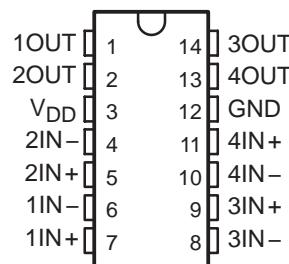


TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

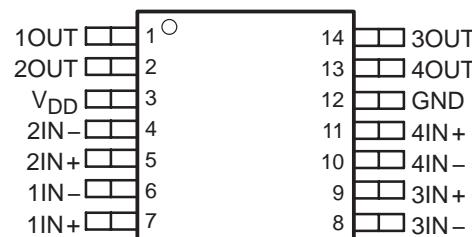
SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

- **Push-Pull CMOS Output Drives Capacitive Loads Without Pullup Resistor, $I_O = \pm 8 \text{ mA}$**
- **Very Low Power . . . 200 μW Typ at 5 V**
- **Fast Response Time . . . $t_{PLH} = 2.7 \mu\text{s}$ Typ With 5-mV Overdrive**
- **Single Supply Operation . . . 3 V to 16 V
TLC3704M . . . 4 V to 16 V**
- **On-Chip ESD Protection**

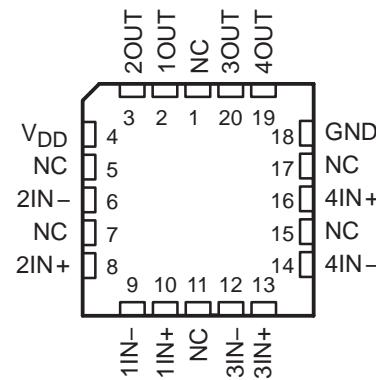
**D, J, OR N PACKAGE
(TOP VIEW)**



**PW PACKAGE
(TOP VIEW)**

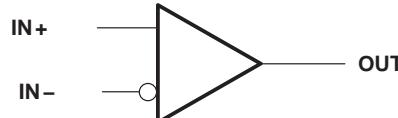


**FK PACKAGE
(TOP VIEW)**



NC – No internal connection

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.

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.

Copyright © 2009, Texas Instruments Incorporated

 **TEXAS
INSTRUMENTS**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

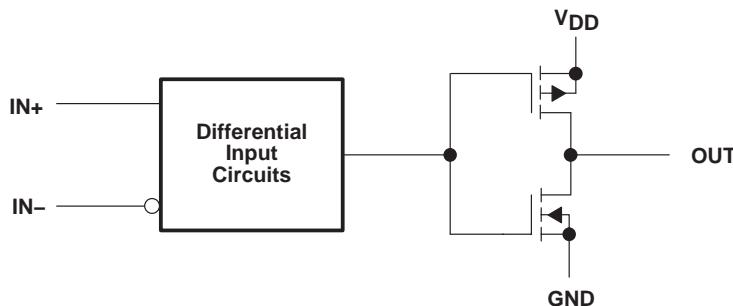
SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

AVAILABLE OPTIONS

TA	V _{I0max} at 25°C	PACKAGE				
		SMALL OUTLINE (D)	CERAMIC (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	TSSOP (PW)
0°C to 70°C	5 mV	TLC3704CD	—	—	TLC3704CN	TLC3704CPW
-40°C to 85°C	5 mV	TLC3704ID	—	—	TLC3704IN	TLC3704IPW
-55°C to 125°C	5 mV	TLC3704MD	TLC3704MFK	TLC3704MJ	—	—
-40°C to 125°C	5 mV	—	—	TLC3704QJ	—	—

The D and PW packages are available taped and reeled. Add R suffix to the device type (e.g., TLC3704CDR).

functional block diagram (each comparator)



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

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

NOTES: 1. All voltage values, except differential voltages, are with respect to network ground.

1. All voltage values, except differential voltages, are
2. Differential voltages are at IN+ with respect to IN-.

TLC3704, TLC3704M
QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

DISSIPATION RATING TABLE

PACKAGE	T _A ≤ 25°C POWER RATING	DERATING FACTOR ABOVE T _A = 25°C	T _A = 70°C POWER RATING	T _A = 85°C POWER RATING	T _A = 125°C POWER RATING
D	950 mW	7.6 mW/°C	608 mW	494 mW	N/A
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
J	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
N	1150 mW	9.2 mW/°C	736 mW	598 mW	N/A
PW	675 mW	5.4 mW/°C	432 mW	351 mW	N/A

recommended operating conditions

	TLC3704C			UNIT
	MIN	NOM	MAX	
Supply voltage, V _{DD}	3	5	16	V
Common-mode input voltage, V _{IC}	– 0.2	V _{DD} – 1.5		V
High-level output current, I _{OH}		– 20		mA
Low-level output current, I _{OL}		20		mA
Operating free-air temperature, T _A	0	70		°C

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

PARAMETER	TEST CONDITIONS [†]	T _A	TLC3704C			UNIT
			MIN	TYP	MAX	
V _{IO}	Input offset voltage V _{IC} = V _{ICRmin} , See Note 3	25°C	1.2	5		mV
		0°C to 70°C			6.5	
I _{IO}	Input offset current V _{IC} = 2.5 V	25°C	1		pA	nA
		70°C			0.3	
I _{IB}	Input bias current V _{IC} = 2.5 V	25°C	5		pA	nA
		70°C			0.6	
V _{ICR}	Common-mode input voltage range	25°C	0 to	V _{DD} – 1		V
		0°C to 70°C	0 to	V _{DD} – 1.5		
CMRR	Common-mode rejection ratio V _{IC} = V _{ICRmin}	25°C	84			dB
		70°C	84			
		0°C	84			
k _{SVR}	Supply-voltage rejection ratio V _{DD} = 5 V to 10 V	25°C	85			dB
		70°C	85			
		0°C	85			
V _{OH}	High-level output voltage V _{ID} = 1 V, I _{OH} = –4 mA	25°C	4.5	4.7		V
		70°C	4.3			
V _{OL}	Low-level output voltage V _{ID} = –1 V, I _{OH} = 4 mA	25°C	210	300		mV
		70°C		375		
I _{DD}	Supply current (all four comparators) Outputs low, No load	25°C	35	80		μA
		0°C to 70°C			100	

[†] All characteristics are measured with zero common-mode voltage unless otherwise noted.

NOTE 3: The offset voltage limits given are the maximum values required to drive the output up to 4.5 V or down to 0.3 V.

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

recommended operating conditions

	TLC3704I			UNIT
	MIN	NOM	MAX	
Supply voltage, V_{DD}	3	5	16	V
Common-mode input voltage, V_{IC}	-0.2		$V_{DD} - 1.5$	V
High-level output current, I_{OH}			-20	mA
Low-level output current, I_{OL}			20	mA
Operating free-air temperature, T_A	-40	85		°C

electrical characteristics at specified operating free-air temperature, $V_{DD} = 5$ V, $V_{IC} = 0$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A	TLC3704I			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{DD} = 5$ V to 10 V, $V_{IC} = V_{ICR\min}$, See Note 3	25°C	1.2	5	7	mV
		-40°C to 85°C				
I_{IO} Input offset current	$V_{IC} = 2.5$ V	25°C	1		pA	pA
		85°C		1		
I_{IB} Input bias current	$V_{IC} = 2.5$ V	25°C	5		pA	nA
		85°C		2		
V_{ICR} Common-mode input voltage range		25°C	0 to $V_{DD} - 1$		V	
		-40°C to 85°C	0 to $V_{DD} - 1.5$			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\min}$	25°C	84		dB	
		85°C	84			
		-40°C	83			
k_{SVR} Supply-voltage rejection ratio	$V_{DD} = 5$ V to 10 V	25°C	85		dB	
		85°C	85			
		-40°C	83			
V_{OH} High-level output voltage	$V_{ID} = 1$ V, $I_{OH} = -4$ mA	25°C	4.5	4.7	V	
		85°C	4.3			
V_{OL} Low-level output voltage	$V_{ID} = -1$ V, $I_{OH} = 4$ mA	25°C	210	300	mV	
		85°C		400		
I_{DD} Supply current (all four comparators)	Outputs low, No load	25°C	35	80	μ A	
		-40°C to 85°C		125		

NOTE 3: The offset voltage limits given are the maximum values required to drive the output up to 4.5 V or down to 0.3 V.

TLC3704, TLC3704M
QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

recommended operating conditions

	TLC3704M			UNIT
	MIN	NOM	MAX	
Supply voltage, V_{DD}	4	5	16	V
Common-mode input voltage, V_{IC}	0	$V_{DD} - 1.5$		V
High-level output current, I_{OH}		- 20		mA
Low-level output current, I_{OL}		20		mA
Operating free-air temperature, T_A	- 55	125		°C

electrical characteristics at specified operating free-air temperature, $V_{DD} = 5$ V, $V_{IC} = 0$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A	TLC3704M			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{DD} = 5$ V to 10 V, $V_{IC} = V_{ICR\min}$, See Note 3	25°C	1.2	5	10	mV
		-55°C to 125°C				
I_{IO} Input offset current	$V_{IC} = 2.5$ V	25°C	1	1	15	pA
		125°C				
I_{IB} Input bias current	$V_{IC} = 2.5$ V	25°C	5	5	30	nA
		125°C				
V_{ICR} Common-mode input voltage range		25°C	0 to $V_{DD} - 1$			V
		-55°C to 125°C	0 to $V_{DD} - 1.5$			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\min}$	25°C	84	84	84	dB
		125°C	83	83	83	
		-55°C	82	82	82	
k_{SVR} Supply-voltage rejection ratio	$V_{DD} = 5$ V to 10 V	25°C	85	85	85	dB
		125°C	85	85	85	
		-55°C	82	82	82	
V_{OH} High-level output voltage	$V_{ID} = 1$ V, $I_{OH} = -4$ mA	25°C	4.5	4.7	4.7	V
		125°C	4.2			
V_{OL} Low-level output voltage	$V_{ID} = -1$ V, $I_{OH} = 4$ mA	25°C	210	300	300	mV
		125°C		500	500	
I_{DD} Supply current (all four comparators)	Outputs low, No load	25°C	35	80	80	μ A
		-55°C to 125°C			175	

NOTE 3: The offset voltage limits given are the maximum values required to drive the output up to 4.5 V or down to 0.3 V.

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

recommended operating conditions

	TLC3704Q			UNIT
	MIN	NOM	MAX	
Supply voltage, V_{DD}	3	5	16	V
Common-mode input voltage, V_{IC}	-0.2		$V_{DD} - 1.5$	V
High-level output current, I_{OH}			-20	mA
Low-level output current, I_{OL}			20	mA
Operating free-air temperature, T_A	-40		125	°C

electrical characteristics at specified operating free-air temperature, $V_{DD} = 5$ V, $V_{IC} = 0$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_A	TLC3704Q			UNIT
			MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{DD} = 5$ V to 10 V, $V_{IC} = V_{ICRmin}$, See Note 3	25°C		1.2	5	mV
		-40°C to 125°C			7	
I_{IO} Input offset current	$V_{IC} = 2.5$ V	25°C		1	pA	nA
		125°C			15	
I_{IB} Input bias current	$V_{IC} = 2.5$ V	25°C		5	pA	nA
		125°C			30	
V_{ICR} Common-mode input voltage range		25°C	0 to $V_{DD} - 1$			V
		-40°C to 125°C	0 to $V_{DD} - 1.5$			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C		84		dB
		125°C		83		
		-40°C		83		
k_{SVR} Supply-voltage rejection ratio	$V_{DD} = 5$ V to 10 V	25°C		85		dB
		125°C		85		
		-40°C		83		
V_{OH} High-level output voltage	$V_{ID} = 1$ V, $I_{OH} = -4$ mA	25°C	4.5	4.7		V
		125°C	4.2			
V_{OL} Low-level output voltage	$V_{ID} = -1$ V, $I_{OH} = 4$ mA	25°C		210	300	mV
		125°C			500	
I_{DD} Supply current (all four comparators)	Outputs low, No load	25°C		35	80	μ A
		-40°C to 125°C			175	

NOTE 3: The offset voltage limits given are the maximum values required to drive the output up to 4.5 V or down to 0.3 V.

TLC3704, TLC3704M
QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

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

PARAMETER	TEST CONDITIONS	TLC3704C, TLC3704I TLC3704M, TLC3704Q			UNIT
		MIN	TYP	MAX	
t_{PLH} Propagation delay time, low-to-high-level output†	$f = 10$ kHz, $C_L = 50$ pF	Overdrive = 2 mV	4.5		μs
		Overdrive = 5 mV	2.7		
		Overdrive = 10 mV	1.9		
		Overdrive = 20 mV	1.4		
		Overdrive = 40 mV	1.1		
		$V_I = 1.4$ -V step at IN+	1.1		
t_{PHL} Propagation delay time, high-to-low-level output†	$f = 10$ kHz, $C_L = 50$ pF	Overdrive = 2 mV	4		μs
		Overdrive = 5 mV	2.3		
		Overdrive = 10 mV	1.5		
		Overdrive = 20 mV	0.95		
		Overdrive = 40 mV	0.65		
		$V_I = 1.4$ -V step at IN+	0.15		
t_f	Fall time	$f = 10$ kHz, $C_L = 50$ pF	Overdrive = 50 mV	50	ns
t_r	Rise time		Overdrive = 50 mV	125	ns

† Simultaneous switching of inputs causes degradation in output response.

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

PRINCIPLES OF OPERATION

LinCMOS process

The LinCMOS process is a linear polysilicon-gate CMOS 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.

This short guide is intended to answer the most frequently asked questions related to the quality and reliability of LinCMOS products. Direct further questions to the nearest TI 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 op amp 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, TI design engineers developed the patented ESD-protection circuit shown in Figure 1. This circuit can withstand several successive 2-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 the TI 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 2000 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.

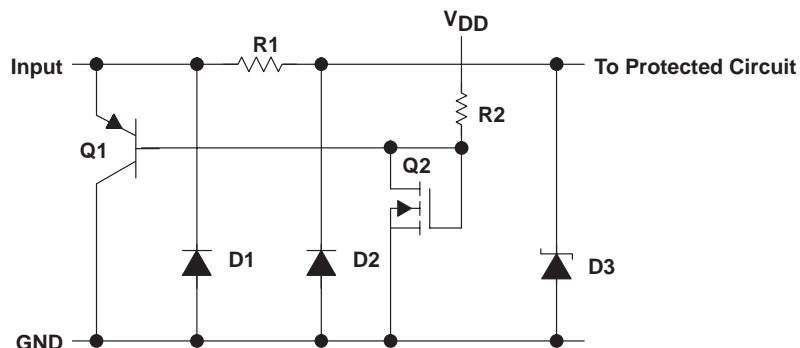


Figure 1. LinCMOS ESD-Protection Schematic

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_{BE} 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 ($V_T \sim 22$ to 26 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 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 V to –1 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 ± 5 mA. Figures 2 and 3 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 2. This internal limiting lasts only as long as the input voltage is below the V_T of Q2.

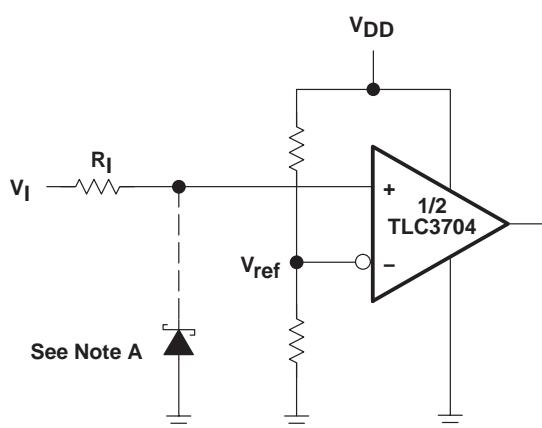
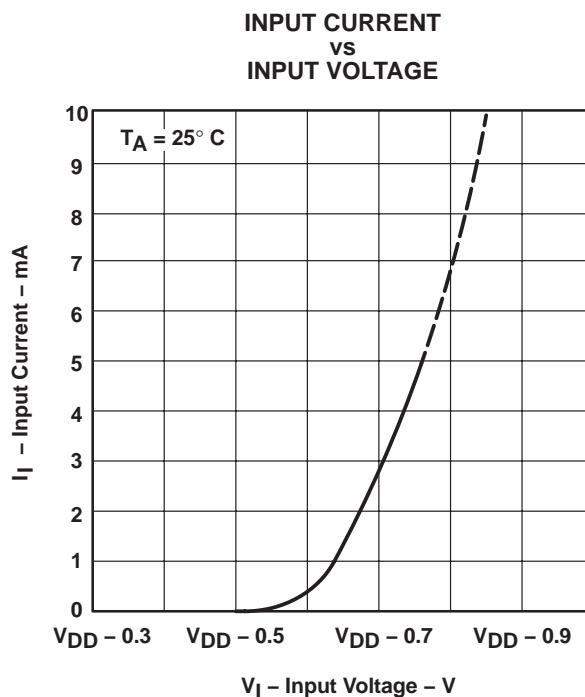
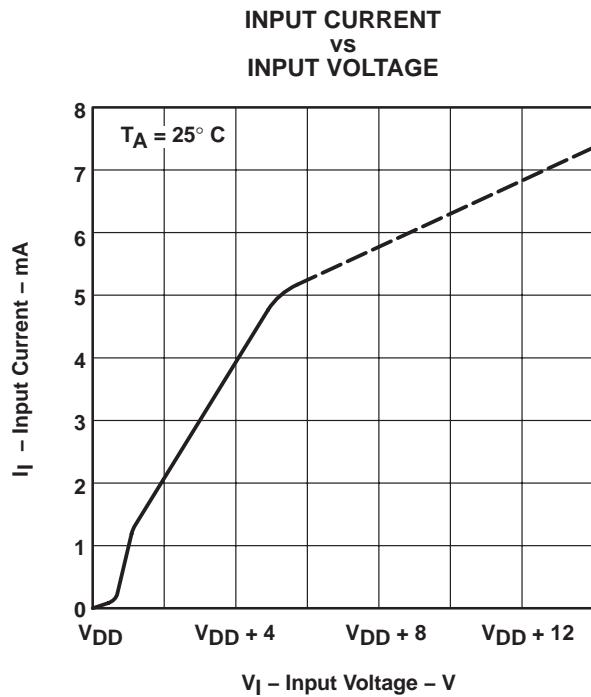
When the input voltage exceeds the negative supply voltage, normal operation is affected and output voltage states may not be correct. Also, the isolation between channels of multiple devices (duals and quads) can be severely affected. External current limiting must be used since this current is directly 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 4).

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

PRINCIPLES OF OPERATION

circuit-design considerations (continued)



NOTE A: If the correct input state is required when the negative input exceeds GND, a Schottky clamp is required.

Figure 4. Typical Input Current-Limiting Configuration for a LinCMOS Comparator

Positive Voltage Input Current Limit :

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

Negative Voltage Input Current Limit :

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

PARAMETER MEASUREMENT INFORMATION

The TLC3704 contains a digital output stage which, if held in the linear region of the transfer curve, can cause damage to the device. Conventional operational amplifier/comparator testing incorporates the use of a servo loop which is designed to force the device output to a level within this linear region. Since the servo-loop method of testing cannot be used, we offer the following alternatives for measuring parameters such as input offset voltage, common-mode rejection, etc.

To verify that the input offset voltage falls within the limits specified, the limit value is applied to the input as shown in Figure 5(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 5(b) for the V_{ICR} test, rather than changing the input voltages, to provide greater accuracy.

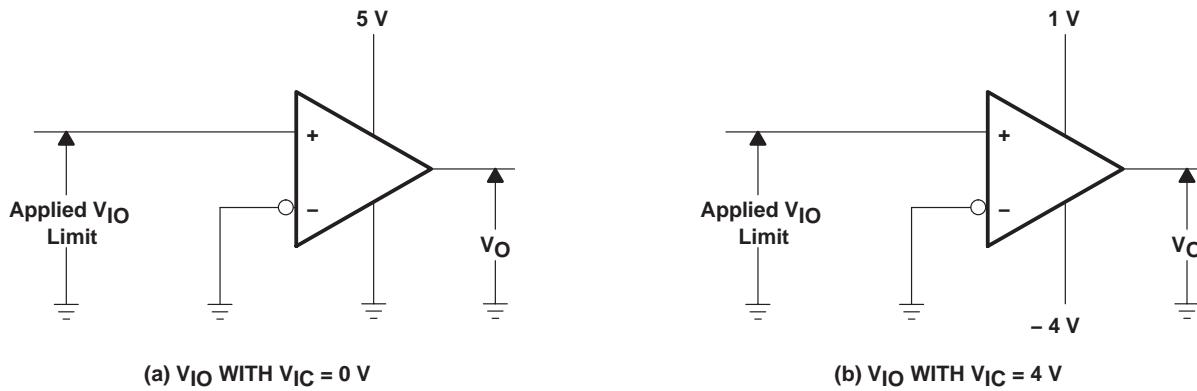


Figure 5. Method for Verifying That Input Offset Voltage Is Within Specified Limits

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 6 illustrates a practical circuit for direct dc measurement of input offset voltage that does not bias the comparator in the linear region. The circuit consists of a switching mode servo loop in which IC1a generates a triangular waveform of approximately 20-mV amplitude. IC1b acts as a buffer, with C2 and R4 removing any residual d.c. 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 IC1c through the voltage divider formed by R8 and R9. 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 R8 and R9 provides an increase in the input offset voltage by a factor of 100 to make measurement easier. The values of R5, R7, R8, and R9 can significantly influence the accuracy of the reading; therefore, it is suggested that their tolerance level be one percent 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.

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

PARAMETER MEASUREMENT INFORMATION

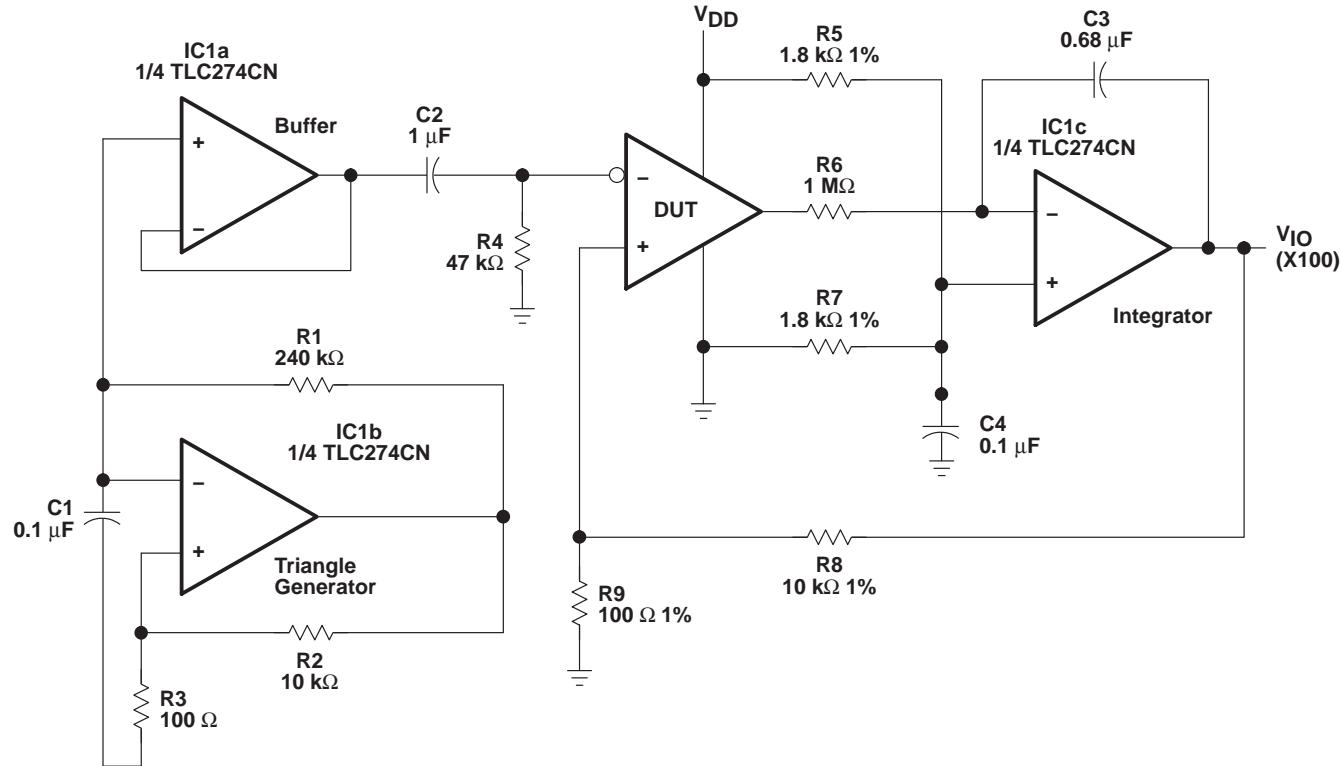
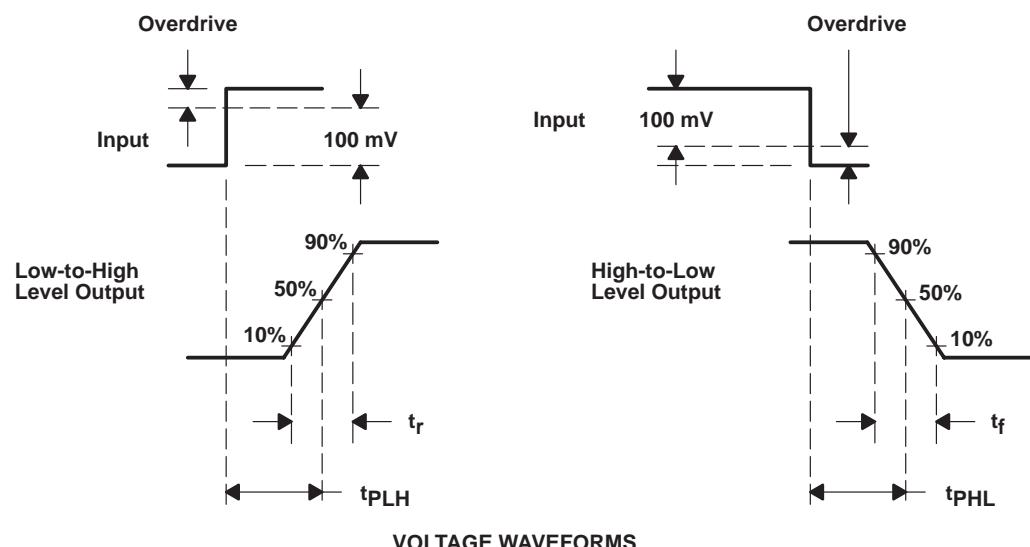
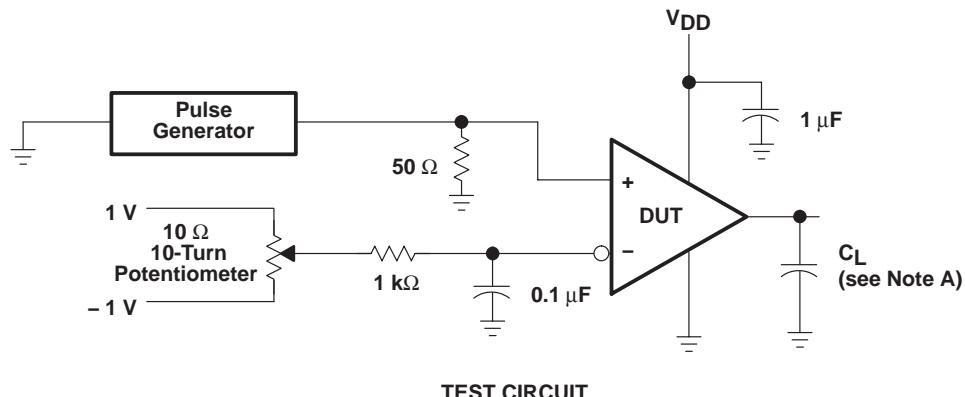


Figure 6. Circuit for Input Offset Voltage Measurement

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 for the low-to-high-level output is measured from the leading edge of the input pulse, while response time for the 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 7, so that the circuit is just at the transition point. A low signal, for example 105-mV or 5-mV overdrive, causes the output to change state.

PARAMETER MEASUREMENT INFORMATION



NOTE A: C_L includes probe and jig capacitance.

Figure 7. Response, Rise, and Fall Times Circuit and Voltage Waveforms

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	Distribution	8
I_{IB}	Input bias current	vs Free-air temperature	9
CMRR	Common-mode rejection ratio	vs Free-air temperature	10
k_{SVR}	Supply-voltage rejection ratio	vs Free-air temperature	11
V_{OH}	High-level output current	vs Free-air temperature	12
		vs High-level output current	13
V_{OL}	Low-level output voltage	vs Low-level output current	14
		vs Free-air temperature	15
t_{ℓ}	Output transition time	vs Load capacitance	16
	Supply current response to an output voltage transition		17
	Low-to-high-level output response for various input overdrives		18
	High-to-low-level output response for various input overdrives		19
t_{PLH}	Low-to-high-level output response time	vs Supply voltage	20
t_{PHL}	High-to-low-level output response time	vs Supply voltage	21
I_{DD}	Supply current	vs Frequency	22
		vs Supply voltage	23
		vs Free-air temperature	24

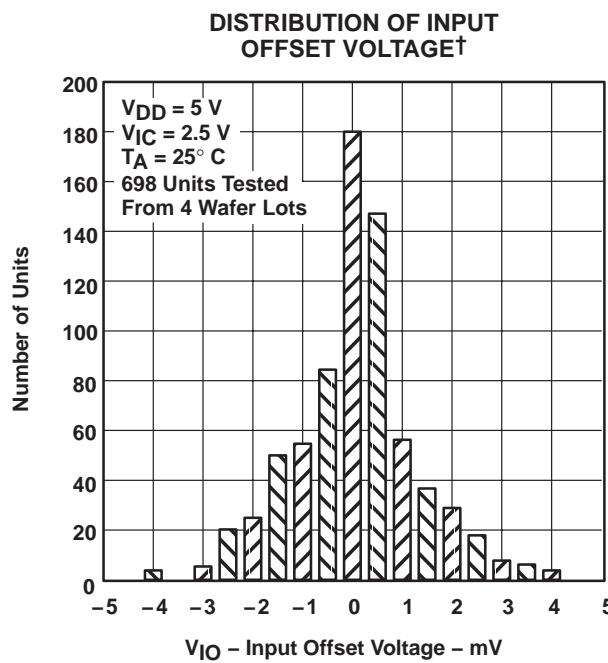


Figure 8

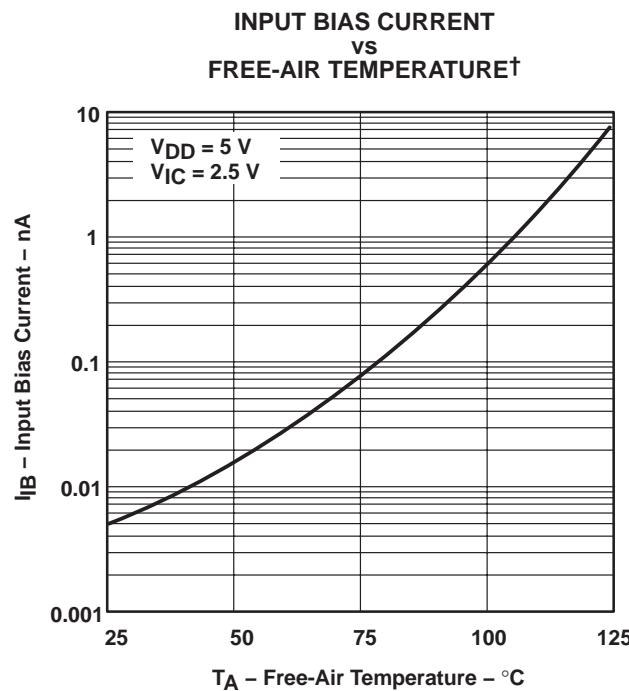
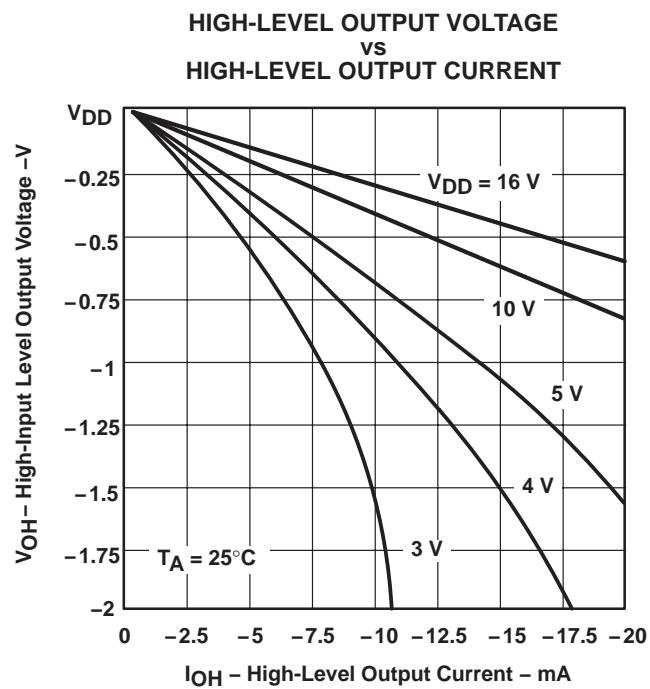
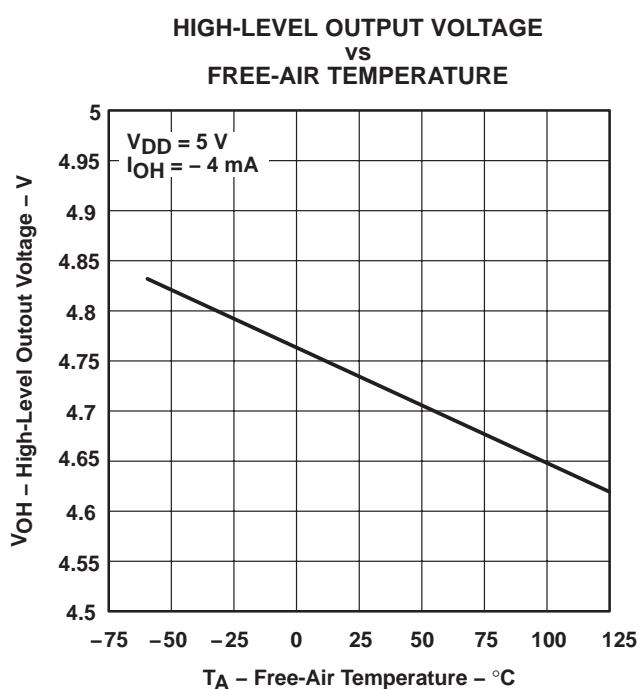
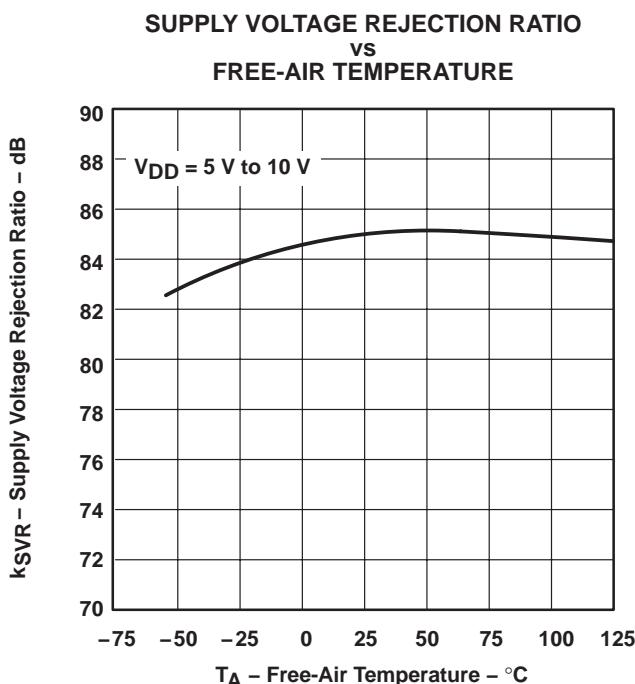
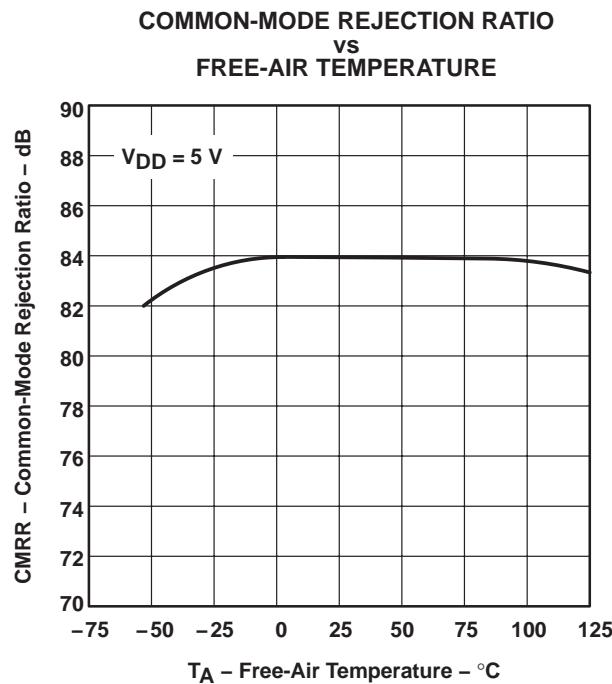


Figure 9

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

TYPICAL CHARACTERISTICS[†]



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

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

TYPICAL CHARACTERISTICS†

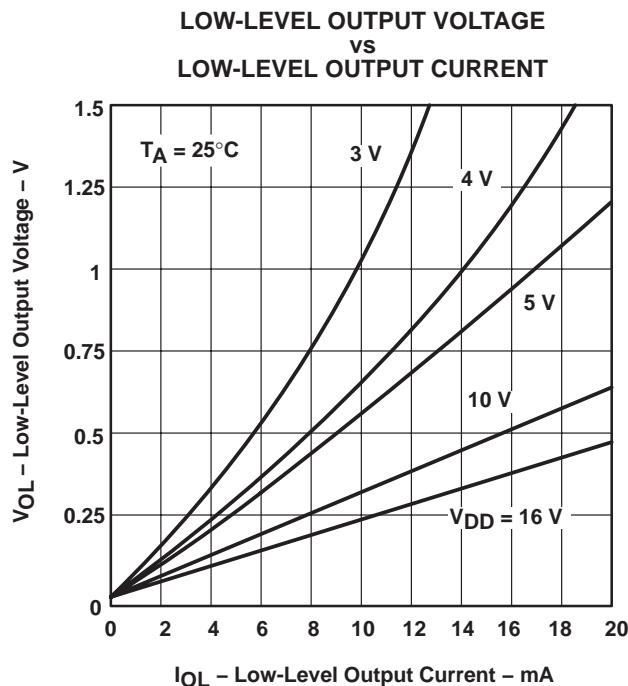


Figure 14

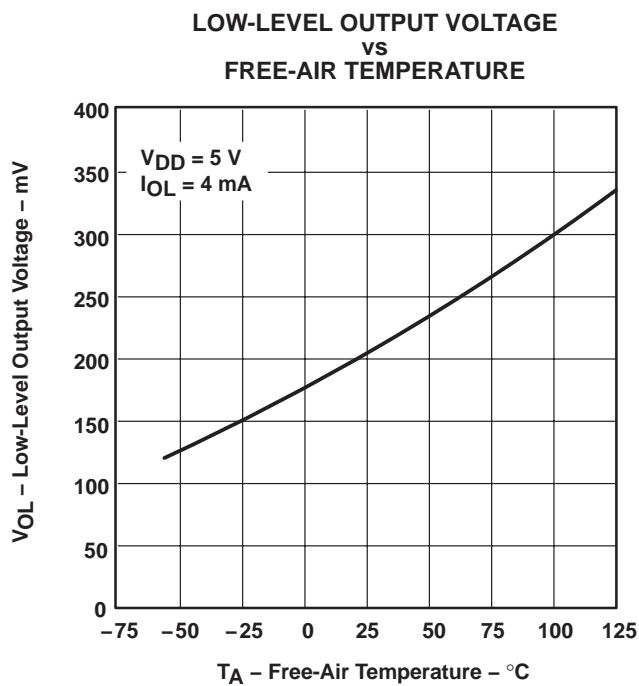


Figure 15

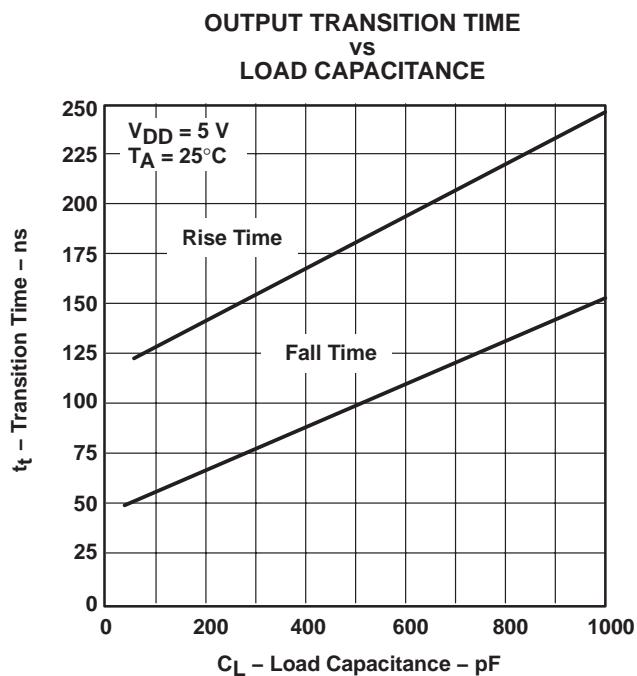


Figure 16

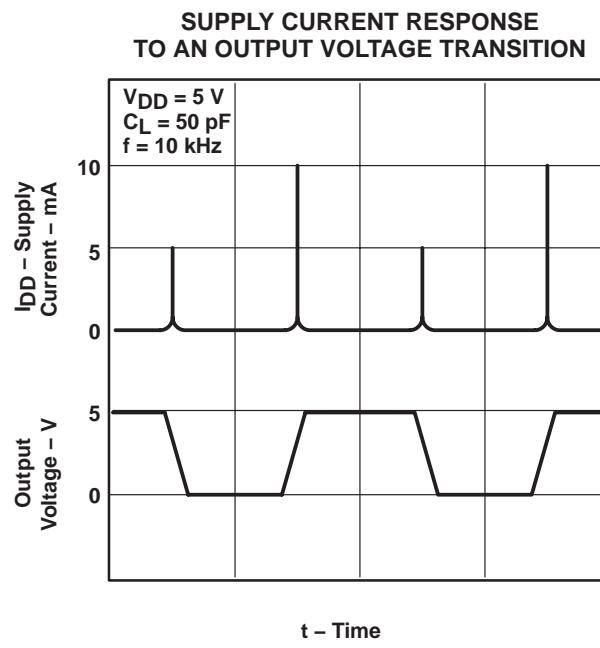


Figure 17

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

TYPICAL CHARACTERISTICS

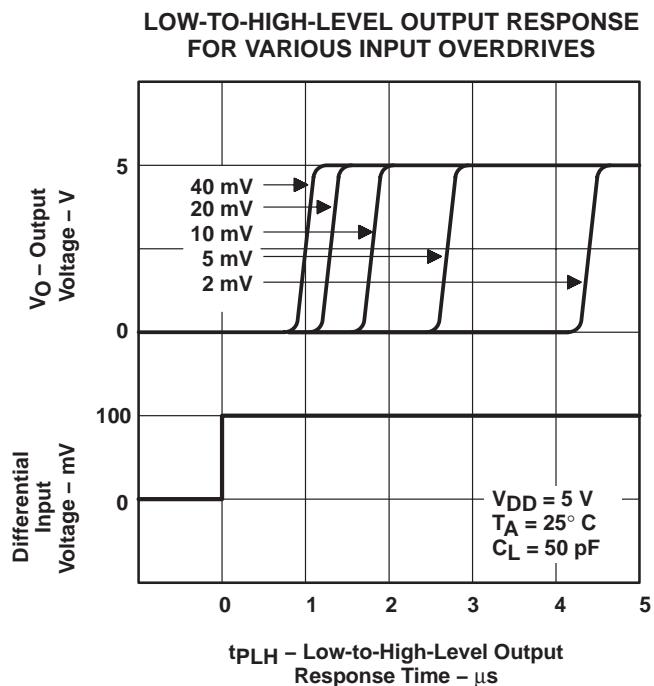


Figure 18

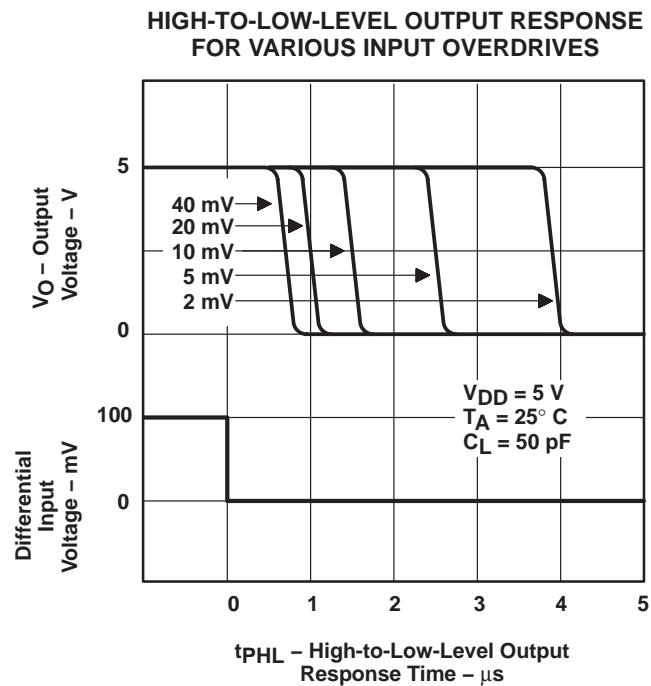


Figure 19

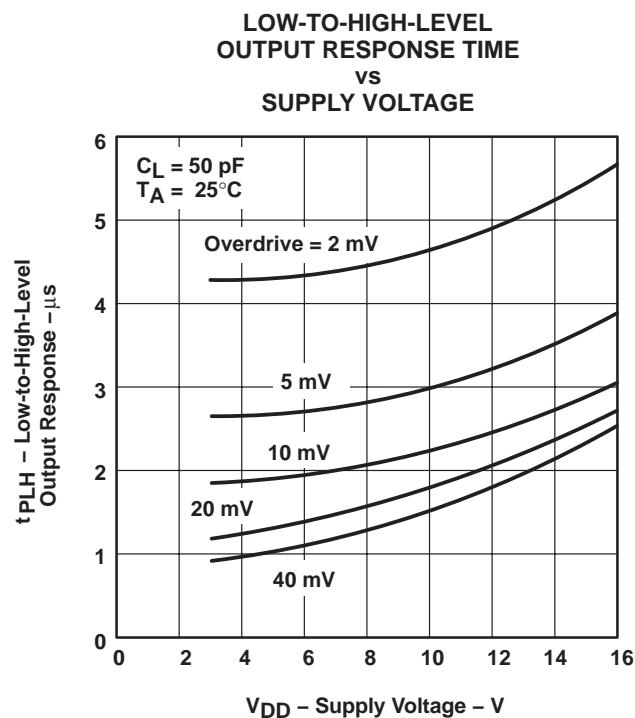


Figure 20

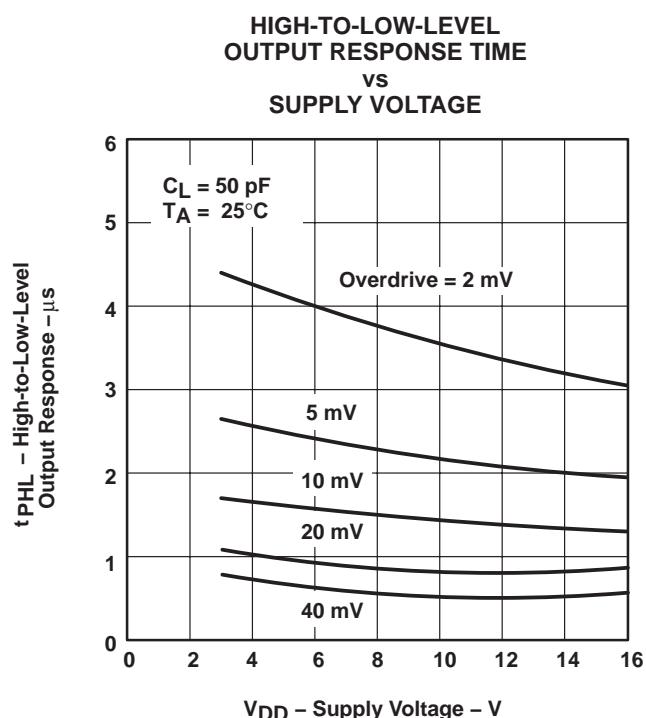


Figure 21

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

TYPICAL CHARACTERISTICS†

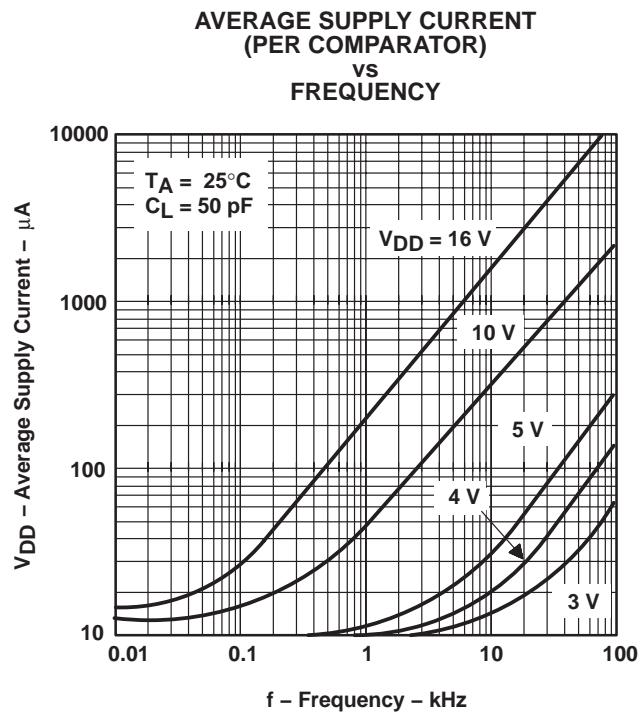


Figure 22

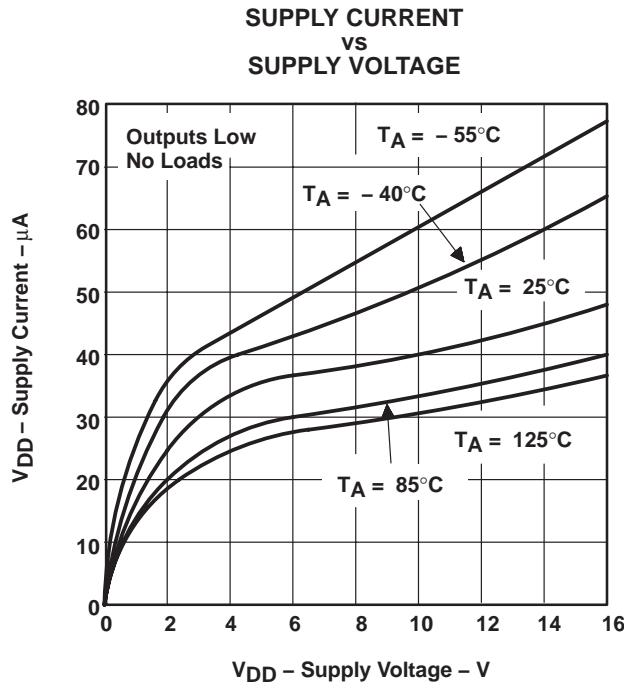


Figure 23

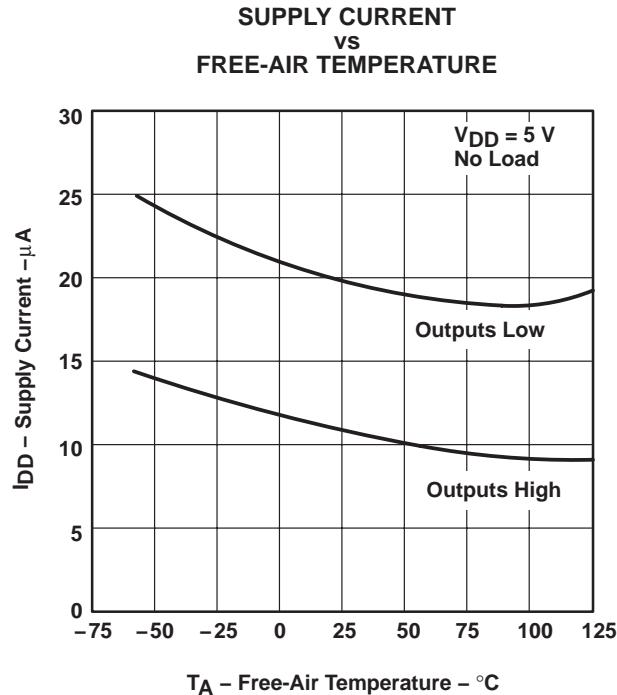


Figure 24

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

APPLICATION INFORMATION

The inputs should always remain within the supply rails in order to avoid forward biasing the diodes in the electrostatic discharge (ESD) protection structure. If either input exceeds this range, the device is not damaged as long as the input is limited to less than 5 mA. To maintain the expected output state, the inputs must remain within the common-mode range. For example, at 25°C with $V_{DD} = 5$ V, both inputs must remain between –0.2 V and 4 V to ensure proper device operation. To ensure reliable operation, the supply should be decoupled with a capacitor (0.1 μ F) that is positioned as close to the device as possible.

Output and supply current limitations should be watched carefully since the TLC3704 does not provide current protection. For example, each output can source or sink a maximum of 20 mA; however, the total current to ground can only be an absolute maximum of 60 mA. This prohibits sinking 20 mA from each of the four outputs simultaneously since the total current to ground would be 80 mA.

The TLC3704 has internal ESD-protection circuits that prevents functional failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015.2; however, care should be exercised in handling these devices as exposure to ESD may result in the degradation of the device parametric performance.

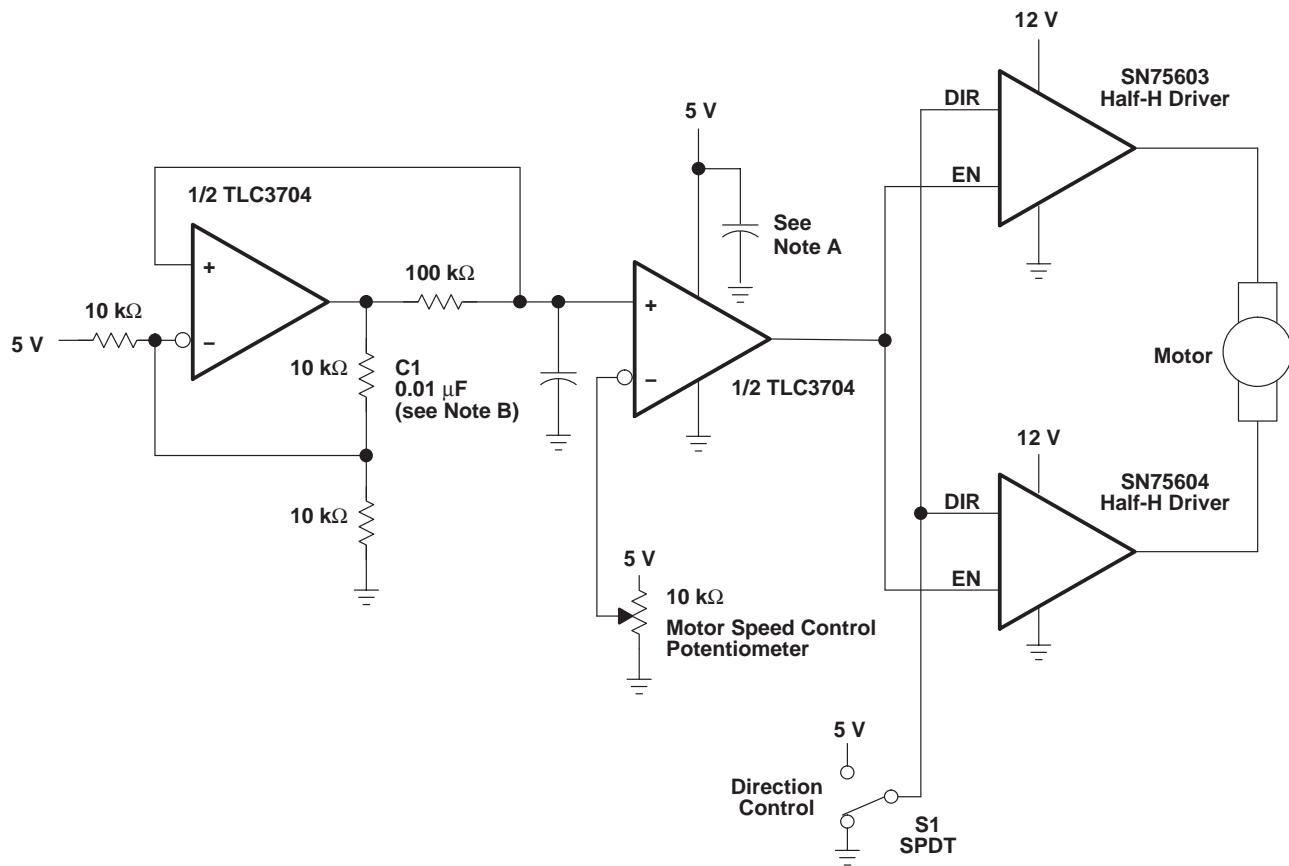
Table of Applications

	FIGURE
Pulse-width-modulated motor speed controller	25
Enhanced supply supervisor	26
Two-phase nonoverlapping clock generator	27
Micropower switching regulator	28

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

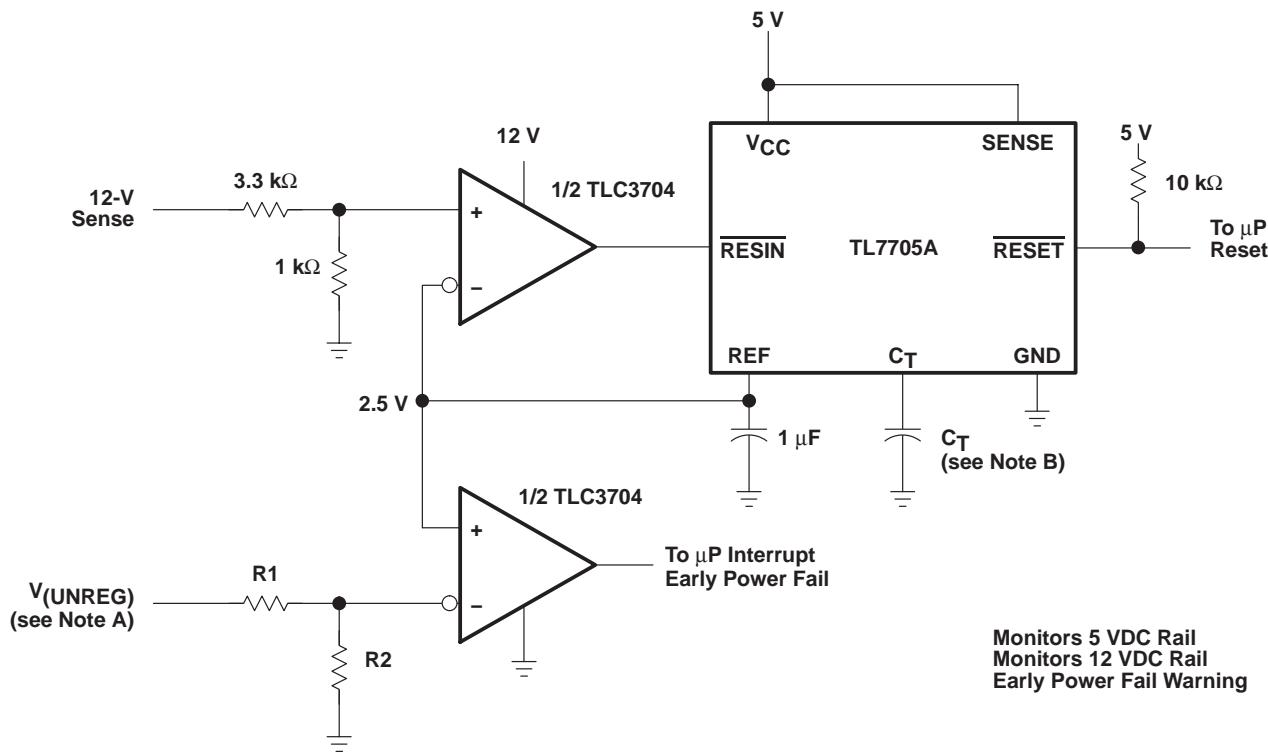
APPLICATION INFORMATION



NOTES: A. The recommended minimum capacitance is 10 μ F to eliminate common ground switching noise.
B. Adjust C1 for change in oscillator frequency

Figure 25. Pulse-Width-Modulated Motor Speed Controller

APPLICATION INFORMATION



NOTES: A. $V_{(UNREG)} = 2.5 \frac{(R1 + R2)}{R2}$

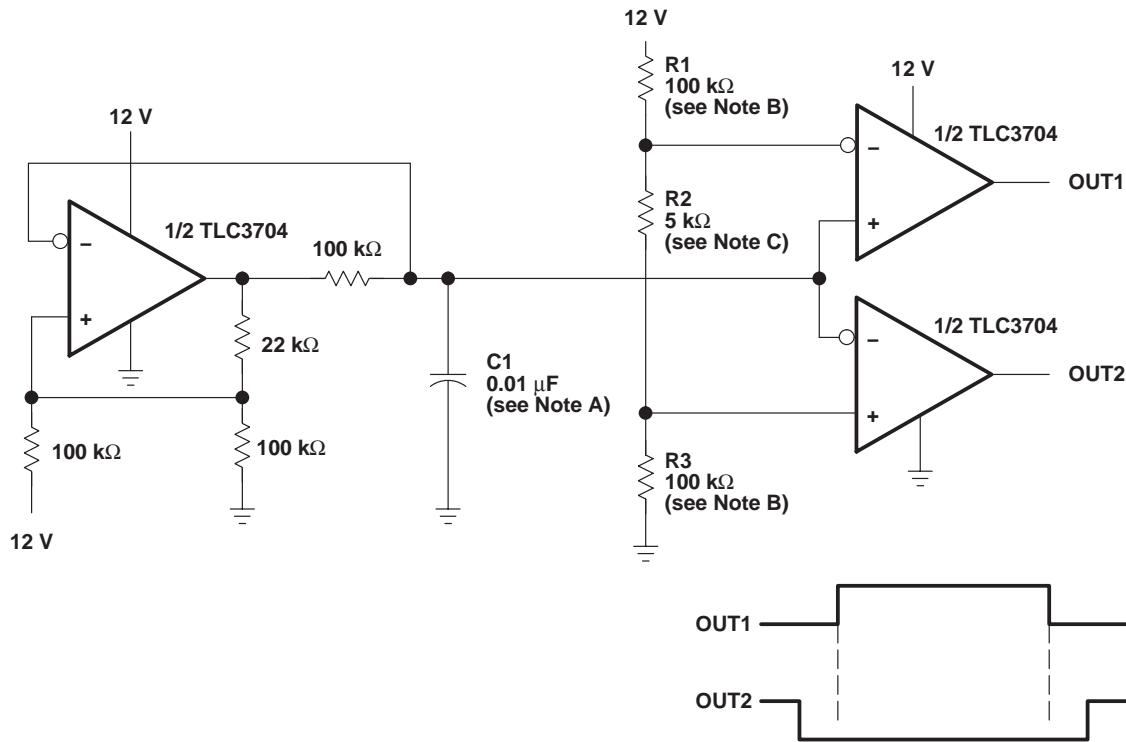
B. The value of C_T determines the time delay of reset.

Figure 26. Enhanced Supply Supervisor

TLC3704, TLC3704M QUAD MICROPOWER LinCMOS™ VOLTAGE COMPARATORS

SLCS117C – NOVEMBER 1986 – REVISED NOVEMBER 2009

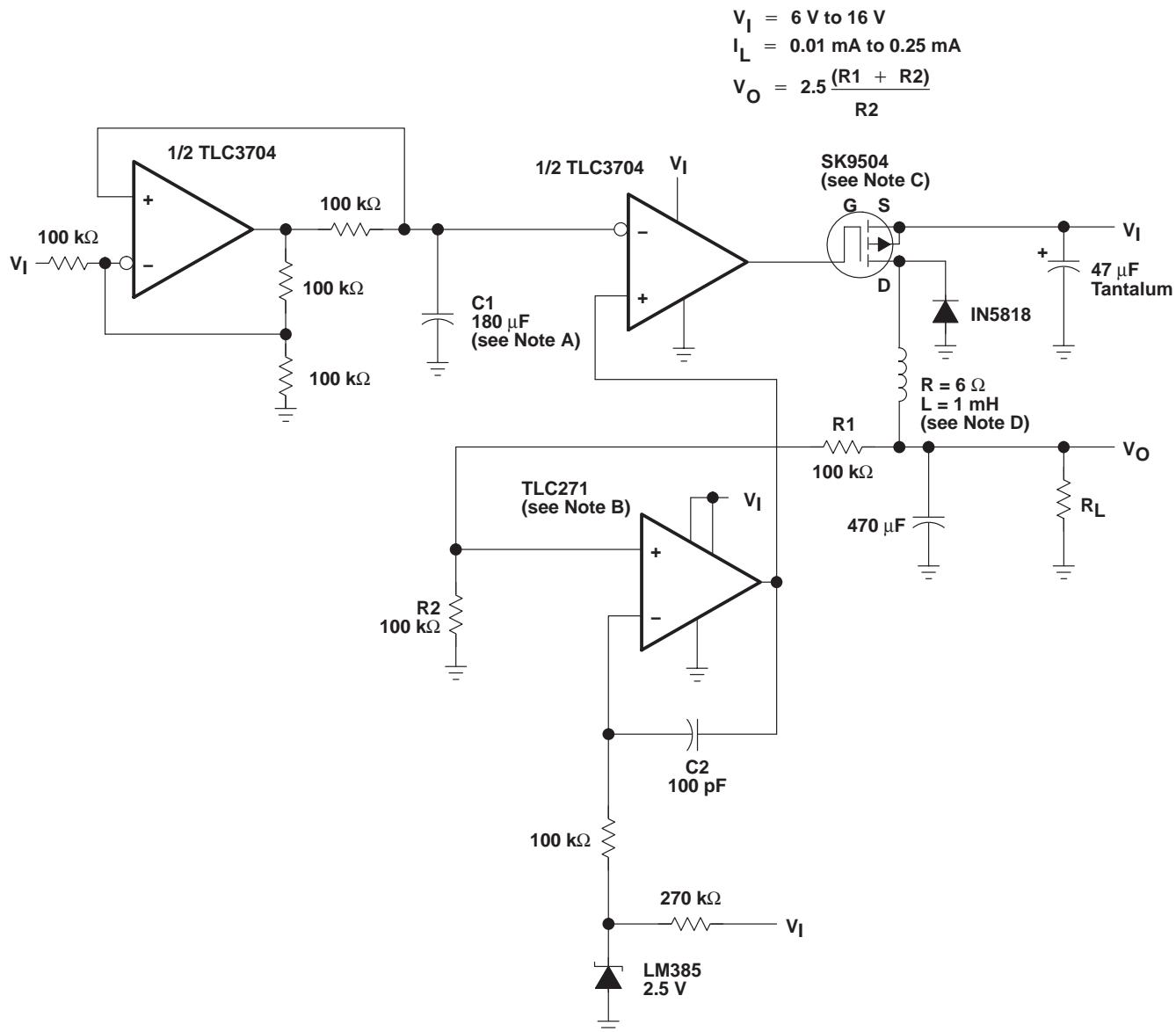
APPLICATION INFORMATION



NOTES: A. Adjust C1 for a change in oscillator frequency where:
 $1/f = 1.85(100 \text{ k}\Omega)C1$
B. Adjust R1 and R3 to change duty cycle
C. Adjust R2 to change deadtime

Figure 27. Two-Phase Nonoverlapping Clock Generator

APPLICATION INFORMATION



NOTES:

- A. Adjust C1 for a change in oscillator frequency
- B. TLC271 – Tie pin 8 to pin 7 for low bias operation
- C. SK9504 – $V_{DS} = 40 \text{ V}$
 $IDS = 1 \text{ A/will}$
- D. To achieve microampere current drive, the inductance of the circuit must be increased.

Figure 28. Micropower Switching Regulator

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
5962-9096901M2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-9096901MCA	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type
TLC3704CD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704CDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704CDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704CDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704CN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC3704CNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC3704CNSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704CNSRG4	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704CPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704CPWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704CPWLE	OBsolete	TSSOP	PW	14		TBD	Call TI	Call TI
TLC3704CPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704CPWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704ID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704IDG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704IDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704IDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704IN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC3704INE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
TLC3704IPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704IPWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704IPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704IPWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704MD	ACTIVE	SOIC	D	14	50	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLC3704MDG4	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)								
TLC3704MDR	ACTIVE	SOIC	D	14	2500	TBD	CU NIPDAU	Level-1-220C-UNLIM
TLC3704MDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLC3704MFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
TLC3704MJ	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type
TLC3704MJB	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type

⁽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.

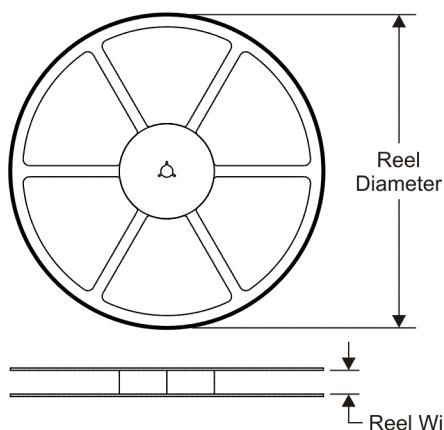
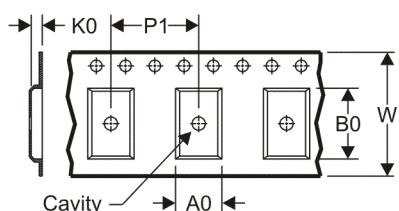
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF TLC3704, TLC3704M :

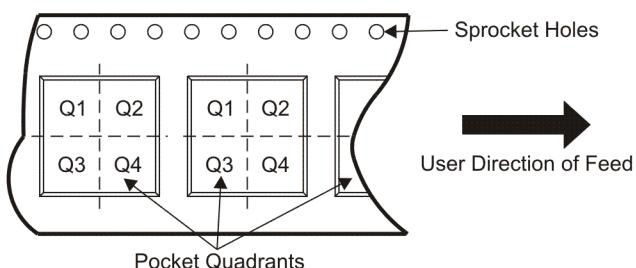
- Automotive: [TLC3704-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION
REEL DIMENSIONS

TAPE DIMENSIONS


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

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLC3704CDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC3704CNSR	SO	NS	14	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1
TLC3704CPWR	TSSOP	PW	14	2000	330.0	12.4	7.0	5.6	1.6	8.0	12.0	Q1
TLC3704IDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLC3704IPWR	TSSOP	PW	14	2000	330.0	12.4	7.0	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS

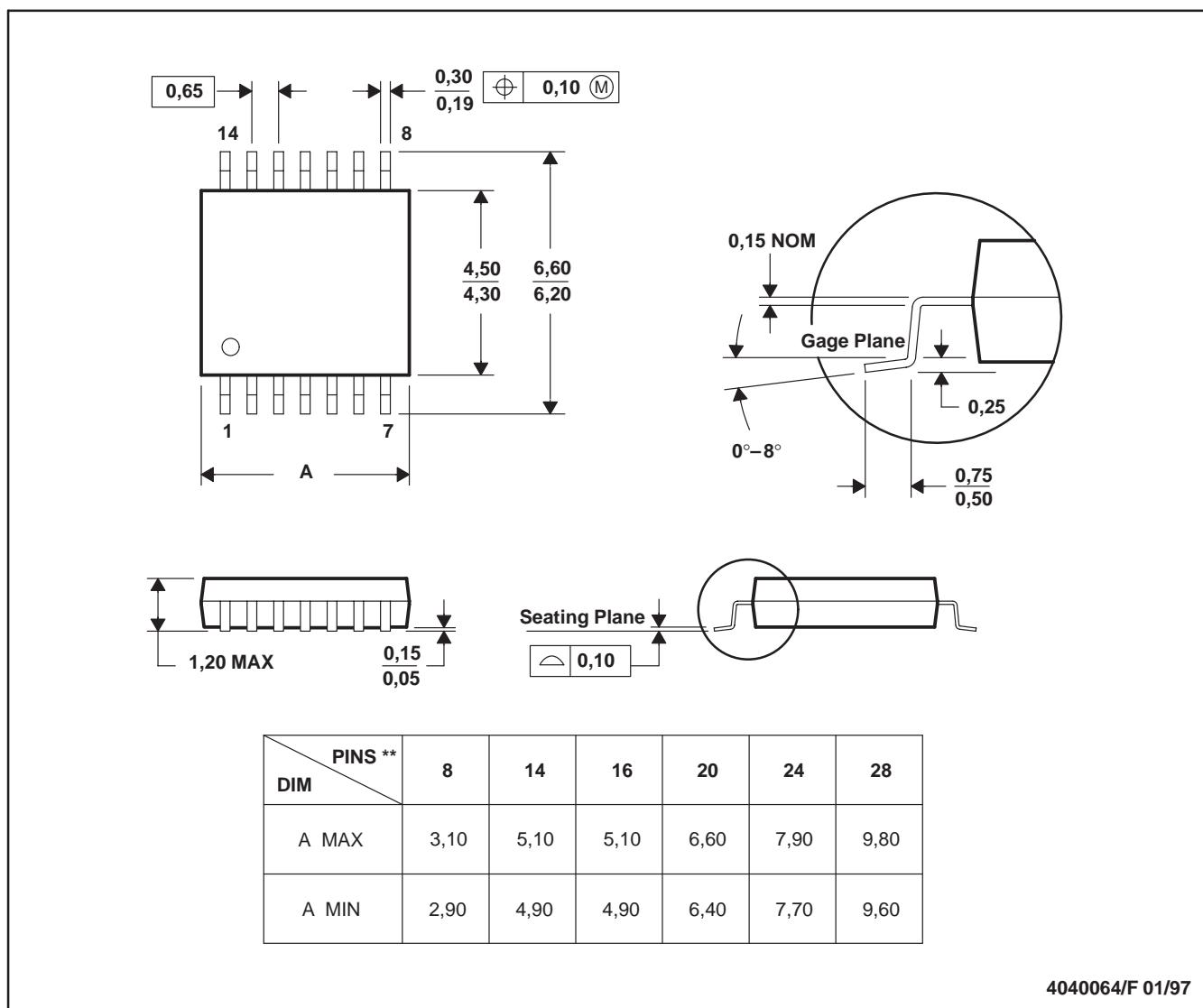

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLC3704CDR	SOIC	D	14	2500	346.0	346.0	33.0
TLC3704CNSR	SO	NS	14	2000	346.0	346.0	33.0
TLC3704CPWR	TSSOP	PW	14	2000	346.0	346.0	29.0
TLC3704IDR	SOIC	D	14	2500	346.0	346.0	33.0
TLC3704IPWR	TSSOP	PW	14	2000	346.0	346.0	29.0

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



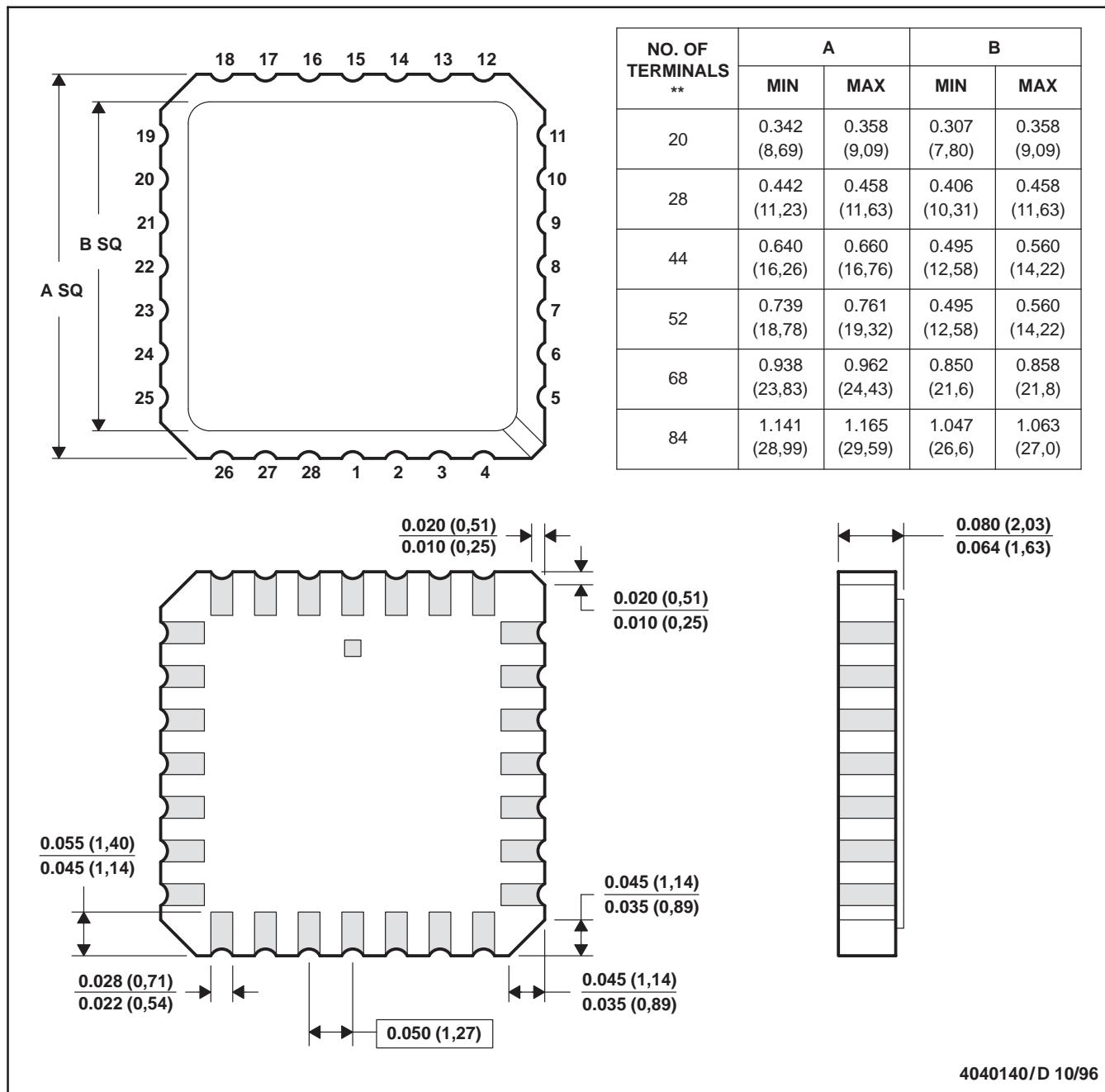
NOTES:

- All linear dimensions are in millimeters.
- This drawing is subject to change without notice.
- Body dimensions do not include mold flash or protrusion not to exceed 0,15.
- Falls within JEDEC MO-153

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



NOTES: A. All linear dimensions are in inches (millimeters).

B. This drawing is subject to change without notice.

C. This package can be hermetically sealed with a metal lid.

D. The terminals are gold plated.

E. Falls within JEDEC MS-004

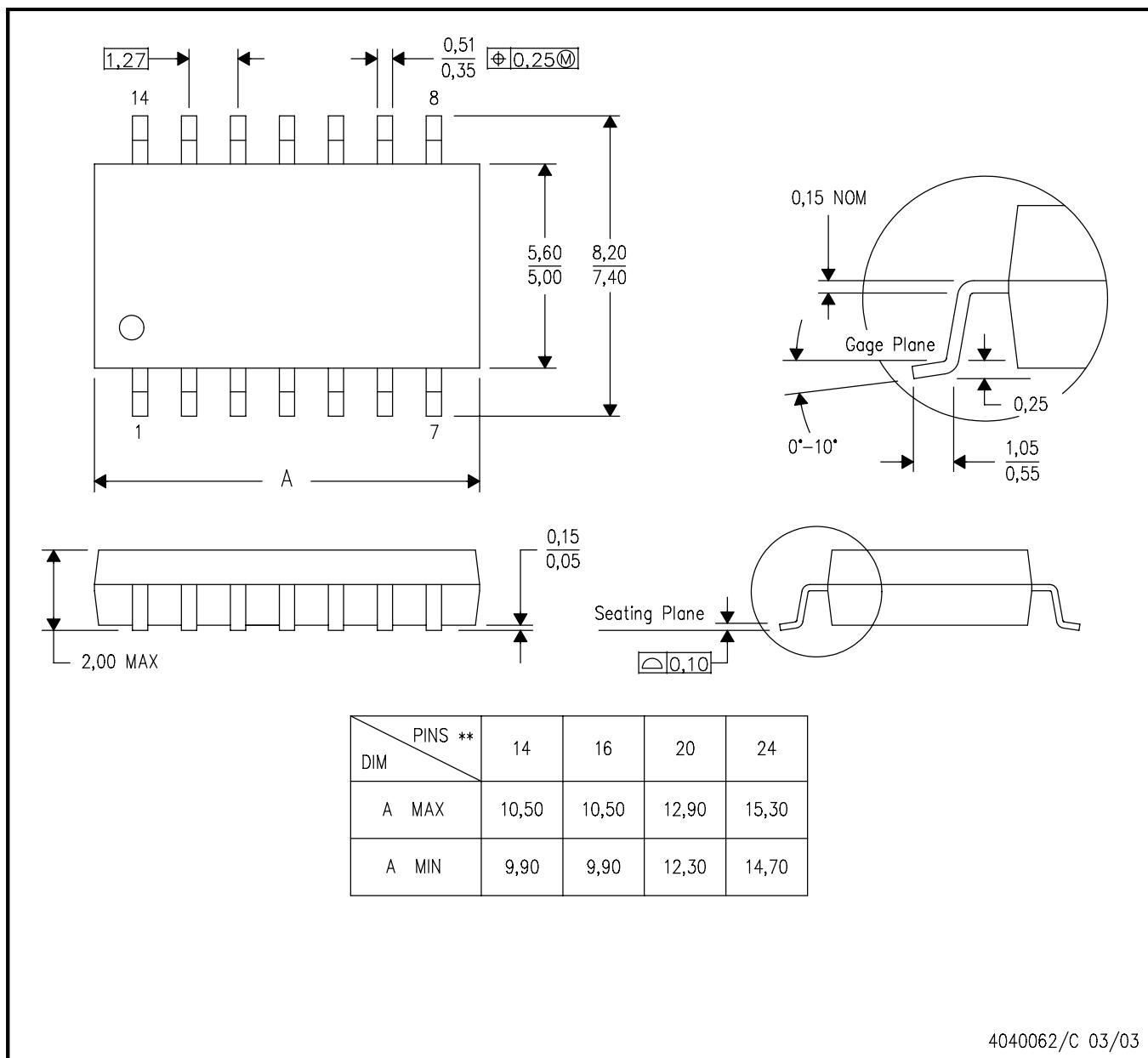
4040140/D 10/96

MECHANICAL DATA

NS (R-PDSO-G**)

14-PINS SHOWN

PLASTIC SMALL-OUTLINE PACKAGE



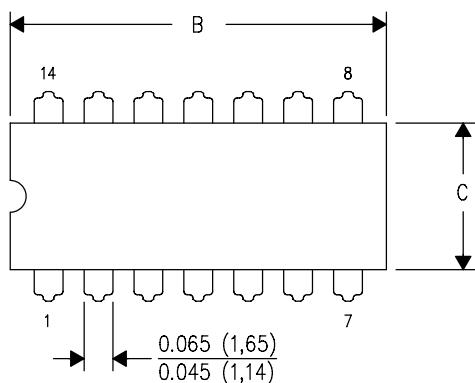
4040062/C 03/03

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.

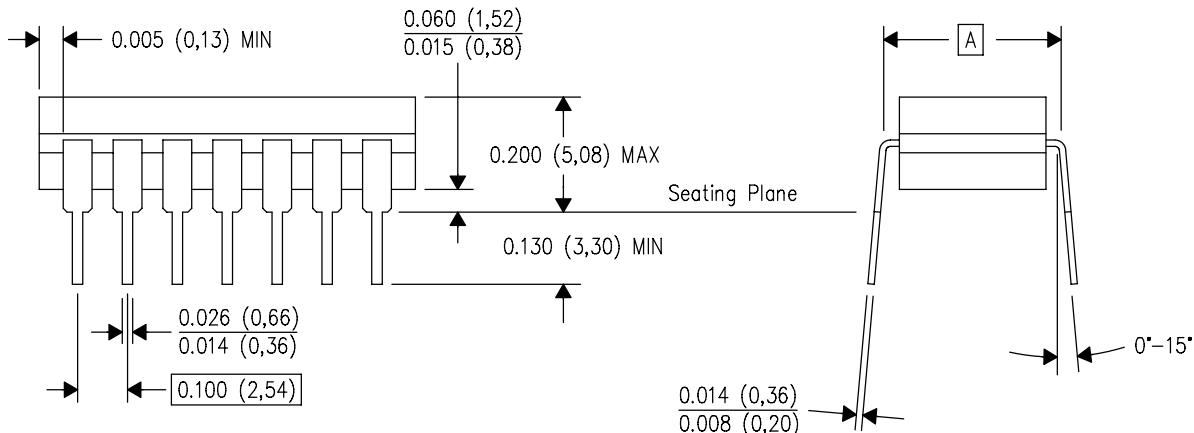
J (R-GDIP-T**)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



PINS ** DIM	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)

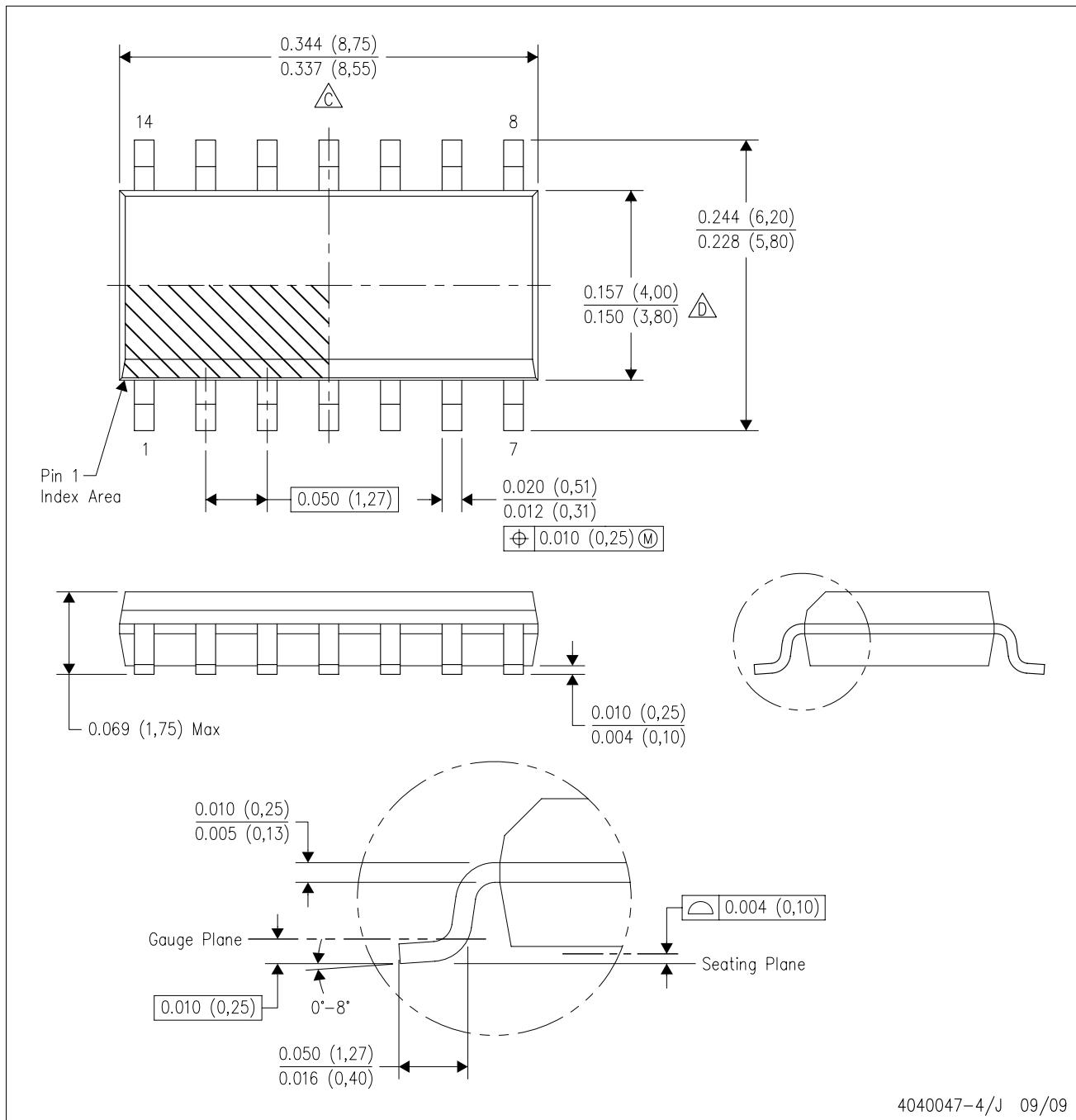


4040083/F 03/03

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package is hermetically sealed with a ceramic lid using glass frit.
D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

D (R-PDSO-G14)

PLASTIC SMALL-OUTLINE PACKAGE



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 TI 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. 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.

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
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
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 © 2009, Texas Instruments Incorporated