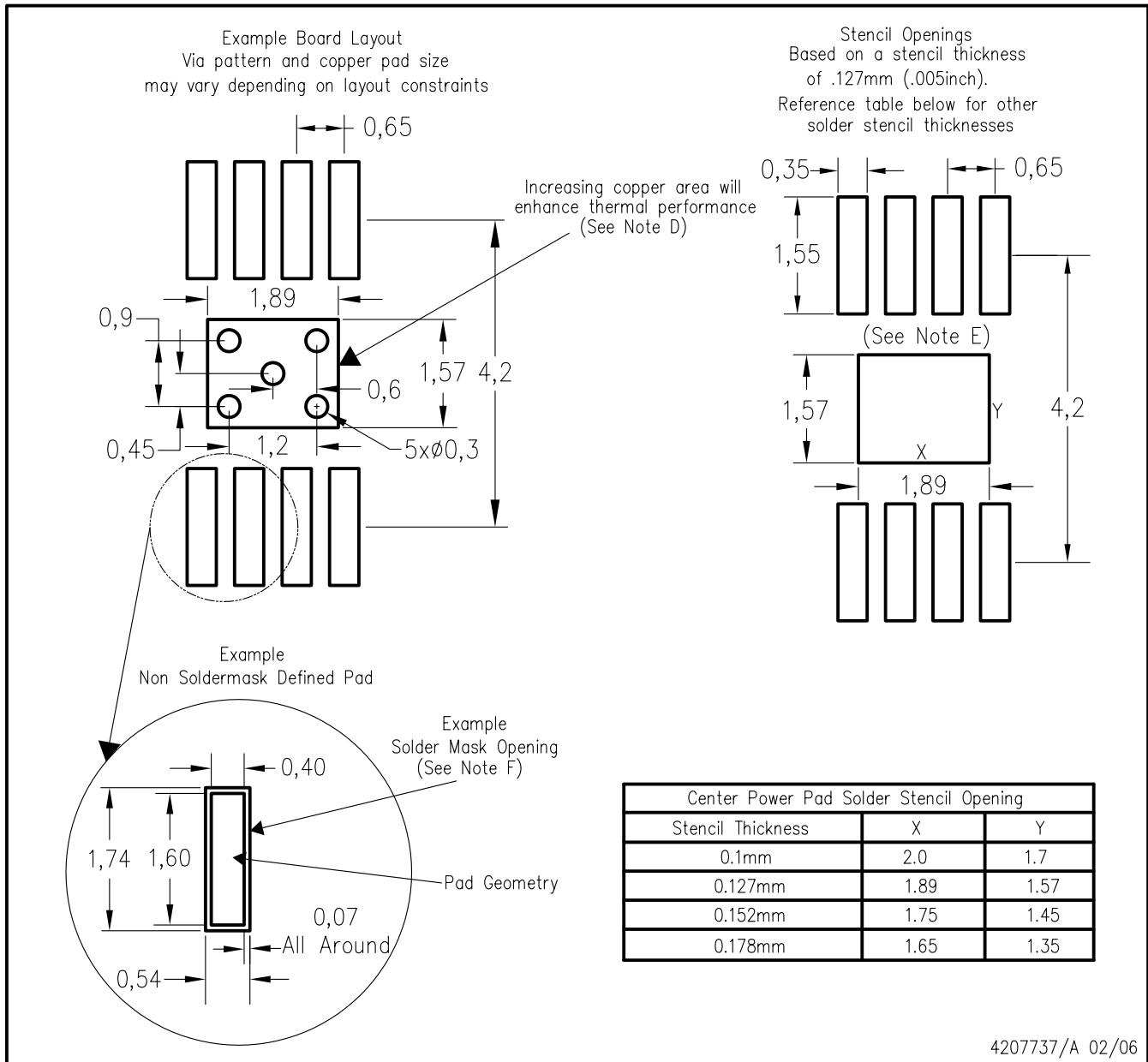
The exposed thermal pad dimensions for this package are shown in the following illustration.



NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions

DGN (R-PDS0-G8) PowerPAD™

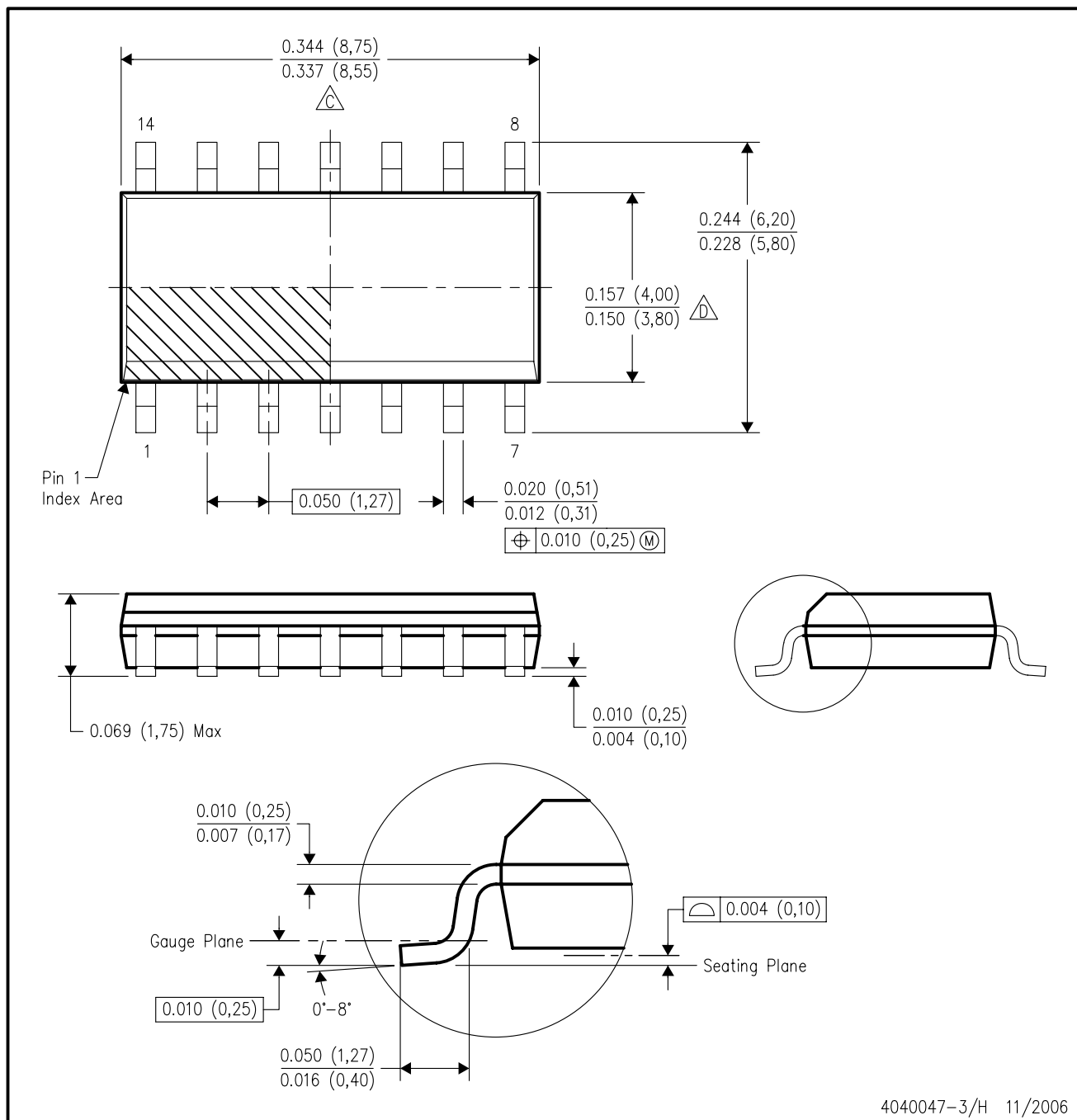


4207737/A 02/06

- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002, SLMA004, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>. Publication IPC-7351 is recommended for alternate designs.
 - 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

D (R-PDSO-G14)

PLASTIC SMALL-OUTLINE PACKAGE



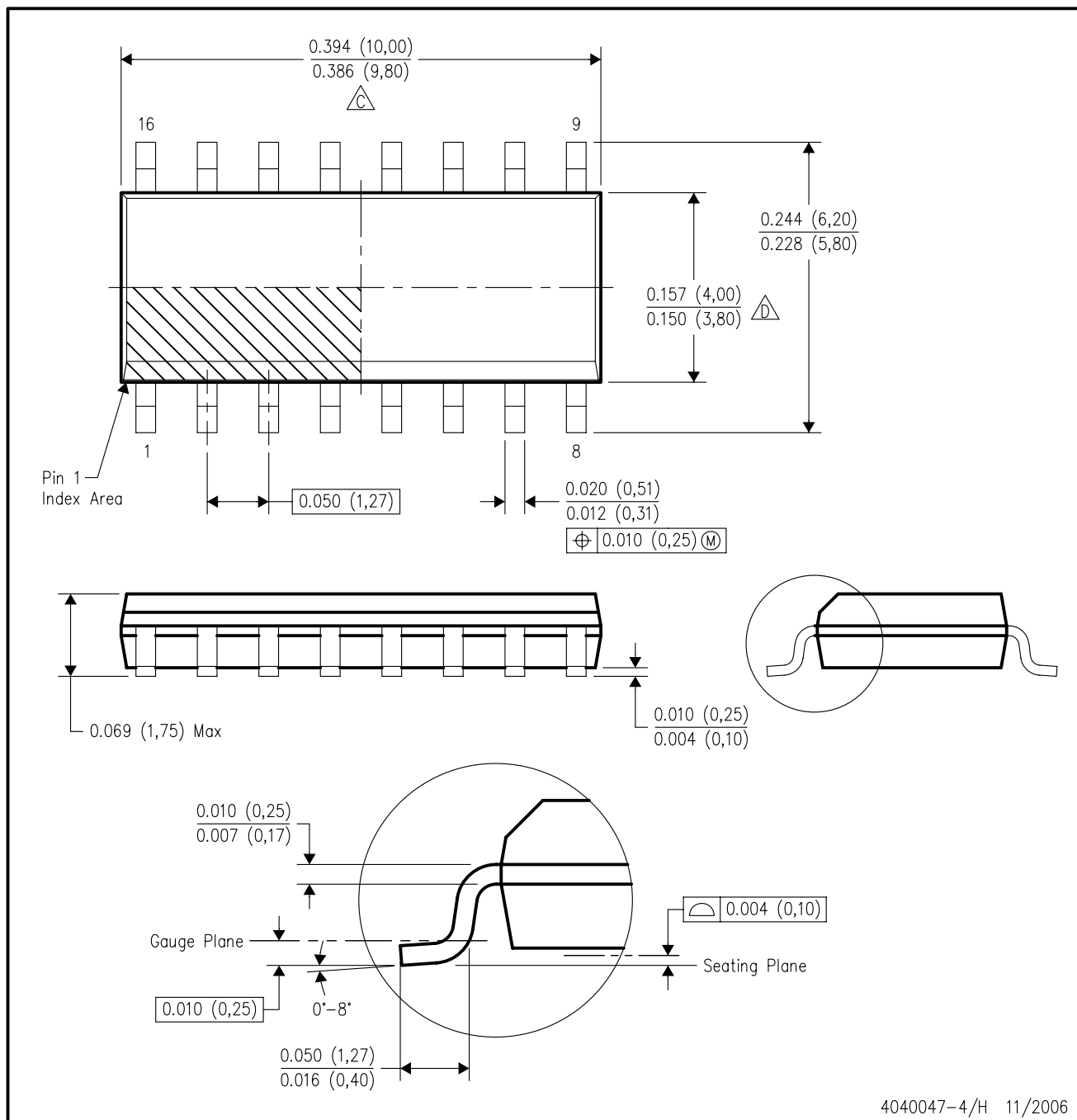
4040047-3/H 11/2006

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 .006 (0,15) per end.
- D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
- E. Reference JEDEC MS-012 variation AB.

D (R-PDSO-G16)

PLASTIC SMALL-OUTLINE PACKAGE



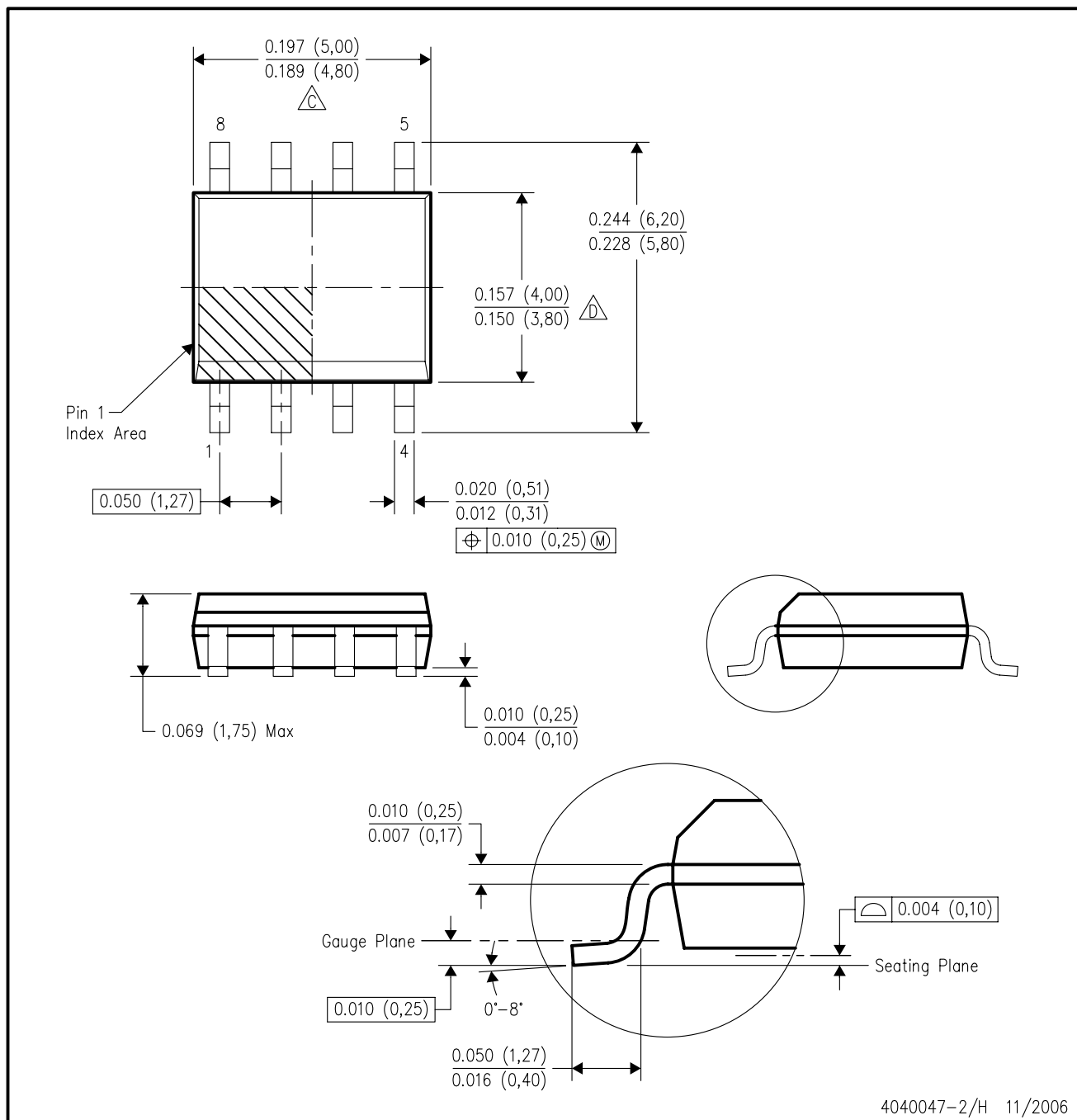
4040047-4/H 11/2006

NOTES:

- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- $\triangle C$ Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
- $\triangle D$ Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
- E. Reference JEDEC MS-012 variation AC.

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - $\triangle C$ Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
 - $\triangle D$ Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
 - E. Reference JEDEC MS-012 variation AA.

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



- 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.
 D. Falls within JEDEC MO-153

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DSP	dsp.ti.com
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
Low Power Wireless	www.ti.com/lpw

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2007, Texas Instruments Incorporated