

TLC372

LinCMOS™ DUAL DIFFERENTIAL COMPARATORS

SLCS114E – NOVEMBER 1983 – REVISED JULY 2008

- **Single or Dual-Supply Operation**
- **Wide Range of Supply Voltages 2 V to 18 V**
- **Low Supply Current Drain**
150 μ A Typ at 5 V
- **Fast Response Time . . . 200 ns Typ for TTL-Level Input Step**
- **Built-in ESD Protection**
- **High Input Impedance . . . $10^{12} \Omega$ Typ**
- **Extremely Low Input Bias Current**
5 pA Typ
- **Ultrastable Low Input Offset Voltage**
- **Input Offset Voltage Change at Worst-Case Input Conditions Typically 0.23 μ V/Month, Including the First 30 Days**
- **Common-Mode Input Voltage Range Includes Ground**
- **Output Compatible With TTL, MOS, and CMOS**
- **Pin-Compatible With LM393**

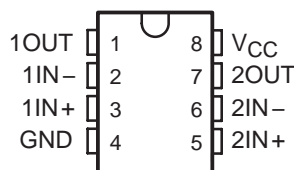
description

This device is fabricated using LinCMOS™ technology and consists of two independent voltage comparators, each designed to operate from a single power supply. Operation from dual supplies is also possible if the difference between the two supplies is 2 V to 18 V. Each device features extremely high input impedance (typically greater than $10^{12} \Omega$), allowing direct interfacing with high-impedance sources. The outputs are n-channel open-drain configurations and can be connected to achieve positive-logic wired-AND relationships.

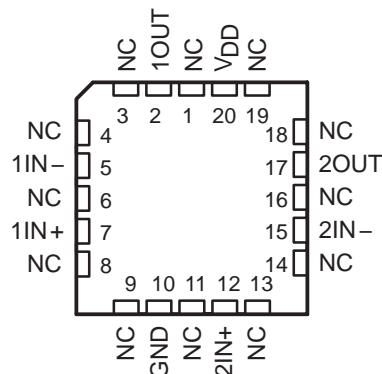
The TLC372 has internal electrostatic discharge (ESD) protection circuits and has been classified with a 1000-V ESD rating using human body model testing. However, care should be exercised in handling this device as exposure to ESD may result in a degradation of the device parametric performance.

The TLC372C is characterized for operation from 0°C to 70°C. The TLC372I is characterized for operation from –40°C to 85°C. The TLC372M is characterized for operation over the full military temperature range of –55°C to 125°C. The TLC372Q is characterized for operation from –40°C to 125°C.

TLC372C, TLC372I, TLC372M, TLC372Q
D, P, OR PW PACKAGE
TLC372M . . . JG PACKAGE
(TOP VIEW)

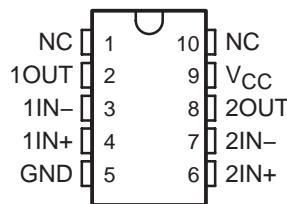


TLC372M . . . FK PACKAGE
(TOP VIEW)

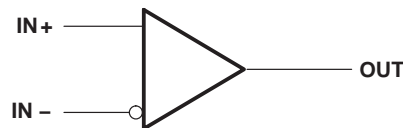


NC – No internal connection

TLC372M
U PACKAGE
(TOP VIEW)



symbol (each comparator)



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.

LinCMOS is a trademark of Texas Instruments Incorporated. All other trademarks are the property of their respective owners.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.



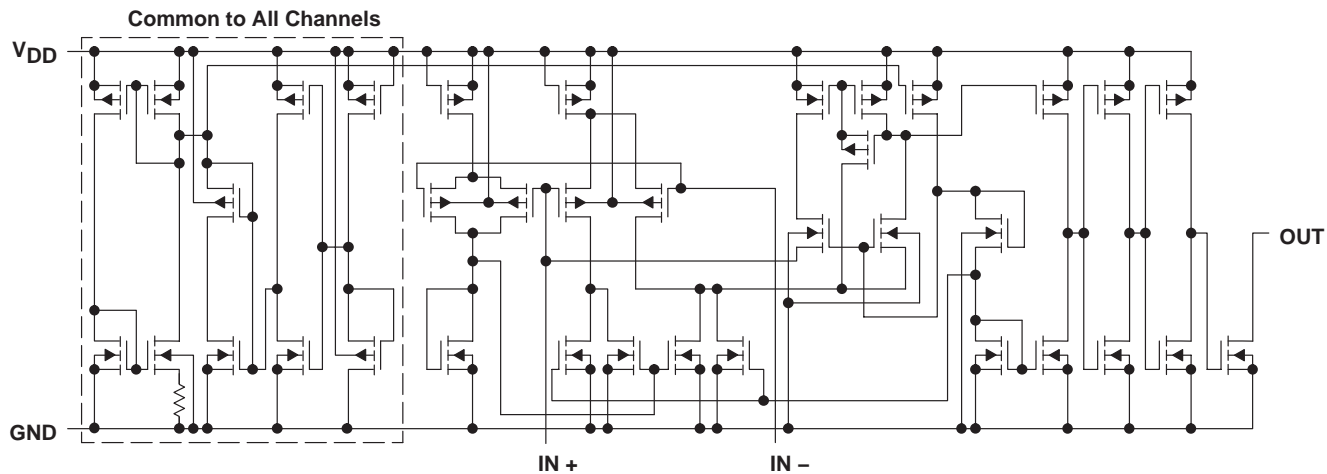
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 1983–2008, Texas Instruments Incorporated

TLC372 LinCMOS™ DUAL DIFFERENTIAL COMPARATORS

SLCS114E – NOVEMBER 1983 – REVISED JULY 2008

equivalent schematic (each comparator)



AVAILABLE OPTIONS⁽¹⁾

T _A	V _{IO} max AT 25°C	PACKAGED DEVICES					
		SMALL OUTLINE (D) ⁽²⁾	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP (PW)	CERAMIC FLAT PACK (U)
0°C to 70°C	5 mV	TLC372CD	—	—	TLC372CP	TLC372CPW	—
–40°C to 85°C	5 mV	TLC372ID	—	—	TLC372IP	—	—
–55°C to 125°C	5 mV	TLC372MD	TLC372MFK	TLC372MJG	TLC372MP	—	TLC372MU
–40°C to 125°C	5 mV	TLC372QD	—	—	TLC372QP	—	—

1. 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 www.ti.com.

2. The D packages are available taped and reeled. Add R suffix to device type (e.g., TLC372CDR).

TLC372 LinCMOS™ DUAL DIFFERENTIAL COMPARATORS

SLCS114E – NOVEMBER 1983 – REVISED JULY 2008

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

Supply voltage, V_{DD} (see Note 1)	18 V	
Differential input voltage, V_{ID} (see Note 2)	± 18 V	
Input voltage range, V_I	–0.3 V to 18 V	
Output voltage, V_O	18 V	
Input current, I_I	± 5 mA	
Output current, I_O	20 mA	
Duration of output short circuit to ground (see Note 3)	unlimited	
Package thermal impedance, θ_{JA} (see Notes 6 and 7):	D package	97.1°C/W
	P package	84.6°C/W
	PW package	149°C/W
Package thermal impedance, θ_{JC} (see Notes 6 and 7):	FK package	5.6°C/W
	JG package	14.5°C/W
	U package	14.7°C/W
Operating free-air temperature range, T_A :	TLC372C	0°C to 70°C
	TLC372I	–40°C to 85°C
	TLC372M	–55°C to 125°C
	TLC372Q	–40°C to 125°C
Storage temperature range	–65°C to 150°C	
Case temperature for 60 seconds: FK package	260°C	
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, P, or PW package	260°C	
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG or U package	300°C	

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

- NOTES:
3. All voltage values except differential voltages are with respect to network ground.
 4. Differential voltages are at $IN+$ with respect to $IN-$.
 5. Short circuits from outputs to V_{DD} can cause excessive heating and eventual device destruction.
 6. Maximum power dissipation is a function of $T_J(\max)$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
 7. The package thermal impedance is calculated in accordance with JESD 51-7 (plastic) or MIL-STD-883 Method 1012 (ceramic).

recommended operating conditions

		TLC372C		TLC372I		TLC372M		TLC372Q		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{DD}		3	16	3	16	4	16	4	16	V
Common-mode input voltage, V_{IC}	$V_{DD} = 5$ V	0	3.5	0	3.5	0	3.5	0	3.5	V
	$V_{DD} = 10$ V	0	8.5	0	8.5	0	8.5	0	8.5	
Operating free-air temperature, T_A		0	70	–40	85	–55	125	–40	125	°C



TLC372 LinCMOS™ DUAL DIFFERENTIAL COMPARATORS

SLCS114E – NOVEMBER 1983 – REVISED JULY 2008

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

PARAMETER	TEST CONDITIONS	T_A †	TLC372C			TLC372I			TLC372M, TLC372Q			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = V_{ICRmin}$, See Note 4	25°C	1	5	5	1	5	1	5	5	mV	
		Full range		6.5	7		7		10			
I_{IO} Input offset current		25°C	1			1		1		1	pA	
		MAX		0.3	1		1		10		nA	
I_{IB} Input bias current		25°C	5			5		5		5	pA	
		MAX		0.6	2		2		20		nA	
V_{ICR} Common-mode input voltage range		25°C	0 to $V_{DD}-1$			0 to $V_{DD}-1$		0 to $V_{DD}-1$		0 to $V_{DD}-1$	V	
		Full range	0 to $V_{DD}-1.5$			0 to $V_{DD}-1.5$		0 to $V_{DD}-1.5$		0 to $V_{DD}-1.5$		
I_{OH} High-level output current	$V_{OH} = 5\text{ V}$ $V_{OH} = 15\text{ V}$	25°C	0.1			0.1		0.1		0.1	nA	
		Full range		1	1		1		3		μA	
V_{OL} Low-level output voltage	$V_{ID} = -1\text{ V}$, $I_{OL} = 4\text{ mA}$	25°C	150	400	400	150	400	150	400	150	400	mV
		Full range		700	700		700		700		700	
I_{OL} Low-level output current	$V_{ID} = -1\text{ V}$, $V_{OL} = 1.5\text{ V}$	25°C	6	16	16	6	16	6	16	6	16	mA
		Full range		150	300		150		300		150	300
I_{DD} Supply current (two comparators)	$V_{ID} = 1\text{ V}$, No load	25°C		400	400		400		400		400	μA
		Full range										

† All characteristics are measured with zero common-mode input voltage unless otherwise noted. Full range is 0°C to 70°C for TLC372C, -40°C to 85°C for TLC372I, and -55°C to 125°C for TLC372M and -40°C to 125°C for TLC372Q. IMPORTANT: See Parameter Measurement Information.

NOTE 8: The offset voltage limits given are the maximum values required to drive the output above 4 V or below 400 mV with a 10-k Ω resistor between the output and V_{DD} . They can be verified by applying the limit value to the input and checking for the appropriate output state.

switching characteristics, $V_{DD} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS				UNIT
	MIN	TYP	MAX	MAX	
Response time	R_L connected to 5 V through 5.1 k Ω , $C_L = 15\text{ pF}$ †, See Note 5				ns
			650	200	
	TTL-level input step				

† C_L includes probe and jig capacitance.

NOTE 9: The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.



electrical characteristics at specified free-air temperature, $V_{DD} = 5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	TLC372Y			UNIT
		MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{IC} = V_{ICRmin}$, See Note 4		1	5	mV
I_{IO} Input offset current			1		pA
I_{IB} Input bias current			5		pA
V_{ICR} Common-mode input voltage range		0 to $V_{DD}-1$			V
I_{OH} High-level output current	$V_{ID} = 1\text{ V}$, $V_{OH} = 5\text{ V}$		0.1		nA
V_{OL} Low-level output voltage	$V_{ID} = -1\text{ V}$, $I_{OL} = 4\text{ mA}$		150	400	mV
I_{OL} Low-level output current	$V_{ID} = -1\text{ V}$, $V_{OL} = 1.5\text{ V}$	6	16		mA
I_{DD} Supply current (two comparators)	$V_{ID} = 1\text{ V}$, No load		150	300	μA

† All characteristics are measured with zero common-mode input voltage unless otherwise noted. IMPORTANT: See Parameter Measurement Information.

NOTE 4: The offset voltage limits given are the maximum values required to drive the output above 4 V or below 400 mV with a 10-k Ω resistor between the output and V_{DD} . They can be verified by applying the limit value to the input and checking for the appropriate output state.

PARAMETER MEASUREMENT INFORMATION

The digital output stage of the TLC372 can be damaged if it is held in the linear region of the transfer curve. Conventional operational amplifier/comparator testing incorporates the use of a servo loop that is designed to force the device output to a level within this linear region. Since the servo-loop method of testing cannot be used, the following alternatives for measuring parameters such as input offset voltage, common-mode rejection, etc., are offered.

To verify that the input offset voltage falls within the limits specified, the limit value is applied to the input as shown in Figure 1(a). With the noninverting input positive with respect to the inverting input, the output should be high. With the input polarity reversed, the output should be low.

A similar test can be made to verify the input offset voltage at the common-mode extremes. The supply voltages can be slewed as shown in Figure 1(b) for the V_{ICR} test, rather than changing the input voltages, to provide greater accuracy.

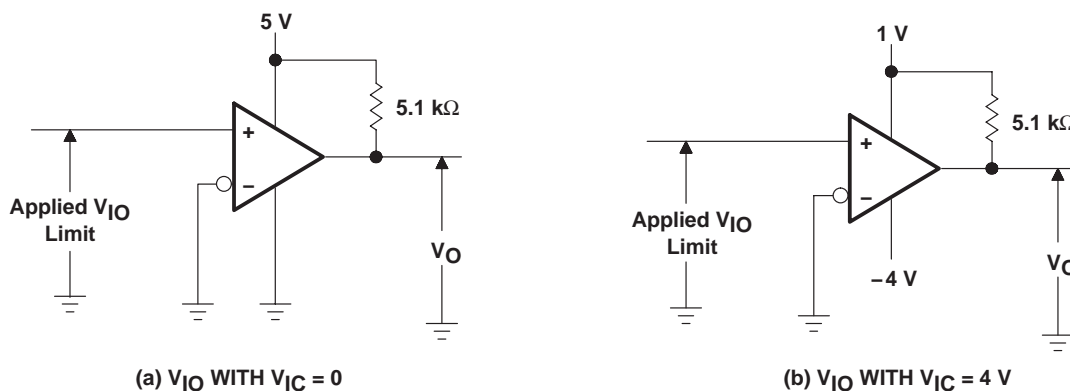


Figure 1. Method for Verifying That Input Offset Voltage is Within Specified Limits

PARAMETER MEASUREMENT INFORMATION

A close approximation of the input offset voltage can be obtained by using a binary search method to vary the differential input voltage while monitoring the output state. When the applied input voltage differential is equal, but opposite in polarity, to the input offset voltage, the output changes states.

Figure 2 illustrates a practical circuit for direct dc measurement of input offset voltage that does not bias the comparator into the linear region. The circuit consists of a switching-mode servo loop in which U1a generates a triangular waveform of approximately 20-mV amplitude. U1b acts as a buffer, with C2 and R4 removing any residual dc offset. The signal is then applied to the inverting input of the comparator under test, while the noninverting input is driven by the output of the integrator formed by U1c through the voltage divider formed by R9 and R10. The loop reaches a stable operating point when the output of the comparator under test has a duty cycle of exactly 50%, which can only occur when the incoming triangle wave is sliced symmetrically or when the voltage at the noninverting input exactly equals the input offset voltage.

Voltage divider R9 and R10 provides a step up of the input offset voltage by a factor of 100 to make measurement easier. The values of R5, R8, R9, and R10 can significantly influence the accuracy of the reading; therefore, it is suggested that their tolerance level be 1% or lower.

Measuring the extremely low values of input current requires isolation from all other sources of leakage current and compensation for the leakage of the test socket and board. With a good picoammeter, the socket and board leakage can be measured with no device in the socket. Subsequently, this open-socket leakage value can be subtracted from the measurement obtained with a device in the socket to obtain the actual input current of the device.

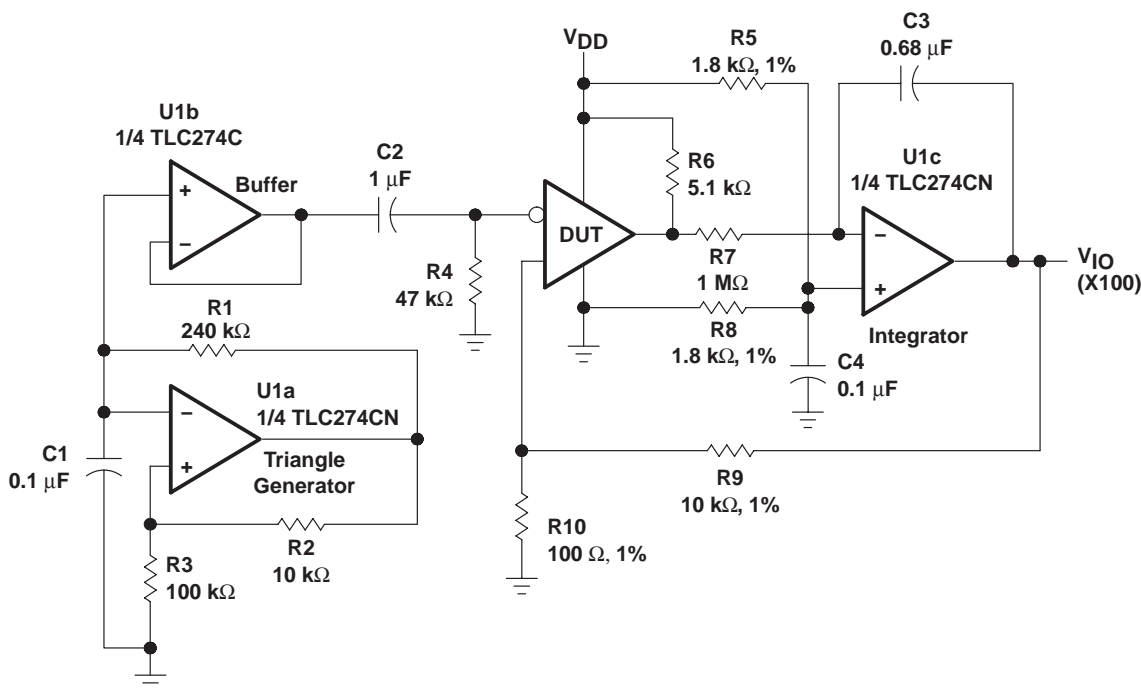
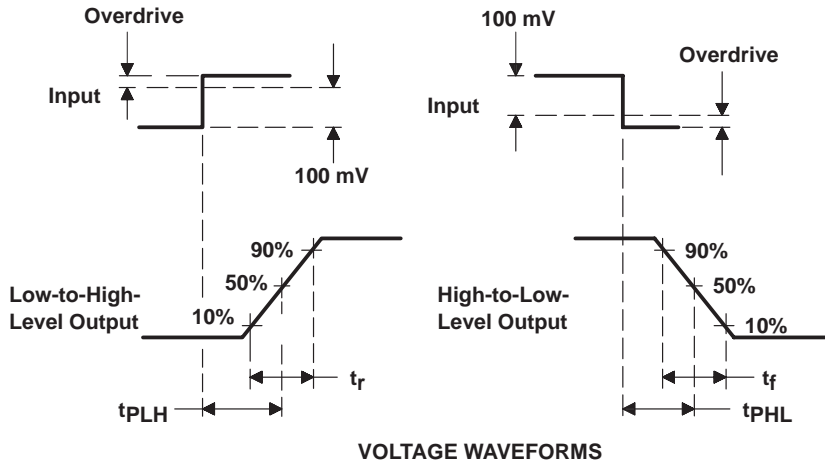
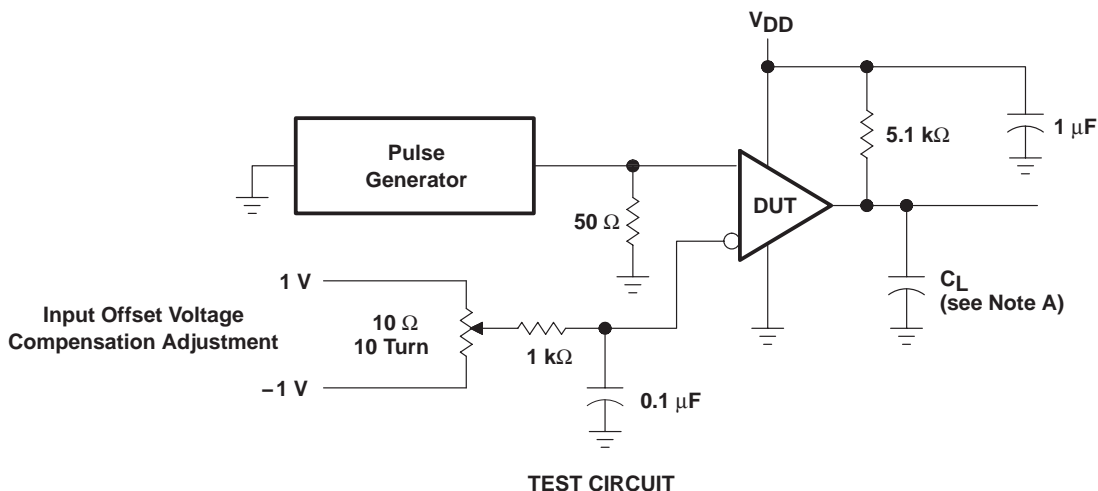


Figure 2. Circuit for Input Offset Voltage Measurement

PARAMETER MEASUREMENT INFORMATION

Response time is defined as the interval between the application of an input step function and the instant when the output reaches 50% of its maximum value. Response time, low-to-high level output, is measured from the leading edge of the input pulse, while response time, high-to-low level output, is measured from the trailing edge of the input pulse. Response-time measurement at low input signal levels can be greatly affected by the input offset voltage. The offset voltage should be balanced by the adjustment at the inverting input as shown in Figure 3, so that the circuit is just at the transition point. Then a low signal, for example 105-mV or 5-mV overdrive, causes the output to change state.



NOTE A: C_L includes probe and jig capacitance.

Figure 3. Response, Rise, and Fall Times Circuit and Voltage Waveforms

PRINCIPLES OF OPERATION

LinCMOS™ process

The LinCMOS™ process is a Linear polysilicon-gate complementary-MOS process. Primarily designed for single-supply applications, LinCMOS™ products facilitate the design of a wide range of high-performance analog functions, from operational amplifiers to complex mixed-mode converters.

While digital designers are experienced with CMOS, MOS technologies are relatively new for analog designers. This short guide is intended to answer the most frequently asked questions related to the quality and reliability of LinCMOS™ products. Further questions should be directed to the nearest Texas Instruments field sales office.

electrostatic discharge

CMOS circuits are prone to gate oxide breakdown when exposed to high voltages even if the exposure is only for very short periods of time. Electrostatic discharge (ESD) is one of the most common causes of damage to CMOS devices. It can occur when a device is handled without proper consideration for environmental electrostatic charges, e.g. during board assembly. If a circuit in which one amplifier from a dual operational amplifier is being used and the unused pins are left open, high voltages tends to develop. If there is no provision for ESD protection, these voltages may eventually punch through the gate oxide and cause the device to fail. To prevent voltage buildup, each pin is protected by internal circuitry.

Standard ESD-protection circuits safely shunt the ESD current by providing a mechanism whereby one or more transistors break down at voltages higher than the normal operating voltages but lower than the breakdown voltage of the input gate. This type of protection scheme is limited by leakage currents which flow through the shunting transistors during normal operation after an ESD voltage has occurred. Although these currents are small, on the order of tens of nanoamps, CMOS amplifiers are often specified to draw input currents as low as tens of picoamps.

To overcome this limitation, Texas Instruments design engineers developed the patented ESD-protection circuit shown in Figure 4. This circuit can withstand several successive 1-kV ESD pulses, while reducing or eliminating leakage currents that may be drawn through the input pins. A more detailed discussion of the operation of Texas Instruments's ESD- protection circuit is presented on the next page.

All input and output pins on LinCMOS and Advanced LinCMOS™ products have associated ESD-protection circuitry that undergoes qualification testing to withstand 1000 V discharged from a 100-pF capacitor through a 1500-Ω resistor (human body model) and 200 V from a 100-pF capacitor with no current-limiting resistor (charged device model). These tests simulate both operator and machine handling of devices during normal test and assembly operations.

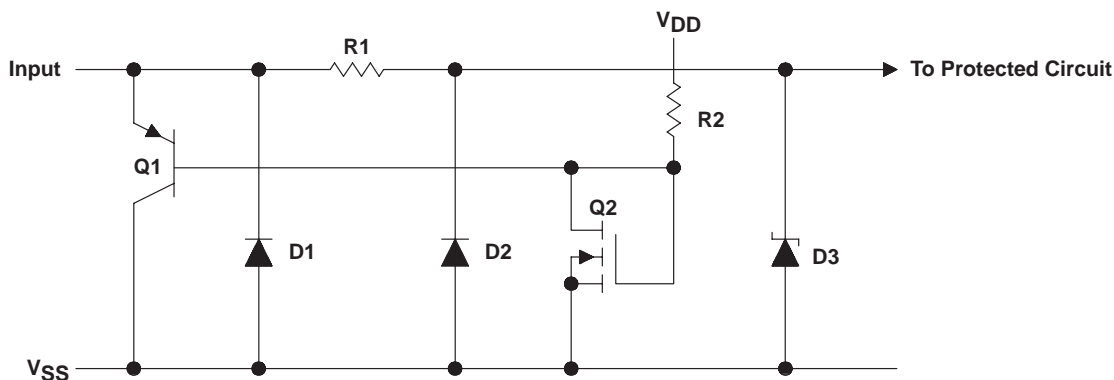


Figure 4. LinCMOS™ ESD-Protection Schematic

Advanced LinCMOS is a trademark of Texas Instruments Incorporated.



PRINCIPLES OF OPERATION

input protection circuit operation

Texas Instruments' patented protection circuitry allows for both positive-and negative-going ESD transients. These transients are characterized by extremely fast rise times and usually low energies, and can occur both when the device has all pins open and when it is installed in a circuit.

positive ESD transients

Initial positive charged energy is shunted through Q1 to V_{SS} . Q1 turns on when the voltage at the input rises above the voltage on the V_{DD} pin by a value equal to the V_{EB} of Q1. The base current increases through R2 with input current as Q1 saturates. The base current through R2 forces the voltage at the drain and gate of Q2 to exceed its threshold level ($V_T \sim 22\text{ V to }26\text{ V}$) and turn Q2 on. The shunted input current through Q1 to V_{SS} is now shunted through the n-channel enhancement-type MOSFET Q2 to V_{SS} . If the voltage on the input pin continues to rise, the breakdown voltage of the zener diode D3 is exceeded, and all remaining energy is dissipated in R1 and D3. The breakdown voltage of D3 is designed to be 24 V to 27 V, which is well below the gate oxide voltage of the circuit to be protected.

negative ESD transients

The negative charged ESD transients are shunted directly through D1. Additional energy is dissipated in R1 and D2 as D2 becomes forward biased. The voltage seen by the protected circuit is $-0.3\text{ V to }-1\text{ V}$ (the forward voltage of D1 and D2).

circuit-design considerations

LinCMOS™ products are being used in actual circuit environments that have input voltages that exceed the recommended common-mode input voltage range and activate the input protection circuit. Even under normal operation, these conditions occur during circuit power up or power down, and in many cases, when the device is being used for a signal conditioning function. The input voltages can exceed V_{ICR} and not damage the device only if the inputs are current limited. The recommended current limit shown on most product data sheets is $\pm 5\text{ mA}$. Figure 5 and Figure 6 show typical characteristics for input voltage versus input current.

Normal operation and correct output state can be expected even when the input voltage exceeds the positive supply voltage. Again, the input current should be externally limited even though internal positive current limiting is achieved in the input protection circuit by the action of Q1. When Q1 is on, it saturates and limits the current to approximately 5-mA collector current by design. When saturated, Q1 base current increases with input current. This base current is forced into the V_{DD} pin and into the device I_{DD} or the V_{DD} supply through R2 producing the current limiting effects shown in Figure 5. This internal limiting lasts only as long as the input voltage is below the V_T of Q2.

When the input voltage exceeds the negative supply voltage, normal operation is affected and output voltage states may not be correct. Also, the isolation between channels of multiple devices (duals and quads) can be severely affected. External current limiting must be used since this current is directly shunted by D1 and D2 and no internal limiting is achieved. If normal output voltage states are required, an external input voltage clamp is required (see Figure 7).

PRINCIPLES OF OPERATION

circuit-design considerations (continued)

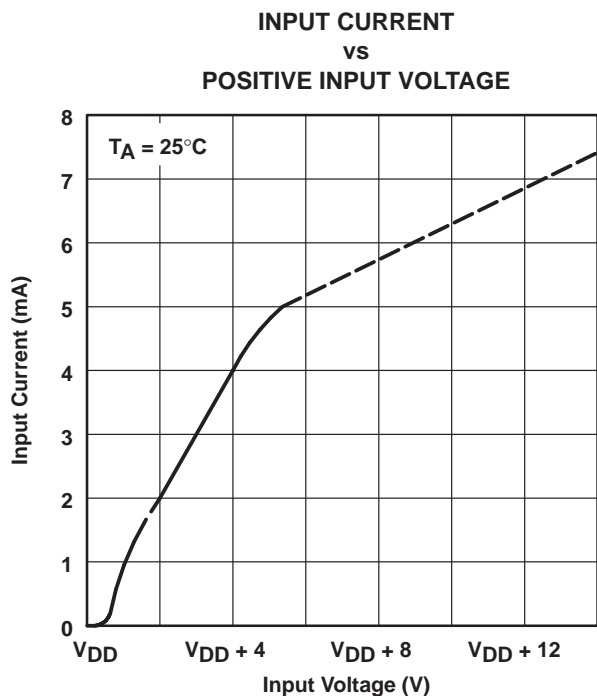


Figure 5

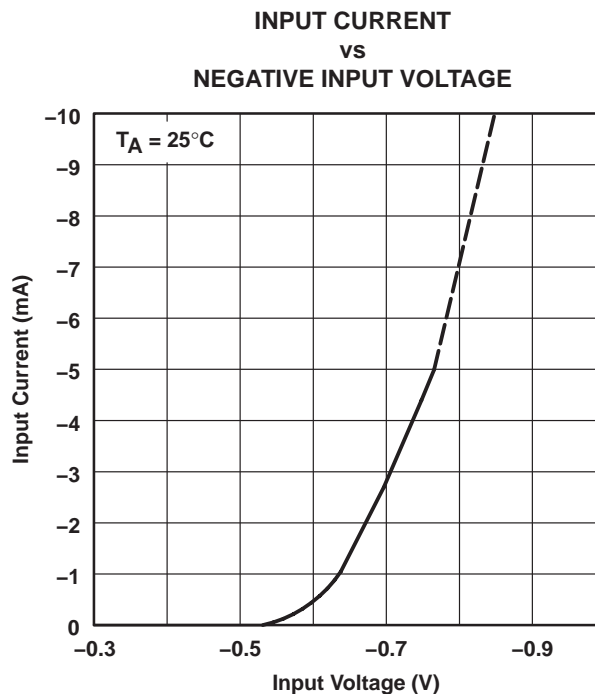
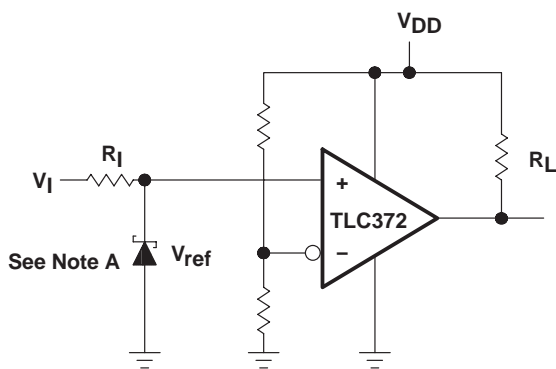


Figure 6



Positive Voltage Input Current Limit:

$$R_I = \frac{+V_I - V_{DD} - 0.3 \text{ V}}{5 \text{ mA}}$$

Negative Voltage Input Current Limit:

$$R_I = \frac{|-V_I| - 0.3 \text{ V}}{5 \text{ mA}}$$

NOTE A: If the correct output state is required when the negative input is less than GND, a schottky clamp is required.

Figure 7. Typical Input Current-Limiting Configuration for a LinCMOS™ Comparator

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-87658012A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type	-55 to 125	5962- 87658012A TLC372MFKB	Samples
5962-8765801PA	ACTIVE	CDIP	JG	8	1	TBD	A42	N / A for Pkg Type	-55 to 125	8765801PA TLC372M	Samples
5962-9554901NXD	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	Q372M	Samples
5962-9554901NXDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	Q372M	Samples
TLC372CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	372C	Samples
TLC372CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	372C	Samples
TLC372CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	372C	Samples
TLC372CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	372C	Samples
TLC372CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TLC372CP	Samples
TLC372CPSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P372	Samples
TLC372CPSRG4	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P372	Samples
TLC372CPW	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P372	Samples
TLC372CPWG4	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P372	Samples
TLC372CPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P372	Samples
TLC372CPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	P372	Samples
TLC372ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	372I	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLC372IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	372I	Samples
TLC372IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	372I	Samples
TLC372IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	372I	Samples
TLC372IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC372IP	Samples
TLC372IPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-40 to 85	TLC372IP	Samples
TLC372MD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	372M	Samples
TLC372MDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		372M	Samples
TLC372MDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	372M	Samples
TLC372MDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM		372M	Samples
TLC372MFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type	-55 to 125	5962-87658012A TLC372MFKB	Samples
TLC372MJG	ACTIVE	CDIP	JG	8	1	TBD	A42	N / A for Pkg Type	-55 to 125	TLC372MJG	Samples
TLC372MJGB	ACTIVE	CDIP	JG	8	1	TBD	A42	N / A for Pkg Type	-55 to 125	8765801PA TLC372M	Samples
TLC372MP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-55 to 125	TLC372MP	Samples
TLC372MUB	ACTIVE	CFP	U	10	1	TBD	A42	N / A for Pkg Type	-55 to 125	TLC372MUB	Samples
TLC372QD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	372Q	Samples
TLC372QDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	372Q	Samples
TLC372QDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	372Q	Samples
TLC372QDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	372Q	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

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

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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.

OTHER QUALIFIED VERSIONS OF TLC372, TLC372M :

● Catalog: [TLC372](#)

● Enhanced Product: [TLC372-EP](#), [TLC372-EP](#)

- Military: [TLC372M](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
5962-9554901NXDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC372CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC372CPSR	SO	PS	8	2000	330.0	16.4	8.2	6.6	2.5	12.0	16.0	Q1
TLC372CPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
TLC372IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC372MDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC372MDRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC372QDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

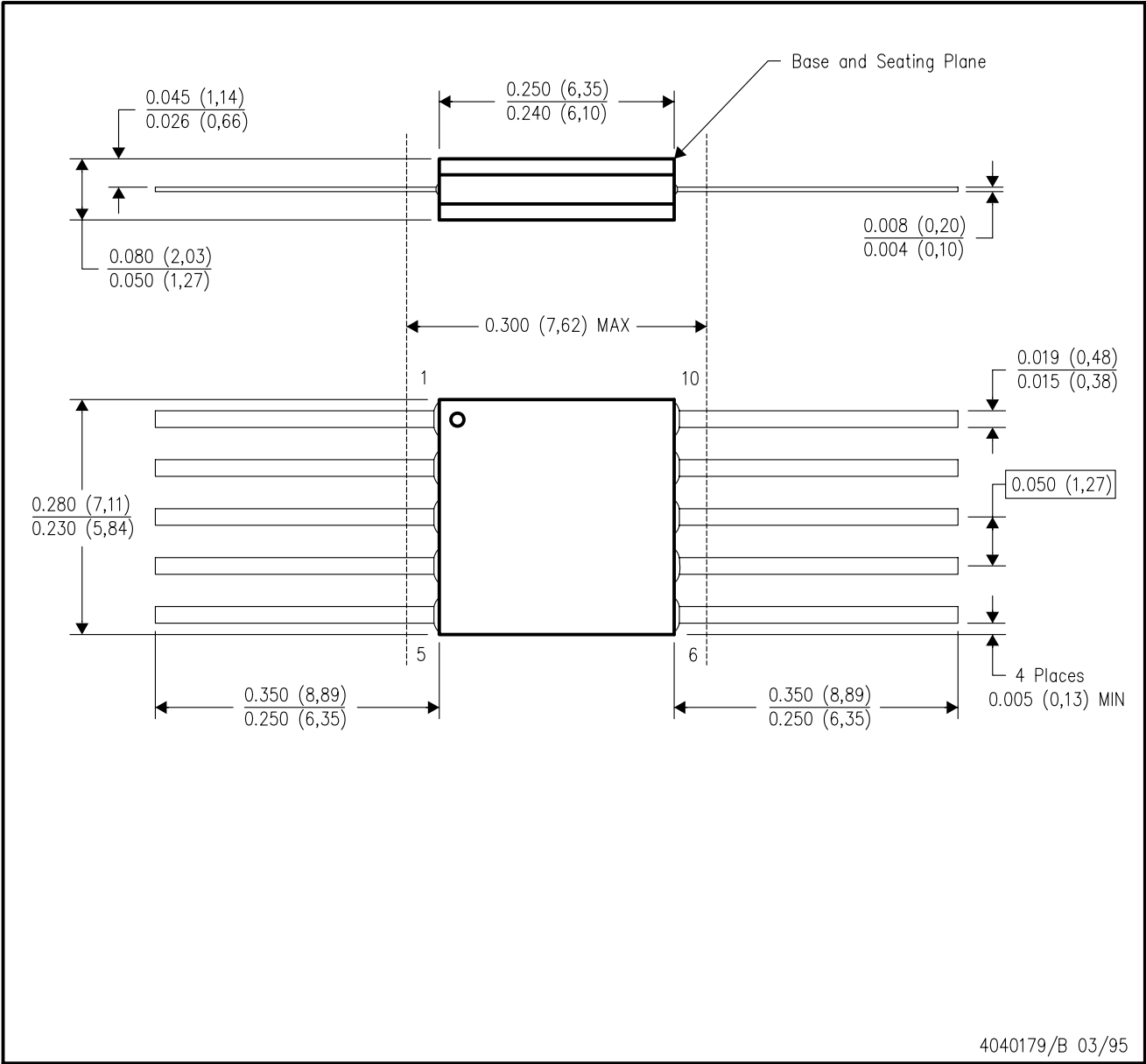
TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
5962-9554901NXDR	SOIC	D	8	2500	367.0	367.0	38.0
TLC372CDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC372CPSR	SO	PS	8	2000	367.0	367.0	38.0
TLC372CPWR	TSSOP	PW	8	2000	367.0	367.0	35.0
TLC372IDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC372MDR	SOIC	D	8	2500	367.0	367.0	38.0
TLC372MDRG4	SOIC	D	8	2500	367.0	367.0	38.0
TLC372QDR	SOIC	D	8	2500	367.0	367.0	38.0

U (S-GDFP-F10)

CERAMIC DUAL FLATPACK



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package can be hermetically sealed with a ceramic lid using glass frit.
 - D. Index point is provided on cap for terminal identification only.
 - E. Falls within MIL STD 1835 GDFP1-F10 and JEDEC MO-092AA

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



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

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



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

MECHANICAL DATA

PS (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



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

PS (R-PDSO-G8)

PLASTIC SMALL OUTLINE



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

JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE



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

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



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

PW0008A



PACKAGE OUTLINE
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



4221848/A 02/2015

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153, variation AA.

EXAMPLE BOARD LAYOUT

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
SCALE:10X



SOLDER MASK DETAILS
NOT TO SCALE

4221848/A 02/2015

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:10X

4221848/A 02/2015

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



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



4040140/D 01/11

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

IMPORTANT NOTICE

Texas Instruments Incorporated (TI) reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

TI's published terms of sale for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>) apply to the sale of packaged integrated circuit products that TI has qualified and released to market. Additional terms may apply to the use or sale of other types of TI products and services.

Reproduction of significant portions of TI information in TI data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such reproduced documentation. Information of third parties may be subject to additional restrictions. 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.

Buyers and others who are developing systems that incorporate TI products (collectively, "Designers") understand and agree that Designers remain responsible for using their independent analysis, evaluation and judgment in designing their applications and that Designers have full and exclusive responsibility to assure the safety of Designers' applications and compliance of their applications (and of all TI products used in or for Designers' applications) with all applicable regulations, laws and other applicable requirements. Designer represents that, with respect to their applications, Designer has all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. Designer agrees that prior to using or distributing any applications that include TI products, Designer will thoroughly test such applications and the functionality of such TI products as used in such applications.

TI's provision of technical, application or other design advice, quality characterization, reliability data or other services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using TI Resources in any way, Designer (individually or, if Designer is acting on behalf of a company, Designer's company) agrees to use any particular TI Resource solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

Designer is authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources 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.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY DESIGNER AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Unless TI has explicitly designated an individual product as meeting the requirements of a particular industry standard (e.g., ISO/TS 16949 and ISO 26262), TI is not responsible for any failure to meet such industry standard requirements.

Where TI specifically promotes products as facilitating functional safety or as compliant with industry functional safety standards, such products are intended to help enable customers to design and create their own applications that meet applicable functional safety standards and requirements. Using products in an application does not by itself establish any safety features in the application. Designers must ensure compliance with safety-related requirements and standards applicable to their applications. Designer may not use any TI products in life-critical medical equipment unless authorized officers of the parties have executed a special contract specifically governing such use. Life-critical medical equipment is medical equipment where failure of such equipment would cause serious bodily injury or death (e.g., life support, pacemakers, defibrillators, heart pumps, neurostimulators, and implantables). Such equipment includes, without limitation, all medical devices identified by the U.S. Food and Drug Administration as Class III devices and equivalent classifications outside the U.S.

TI may expressly designate certain products as completing a particular qualification (e.g., Q100, Military Grade, or Enhanced Product). Designers agree that it has the necessary expertise to select the product with the appropriate qualification designation for their applications and that proper product selection is at Designers' own risk. Designers are solely responsible for compliance with all legal and regulatory requirements in connection with such selection.

Designer will fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of Designer's non-compliance with the terms and provisions of this Notice.