

# TLC193, TLC393 DUAL MICROPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115E – DECEMBER 1986 – REVISED JULY 2003

- Very Low Power . . . 110  $\mu$ W Typ at 5 V
- Fast Response Time . . .  $t_{PLH} = 2.5 \mu$ s Typ With 5-mV Overdrive
- Single Supply Operation:
  - TLC393C . . . 3 V to 16 V
  - TLC393I . . . 3 V to 16 V
  - TLC393Q . . . 4 V to 16 V
  - TLC393M . . . 4 V to 16 V
  - TLC193M . . . 4 V to 16 V
- On-Chip ESD Protection

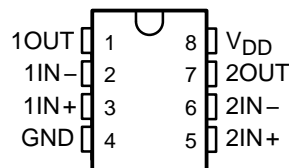
## description

The TLC193 and TLC393 consist of dual independent micropower voltage comparators designed to operate from a single supply. They are functionally similar to the LM393 but uses one-twentieth the power for similar response times. The open-drain MOS output stage interfaces to a variety of loads and supplies. For a similar device with a push-pull output configuration (see the TLC3702 data sheet).

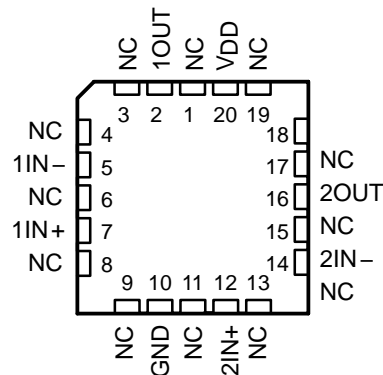
Texas Instruments LinCMOS™ process offers superior analog performance to standard CMOS processes. Along with the standard CMOS advantages of low power without sacrificing speed, high input impedance, and low bias currents, the LinCMOS™ process offers extremely stable input offset voltages, even with differential input stresses of several volts. This characteristic makes it possible to build reliable CMOS comparators.

The TLC393C is characterized for operation over the commercial temperature range of  $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ . The TLC393I is characterized for operation over the extended industrial temperature range of  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ . The TLC393Q is characterized for operation over the full automotive temperature range of  $T_A = -40^\circ\text{C}$  to  $125^\circ\text{C}$ . The TLC193M and TLC393M are characterized for operation over the full military temperature range of  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C}$ .

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

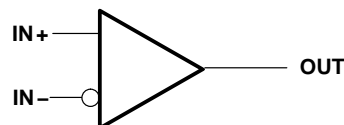


FK PACKAGE  
(TOP VIEW)



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. 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.

 **TEXAS  
INSTRUMENTS**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265  
POST OFFICE BOX 1443 • HOUSTON, TEXAS 77251-1443

Copyright © 1986-2003, Texas Instruments Incorporated

# TLC193, TLC393

## DUAL MICROWPOWER LinCMOS™ VOLTAGE COMPARATOR

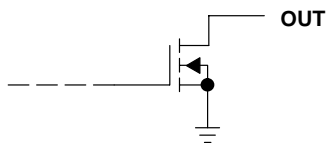
SLCS115D – DECEMBER 1986 – REVISED JULY 2003

### AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IOmax</sub> at 25°C	PACKAGES				
		SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (JG)	PLASTIC DIP (P)	TSSOP (PW)
0°C to 70°C	5 mV	TLC393CD	—	—	TLC393CP	TLC393CPWLE
– 40°C to 85°C	5 mV	TLC393ID	—	—	TLC393IP	TLC393IPWLE
– 40°C to 125°C	5 mV	TLC393QD	—	—	—	—
– 55°C to 125°C	5 mV	TLC393MD	TLC193MFK	TLC193MJG	TLC393MP	—

The D package is available taped and reeled. Add the suffix R to the device type (e.g., TLC393CDR).

### schematic



OPEN-DRAIN CMOS OUTPUT

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

Supply voltage range, V <sub>DD</sub> (see Note 1)	– 0.3 V to 18 V
Differential input voltage, V <sub>ID</sub> (see Note 2)	±18 V
Input voltage range, V <sub>I</sub>	– 0.3 V to V <sub>DD</sub>
Output voltage range, V <sub>O</sub>	– 0.3 V to 16 V
Input current, I <sub>I</sub>	±5 mA
Output current, I <sub>O</sub> (each output)	20 mA
Total supply current into V <sub>DD</sub>	40 mA
Total current out of GND	40 mA
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range:	
TLC393C	0°C to 70°C
TLC393I	– 40°C to 85°C
TLC393Q	– 40°C to 125°C
TLC393M	– 55°C to 125°C
TLC193M	– 55°C to 125°C
Storage temperature range	– 65°C to 150°C
Case temperature for 60 seconds: FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or P package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°C

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

- NOTES: 1. All voltage values, except differential voltages, are with respect to network ground.  
2. Differential voltages are at IN+ with respect to IN–.

### DISSIPATION RATING TABLE

PACKAGE	T <sub>A</sub> ≤ 25°C POWER RATING	DERATING FACTOR ABOVE T <sub>A</sub> = 25°C	T <sub>A</sub> = 70°C POWER RATING	T <sub>A</sub> = 85°C POWER RATING	T <sub>A</sub> = 125°C POWER RATING
D	725 mW	5.8 mW/°C	464 mW	377 mW	145 mW
FK	1375 mW	11.0 mW/°C	880 mW	715 mW	275 mW
JG	1050 mW	8.4 mW/°C	672 mW	546 mW	210 mW
P	1000 mW	8.0 mW/°C	640 mW	520 mW	—
PW	525 mW	4.2 mW/°C	336 mW	273 mW	—



# TLC193, TLC393

## DUAL MICROPPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115E – DECEMBER 1986 – REVISED JULY 2003

### recommended operating conditions

	TLC393C			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
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†	$T_A$	TLC393C			UNIT
			MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = V_{ICRmin}$ , $V_{DD} = 5$ V to 10 V, See Note 3	25°C		1.4	5	mV
		0°C to 70°C			6.5	
$I_{IO}$ Input offset current	$V_{IC} = 2.5$ V	25°C		1		pA
		70°C			0.3	nA
$I_{IB}$ Input bias current	$V_{IC} = 2.5$ V	25°C		5		pA
		70°C			0.6	nA
$V_{ICR}$ Common-mode input voltage range		25°C	0 to $V_{DD} - 1$			V
		0°C to 70°C	0 to $V_{DD} - 1.5$			
CMMR 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			
$V_{OL}$ Low-level output voltage	$V_{ID} = -1$ V, $I_{OL} = 6$ mA	25°C		300	400	mV
		70°C			650	
$I_{OH}$ High-level output current	$V_{ID} = 1$ V, $V_O = 5$ V	25°C		0.8	40	nA
		70°C			1	μA
$I_{DD}$ Supply current (both comparators)	Outputs low, No load	25°C		22	40	μA
		0°C to 70°C			50	

† 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.



# TLC193, TLC393

## DUAL MICROWPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115D – DECEMBER 1986 – REVISED JULY 2003

### recommended operating conditions

	TLC393I			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
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 (unless otherwise noted)

PARAMETER	TEST CONDITION†	$T_A$	TLC393I			UNIT
			MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = V_{ICRmin}$ , $V_{DD} = 5$ V to 10 V, See Note 3	25°C		1.4	5	mV
		-40°C to 85°C			7	
$I_{IO}$ Input offset current	$V_{IC} = 2.5$ V	25°C		1		pA
		85°C			1	nA
$I_{IB}$ Input bias current	$V_{IC} = 2.5$ V	25°C		5		pA
		85°C			2	nA
$V_{ICR}$ Common-mode input voltage range		25°C	0 to $V_{DD} - 1$			V
		-40°C to 85°C	0 to $V_{DD} - 1.5$			
CMMR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C	84			dB
		85°C	84			
		-40°C	84			
$k_{SVR}$ Supply-voltage rejection ratio	$V_{DD} = 5$ V to 10 V	25°C	85			dB
		85°C	85			
		-40°C	84			
$V_{OL}$ Low-level output voltage	$V_{ID} = -1$ V, $I_{OL} = 6$ mA	25°C	300	400		mV
		85°C	700			
$I_{OH}$ High-level output current	$V_{ID} = 1$ V, $V_O = 5$ V	25°C	0.8		40	nA
		85°C	1			μA
$I_{DD}$ Supply current (both comparators)	Outputs low, No load	25°C	22		40	μA
		-40°C to 85°C	65			

† 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.



# TLC193, TLC393

## DUAL MICROPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115E – DECEMBER 1986 – REVISED JULY 2003

### recommended operating conditions

	TLC393Q			UNIT
	MIN	NOM	MAX	
Supply voltage, $V_{DD}$	4	5	16	V
Common-mode input voltage, $V_{IC}$	0	$V_{DD} - 1.5$		V
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 (unless otherwise noted)

PARAMETER	TEST CONDITION†	$T_A$	TLC393Q			UNIT
			MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = V_{ICRmin}$ , $V_{DD} = 5$ V to 10 V, See Note 4	25°C	1.4		5	mV
		-40°C to 125°C	10			
$I_{IO}$ Input offset current	$V_{IC} = 2.5$ V	25°C	1			pA
		125°C			15	nA
$I_{IB}$ Input bias current	$V_{IC} = 2.5$ V	25°C	5			pA
		125°C			30	nA
$V_{ICR}$ Common-mode input voltage range		25°C	0 to $V_{DD} - 1$			V
		-40°C to 125°C	0 to $V_{DD} - 1.5$			
CMMR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C	84			dB
		125°C	84			
		-40°C	84			
$k_{SVR}$ Supply-voltage rejection ratio	$V_{DD} = 5$ V to 10 V	25°C	85			dB
		125°C	84			
		-40°C	84			
$V_{OL}$ Low-level output voltage	$V_{ID} = -1$ V, $I_{OL} = 6$ mA	25°C	300	400		mV
		125°C	800			
$I_{OH}$ High-level output current	$V_{ID} = 1$ V, $V_O = 5$ V	25°C	0.8	40		nA
		125°C	1			μA
$I_{DD}$ Supply current (both comparators)	Outputs low, No load	25°C	22	40		μA
		-40°C to 125°C	90			

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

NOTE 4: 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 (with a 2.5-kΩ load to  $V_{DD}$ ).



# TLC193, TLC393

## DUAL MICROWPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115D – DECEMBER 1986 – REVISED JULY 2003

### recommended operating conditions

	TLC193M, TLC393M			UNIT
	MIN	NOM	MAX	
Supply voltage, $V_{DD}$	4	5	16	V
Common-mode input voltage, $V_{IC}$	0		$V_{DD} - 1.5$	V
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 (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	$T_A$	TLC193M, TLC393M			UNIT
			MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{IC} = V_{ICRmin}$ , $V_{DD} = 5$ V to 10 V, See Note 4	25°C		1.4	5	mV
		-55°C to 125°C			10	
$I_{IO}$ Input offset current	$V_{IC} = 2.5$ V	25°C		1		pA
		125°C			15	nA
$I_{IB}$ Input bias current	$V_{IC} = 2.5$ V	25°C		5		pA
		125°C			30	nA
$V_{ICR}$ Common-mode input voltage range		25°C	0 to $V_{DD} - 1$			V
		-55°C to 125°C	0 to $V_{DD} - 1.5$			
CMMR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C	84			dB
		125°C	84			
		-55°C	84			
$k_{SVR}$ Supply-voltage rejection ratio	$V_{DD} = 5$ V to 10 V	25°C	85			dB
		125°C	84			
		-55°C	84			
$V_{OL}$ Low-level output voltage	$V_{ID} = -1$ V, $I_{OL} = 6$ mA	25°C	300	400		mV
		125°C	800			
$I_{OH}$ High-level output current	$V_{ID} = 1$ V, $V_O = 5$ V	25°C	0.8		40	nA
		125°C	1			μA
$I_{DD}$ Supply current (both comparators)	Outputs low, No load	25°C	22		40	μA
		-55°C to 125°C	90			

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

NOTE 4: 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 (with a 2.5-kΩ load to  $V_{DD}$ ).



# TLC193, TLC393 DUAL MICROPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115E – DECEMBER 1986 – REVISED JULY 2003

switching characteristics,  $V_{DD} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (see Figure 3)

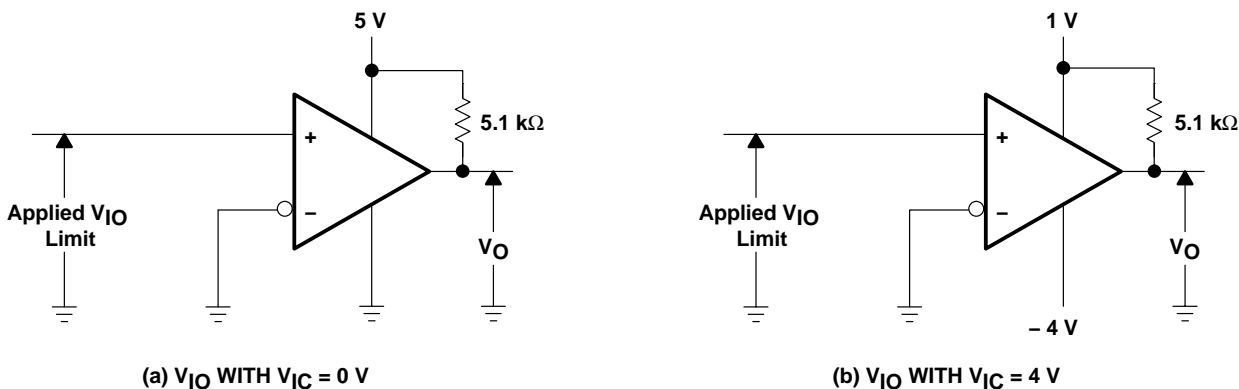
PARAMETER	TEST CONDITIONS	TLC393C, TLC393I TLC393Q, TLC193M, TLC393M			UNIT
		MIN	TYP	MAX	
$t_{PLH}$ Propagation delay time, low-to-high-level output	$f = 10\text{ kHz}$ , $C_L = 15\text{ pF}$	Overdrive = 2 mV	4.5		$\mu\text{s}$
		Overdrive = 5 mV	2.5		
		Overdrive = 10 mV	1.7		
		Overdrive = 20 mV	1.2		
		Overdrive = 40 mV	1.1		
$t_{PHL}$ Propagation delay time, high-to-low-level output	$f = 10\text{ kHz}$ , $C_L = 15\text{ pF}$	$V_I = 1.4\text{-V}$ step at IN+	1.1		$\mu\text{s}$
		Overdrive = 2 mV	3.6		
		Overdrive = 5 mV	2.1		
		Overdrive = 10 mV	1.3		
		Overdrive = 20 mV	0.85		
		Overdrive = 40 mV	0.55		
$t_f$ Fall time, output	$f = 10\text{ kHz}$ , $C_L = 15\text{ pF}$	$V_I = 1.4\text{-V}$ step at IN+	0.10		ns
		Overdrive = 50 mV	22		

## PARAMETER MEASUREMENT INFORMATION

The TLC393 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 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 testing parameters such as input offset voltage, common-mode rejection ratio, etc., are suggested.

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**



# TLC193, TLC393 DUAL MICROWPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115D – DECEMBER 1986 – REVISED JULY 2003

## 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 in 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.

The voltage divider formed by R9 and R10 provides an increase in 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.

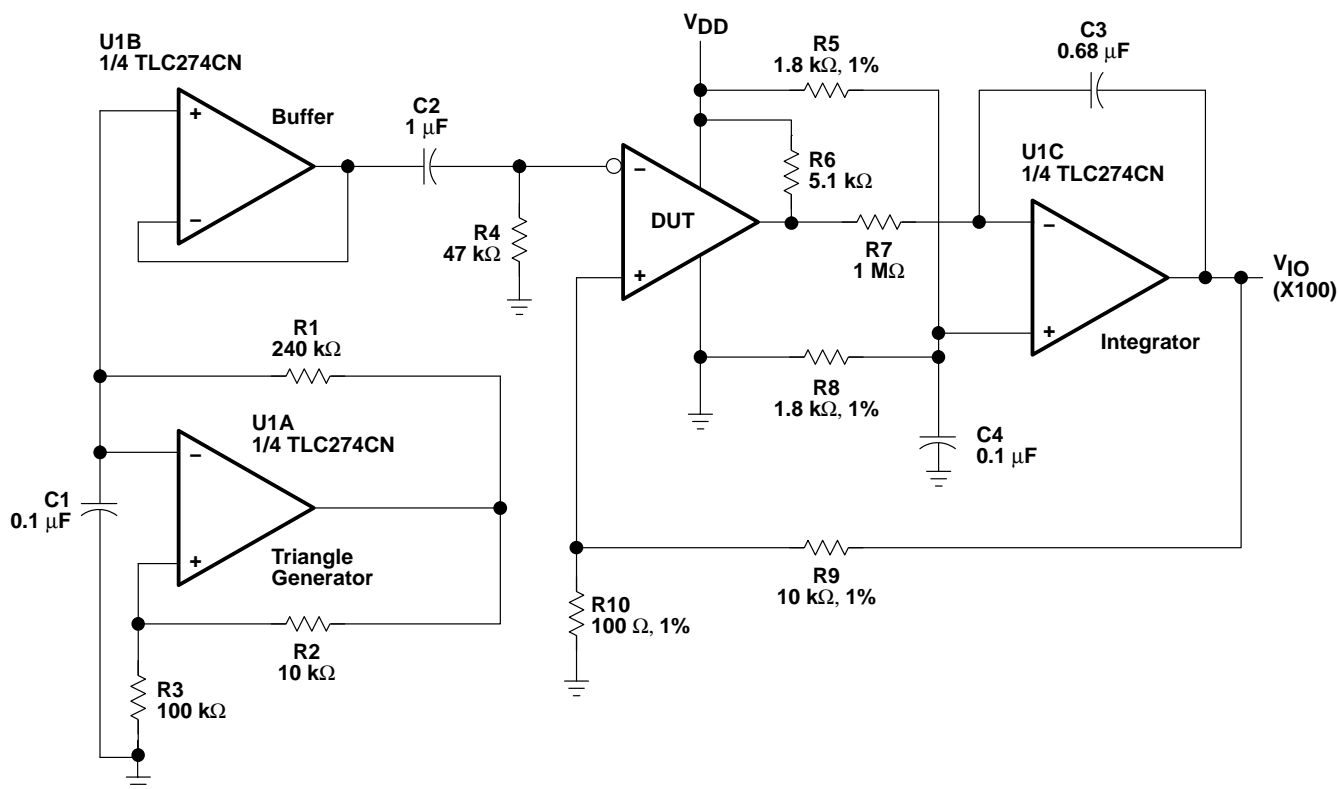
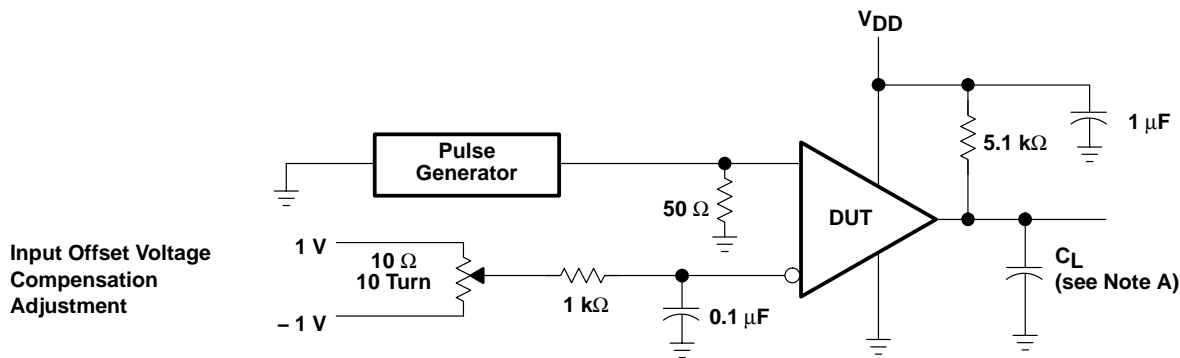


Figure 2. Circuit for Input Offset Voltage Measurement

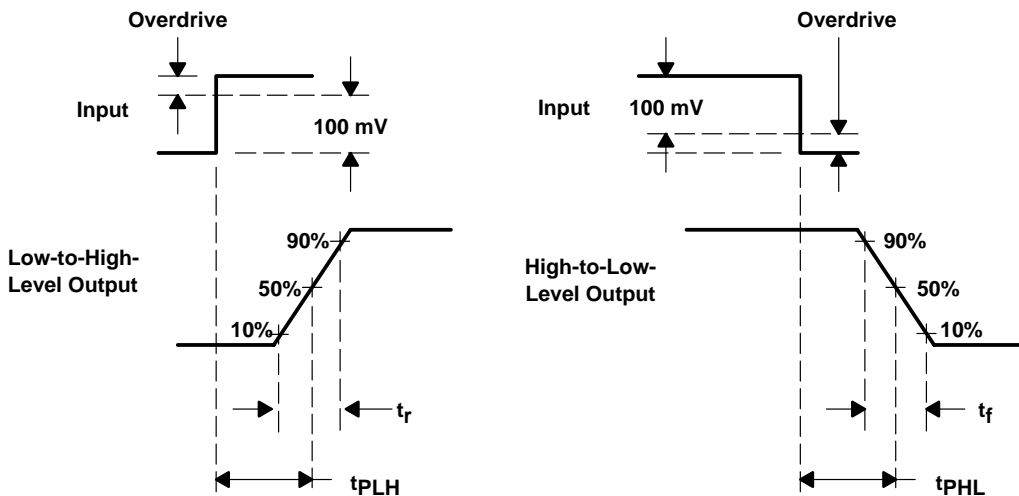


**PARAMETER MEASUREMENT INFORMATION**

Propagation delay 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. Propagation delay time, low-to-high-level output, is measured from the leading edge of the input pulse, while propagation delay time, high-to-low-level output, is measured from the trailing edge of the input pulse. Propagation delay 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.



**TEST CIRCUIT**



**VOLTAGE WAVEFORMS**

NOTE A:  $C_L$  includes probe and jig capacitance.

**Figure 3. Propagation Delay, Rise Time, and Fall Time Circuit and Voltage Waveforms**

# TLC193, TLC393 DUAL MICROWPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115D – DECEMBER 1986 – REVISED JULY 2003

## TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
$V_{IO}$	Input offset voltage	Distribution	4
$I_{IB}$	Input bias current	vs Free-air temperature	5
CMRR	Common-mode rejection ratio	vs Free-air temperature	6
$k_{SVR}$	Supply-voltage rejection ratio	vs Free-air temperature	7
$V_{OL}$	Low-level output voltage	vs Low-level output current	8
		vs Free-air temperature	9
$I_{OH}$	Low-level output current	vs High-level output voltage	10
		vs Free-air temperature	11
$I_{DD}$	Supply current	vs Supply voltage	12
		vs Free-air temperature	13
$t_{PLH}$	Low-to-high level output propagation delay time	vs Supply voltage	14
$t_{PHL}$	High-to-low level output propagation delay time	vs Supply voltage	15
	Low-to-high-level output response	Low-to-high level output propagation delay time	16
	High-to-low level output response	High-to-low level output propagation delay time	17
$t_f$	Fall time	vs Supply voltage	18

DISTRIBUTION OF INPUT  
OFFSET VOLTAGE†

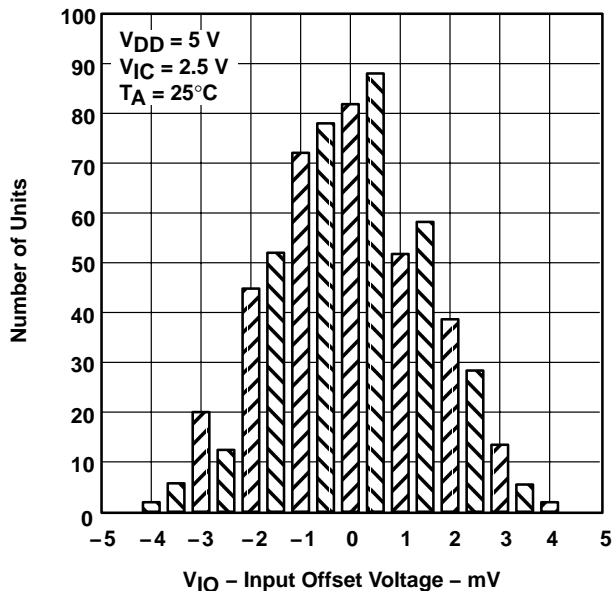


Figure 4

INPUT BIAS CURRENT  
VS  
FREE-AIR TEMPERATURE†

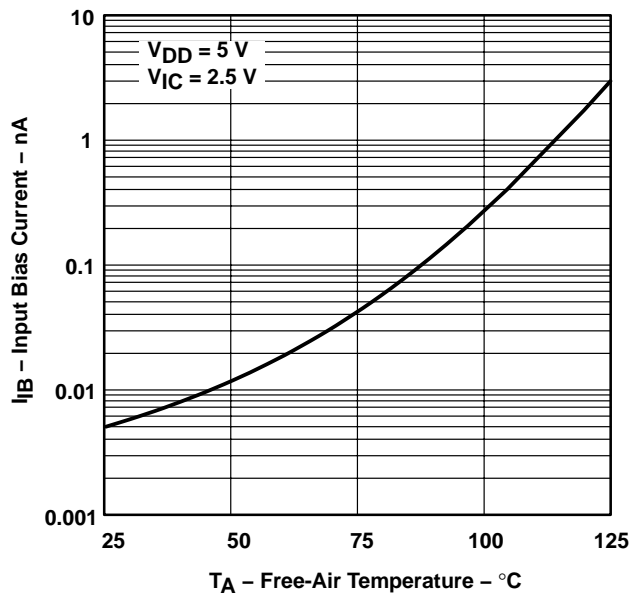


Figure 5

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

**TYPICAL CHARACTERISTICS†**

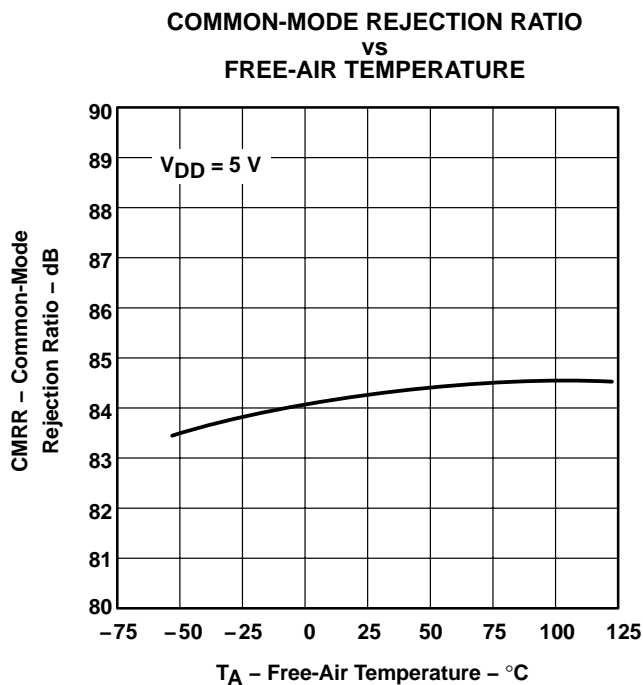


Figure 6

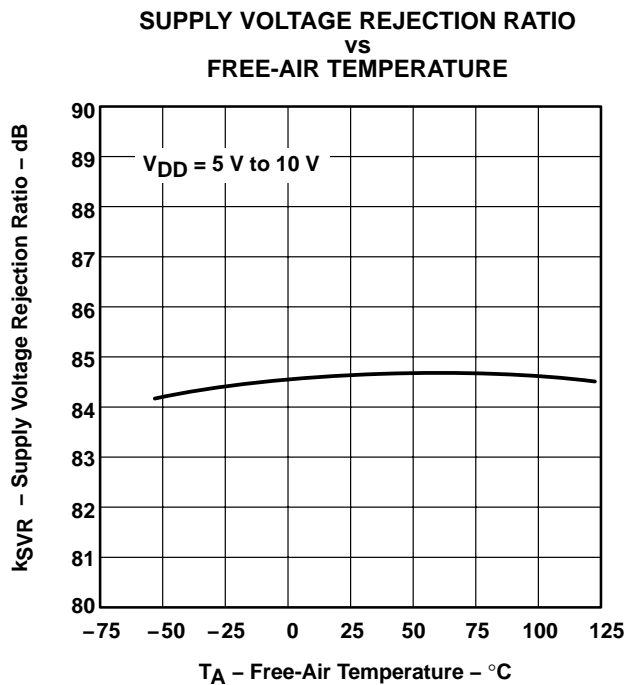


Figure 7

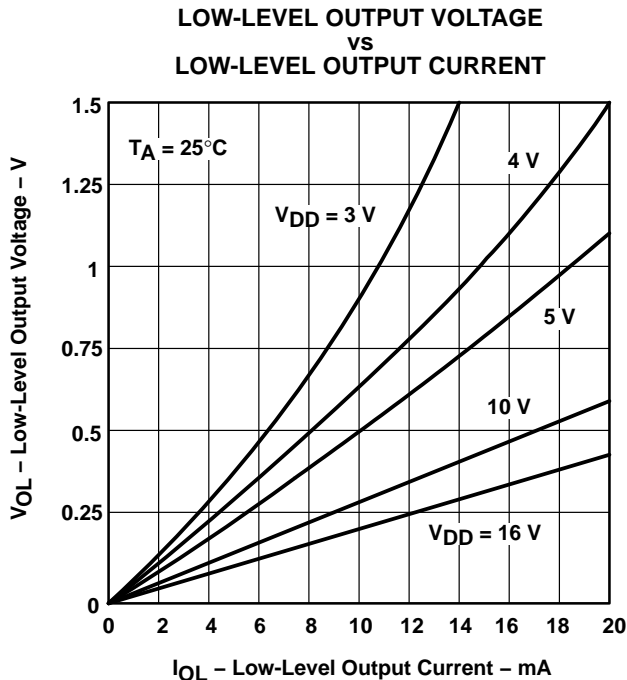


Figure 8

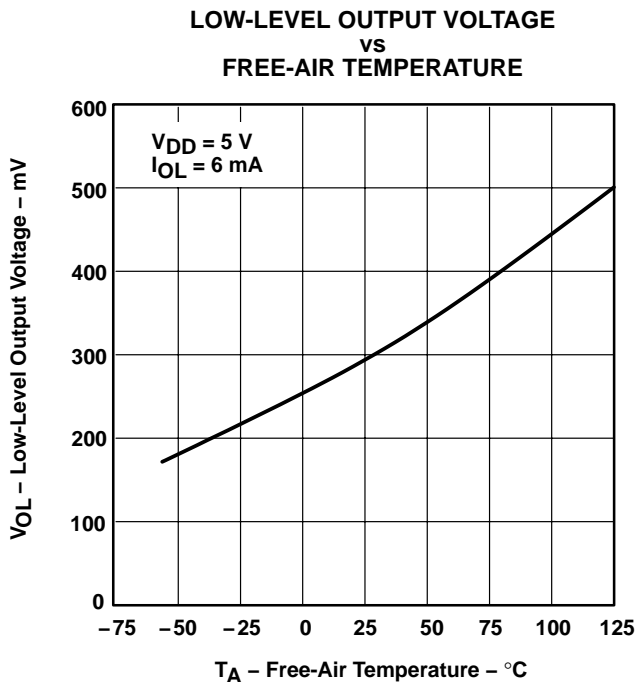


Figure 9

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

# TLC193, TLC393 DUAL MICROPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115D – DECEMBER 1986 – REVISED JULY 2003

## TYPICAL CHARACTERISTICS†

HIGH-LEVEL OUTPUT CURRENT  
vs  
HIGH-LEVEL OUTPUT VOLTAGE

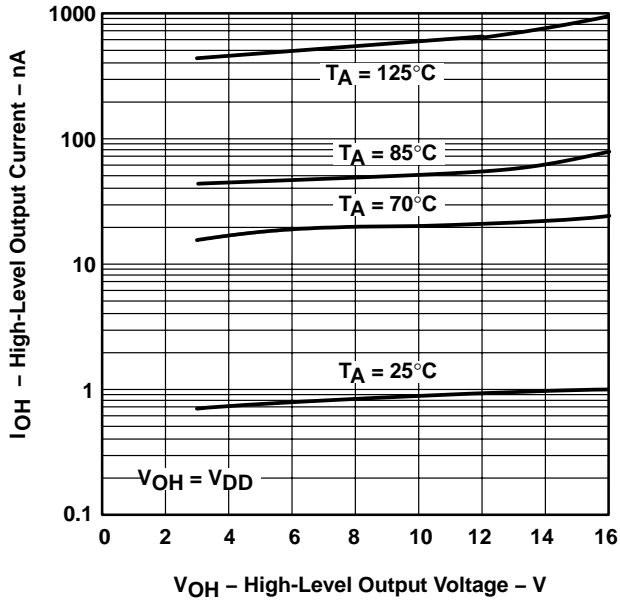


Figure 10

HIGH-LEVEL OUTPUT CURRENT  
vs  
FREE-AIR TEMPERATURE

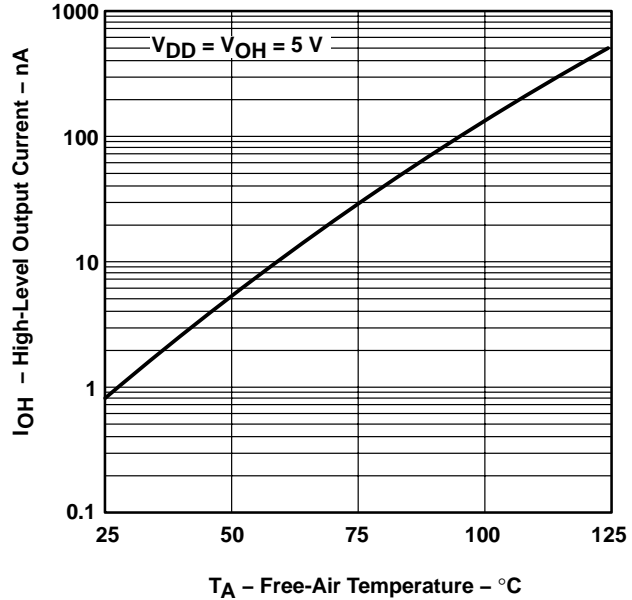


Figure 11

SUPPLY CURRENT  
vs  
SUPPLY VOLTAGE

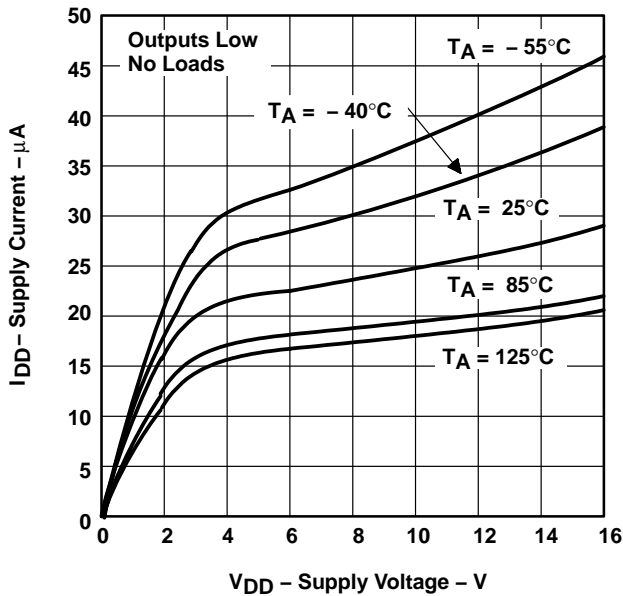


Figure 12

SUPPLY CURRENT  
vs  
FREE-AIR TEMPERATURE

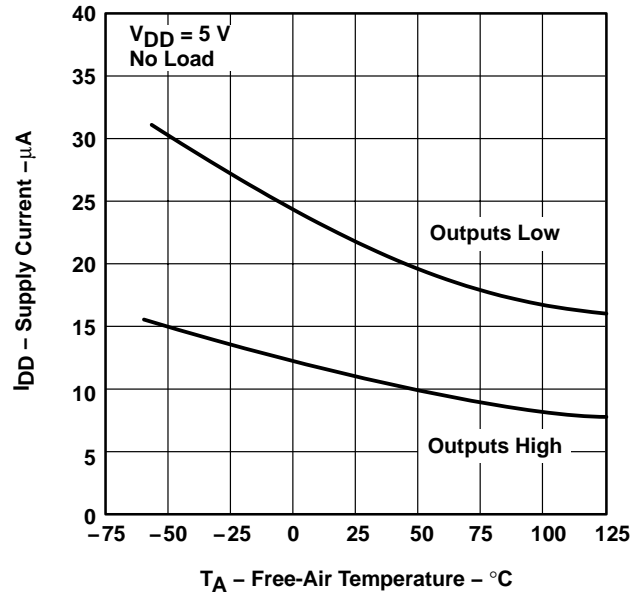
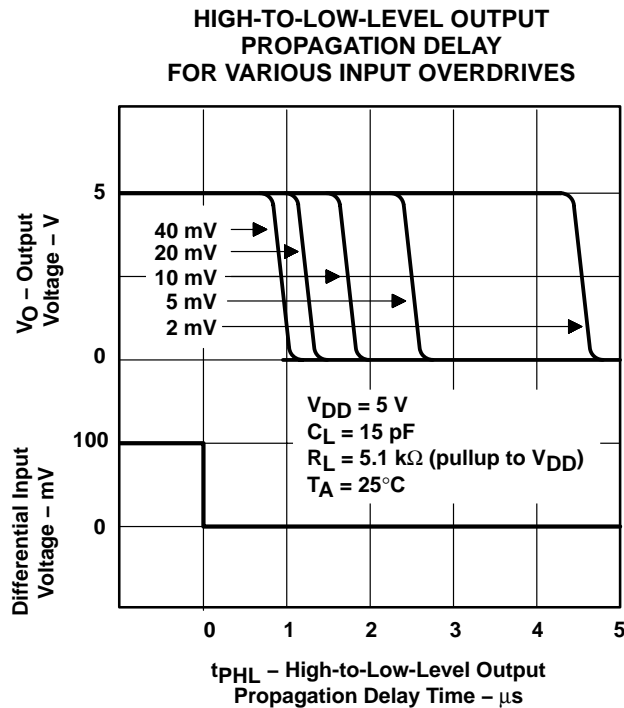
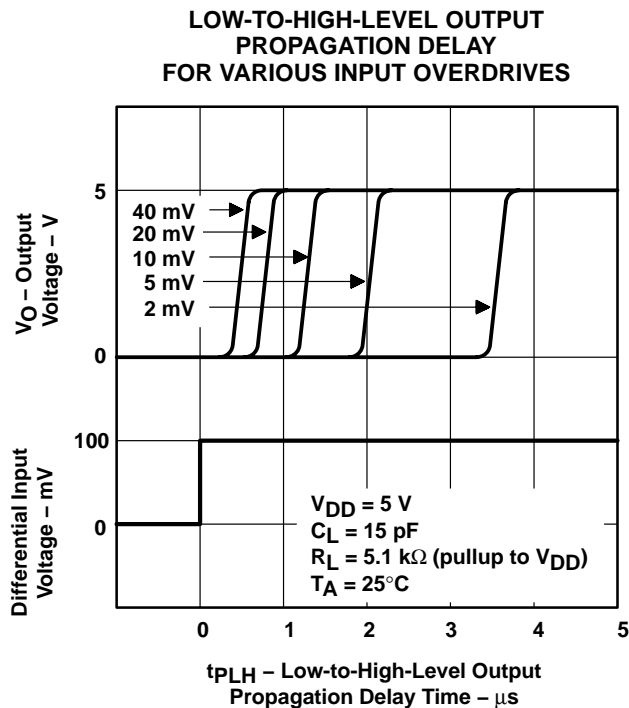
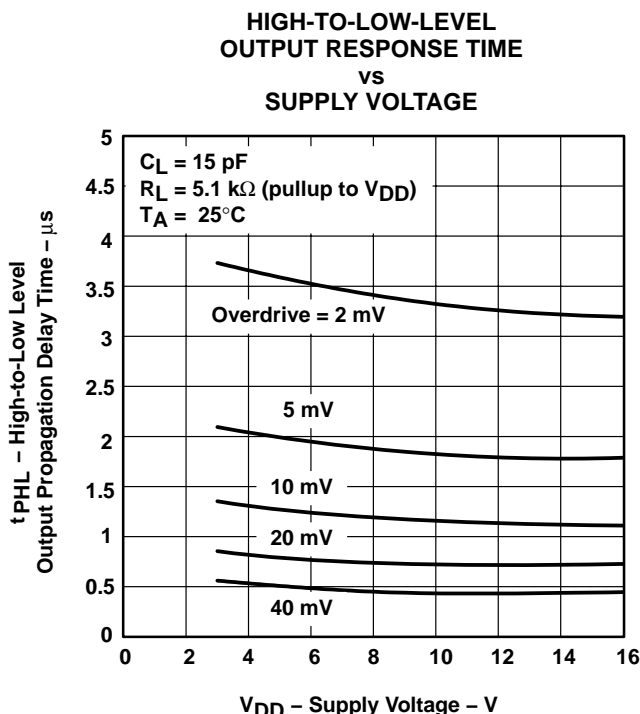
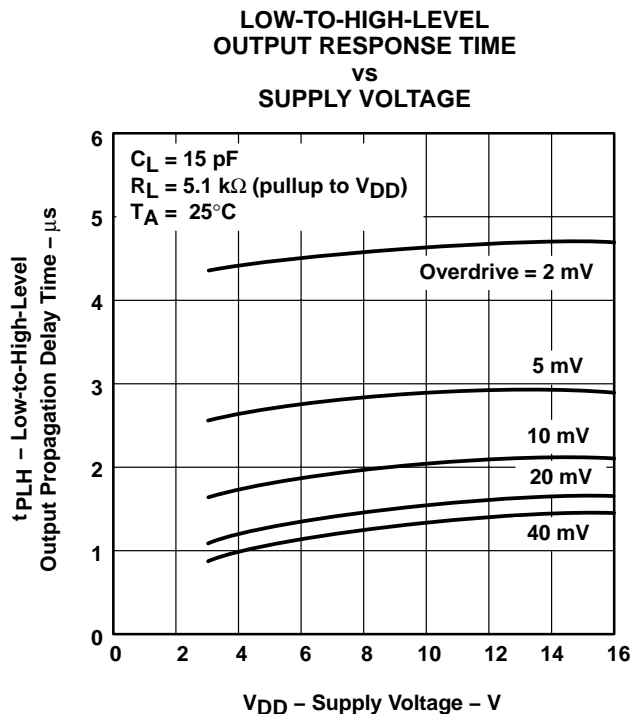


Figure 13

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



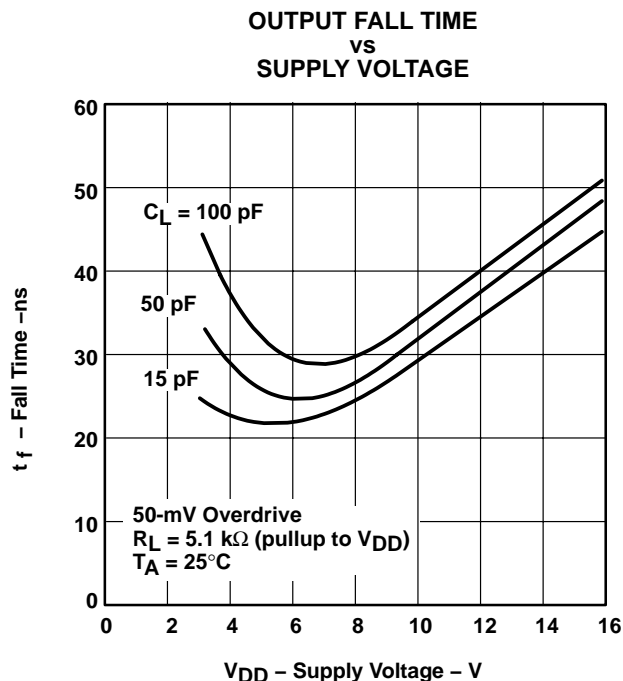
TYPICAL CHARACTERISTICS



# TLC193, TLC393 DUAL MICROPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115D – DECEMBER 1986 – REVISED JULY 2003

## TYPICAL CHARACTERISTICS



## APPLICATION INFORMATION

The input 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 will not be damaged as long as the input current 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 assure proper device operation.

To assure reliable operation, the supply should be decoupled with a capacitor (0.1- $\mu$ F) positioned as close to the device as possible.

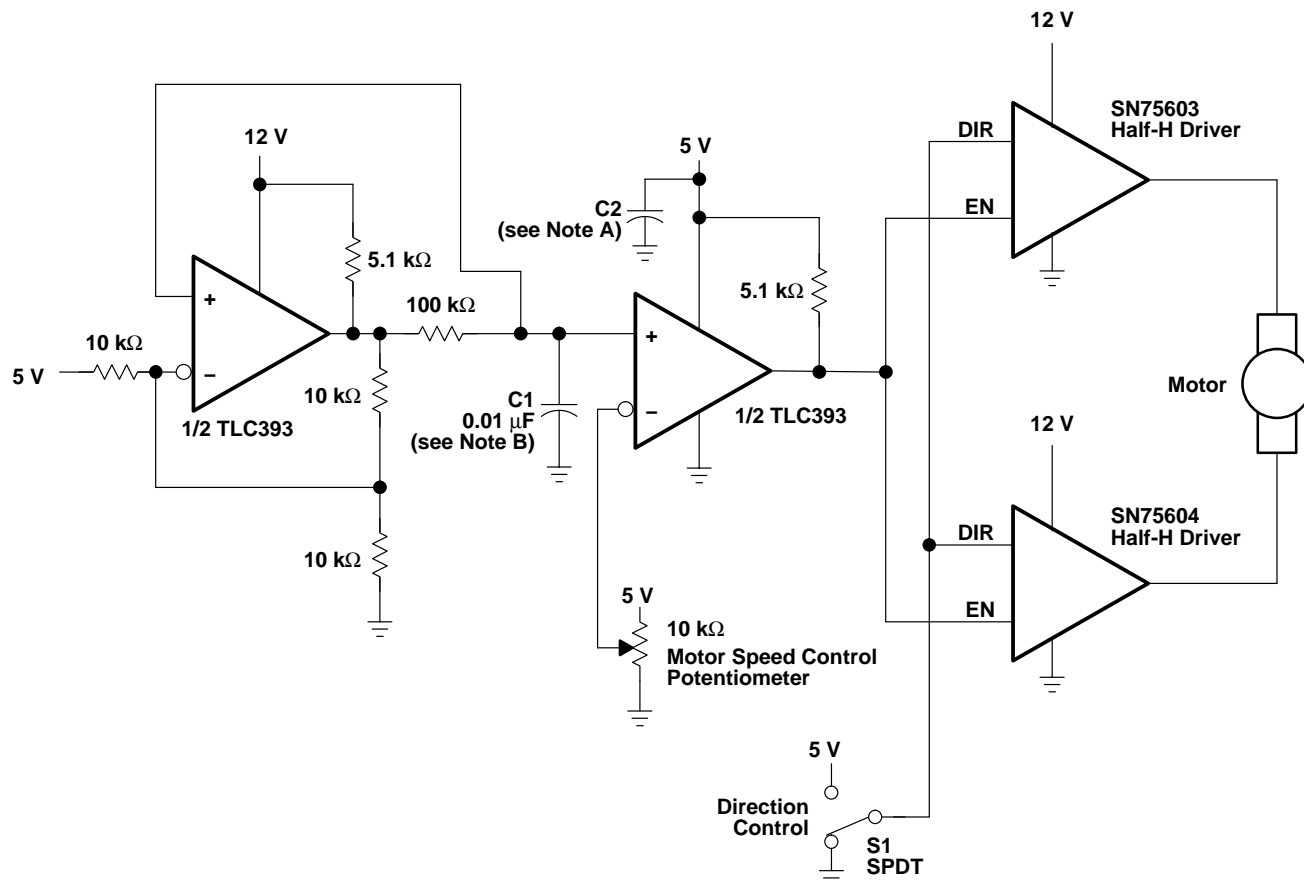
The TLC393 has internal ESD-protection circuits that prevent functional failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015.2; however, care should be exercised in handling these devices, as exposure to ESD may result in the degradation of the device parametric performance.

Table of Applications

	FIGURE
Pulse-width-modulated motor speed controller	19
Enhanced supply supervisor	20
Two-phase nonoverlapping clock generator	21
Micropower switching regulator	28



**APPLICATION INFORMATION**



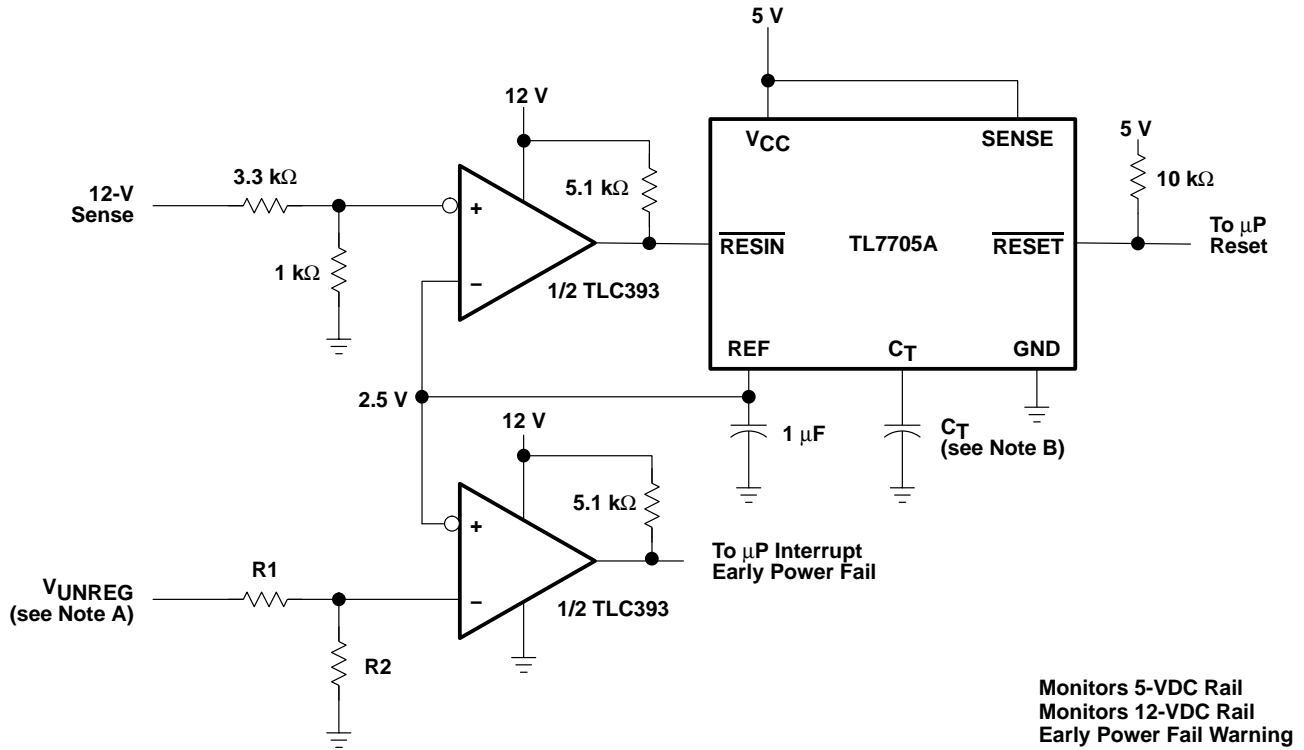
NOTES: A. The recommended minimum capacitance is 10  $\mu\text{F}$  to eliminate common ground switching noise.  
 B. Adjust C1 for change in oscillator frequency.

**Figure 19. Pulse-Width-Modulated Motor Speed Controller**

# TLC193, TLC393 DUAL MICROPPOWER LinCMOS™ VOLTAGE COMPARATOR

SLCS115D – DECEMBER 1986 – REVISED JULY 2003

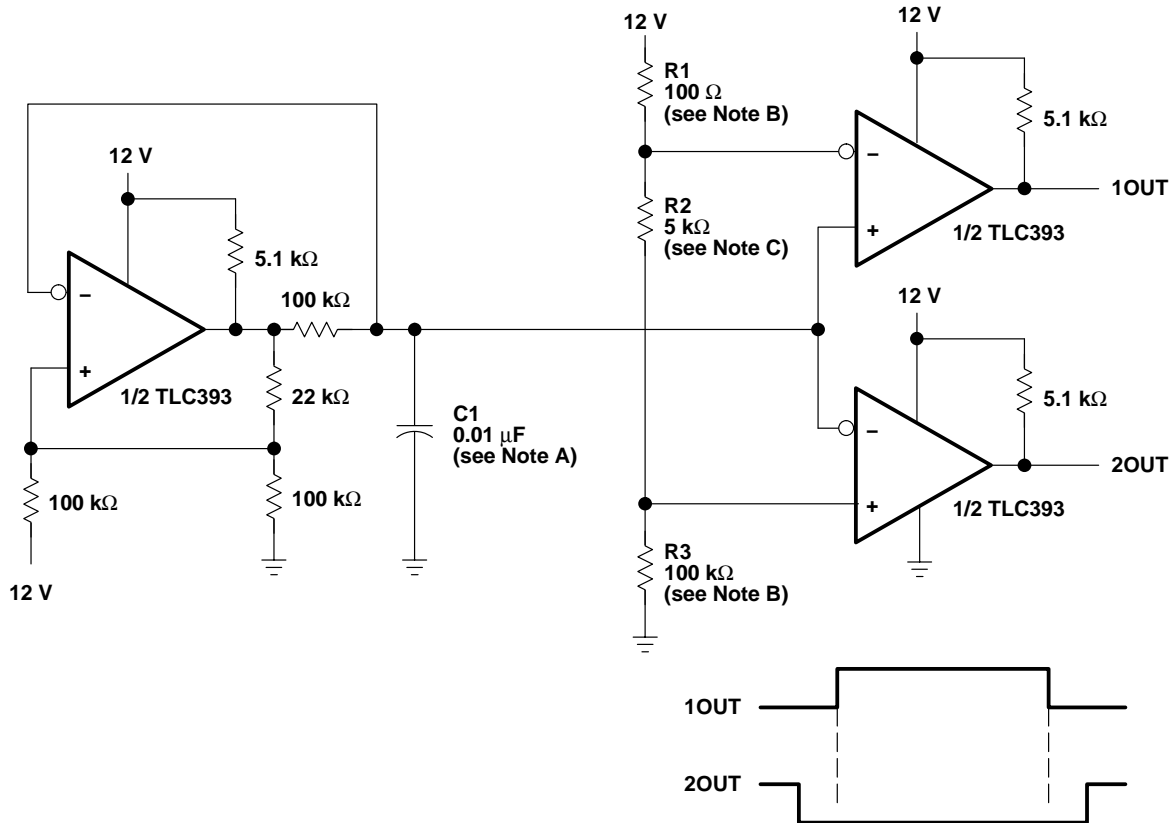
## APPLICATION INFORMATION



- NOTES: A.  $V_{UNREG} = 2.5 \frac{(R1 + R2)}{R2}$   
 B. The value of  $C_T$  determines the time delay of reset.

**Figure 20. Enhanced Supply Supervisor**

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 21. Two-Phase Nonoverlapping Clock Generator

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
5962-9555101NXD	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
5962-9555101NXDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
5962-9555101QPA	ACTIVE	CDIP	JG	8	1	TBD	Call TI	Call TI	
TLC193MFKB	OBSOLETE	LCCC	FK	20		TBD	Call TI	Call TI	
TLC193MJGB	ACTIVE	CDIP	JG	8	1	TBD	A42	N / A for Pkg Type	
TLC393CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393CDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	
TLC393CPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	
TLC393CPSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393CPSRG4	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393CPW	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393CPWG4	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393CPWLE	OBSOLETE	TSSOP	PW	8		TBD	Call TI	Call TI	
TLC393CPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393CPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
TLC393IDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393IDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393IP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	
TLC393IPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	
TLC393IPW	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393IPWG4	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393IPWLE	OBSOLETE	TSSOP	PW	8		TBD	Call TI	Call TI	
TLC393IPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393IPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393MD	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI	
TLC393MP	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI	
TLC393QDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLC393QDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

<sup>(3)</sup> 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 TLC393 :**

- Automotive: [TLC393-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

**TAPE AND REEL INFORMATION**

\*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
5962-9555101NXDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC393CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC393CPSR	SO	PS	8	2000	330.0	16.4	8.2	6.6	2.5	12.0	16.0	Q1
TLC393CPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
TLC393IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLC393IPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
TLC393QDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

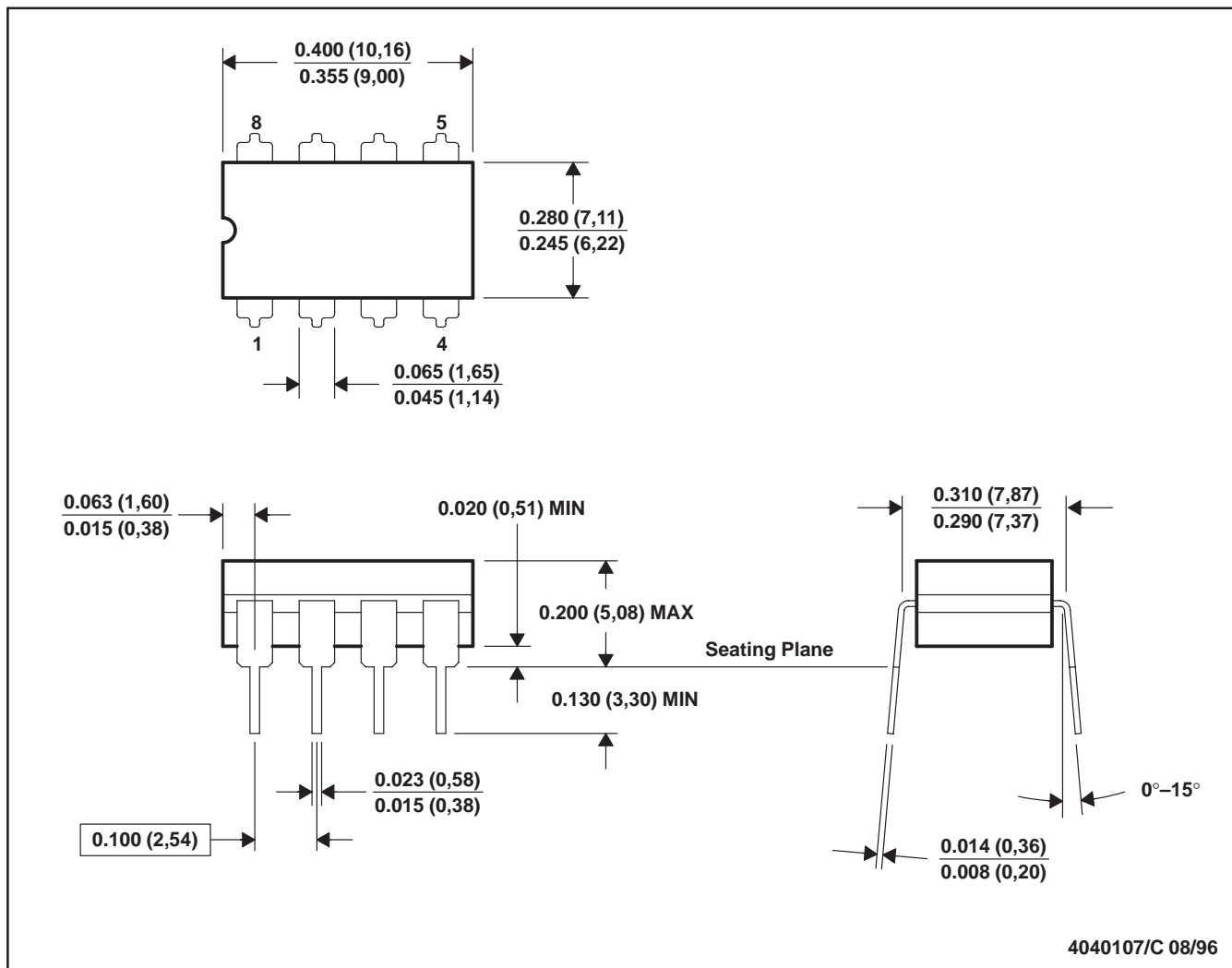
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
5962-9555101NXDR	SOIC	D	8	2500	367.0	367.0	35.0
TLC393CDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC393CPSR	SO	PS	8	2000	367.0	367.0	38.0
TLC393CPWR	TSSOP	PW	8	2000	367.0	367.0	35.0
TLC393IDR	SOIC	D	8	2500	340.5	338.1	20.6
TLC393IPWR	TSSOP	PW	8	2000	367.0	367.0	35.0
TLC393QDR	SOIC	D	8	2500	367.0	367.0	35.0

JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE



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

FK (S-CQCC-N\*\*)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



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



4040140/D 01/11

- NOTES:
- 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

P (R-PDIP-T8)

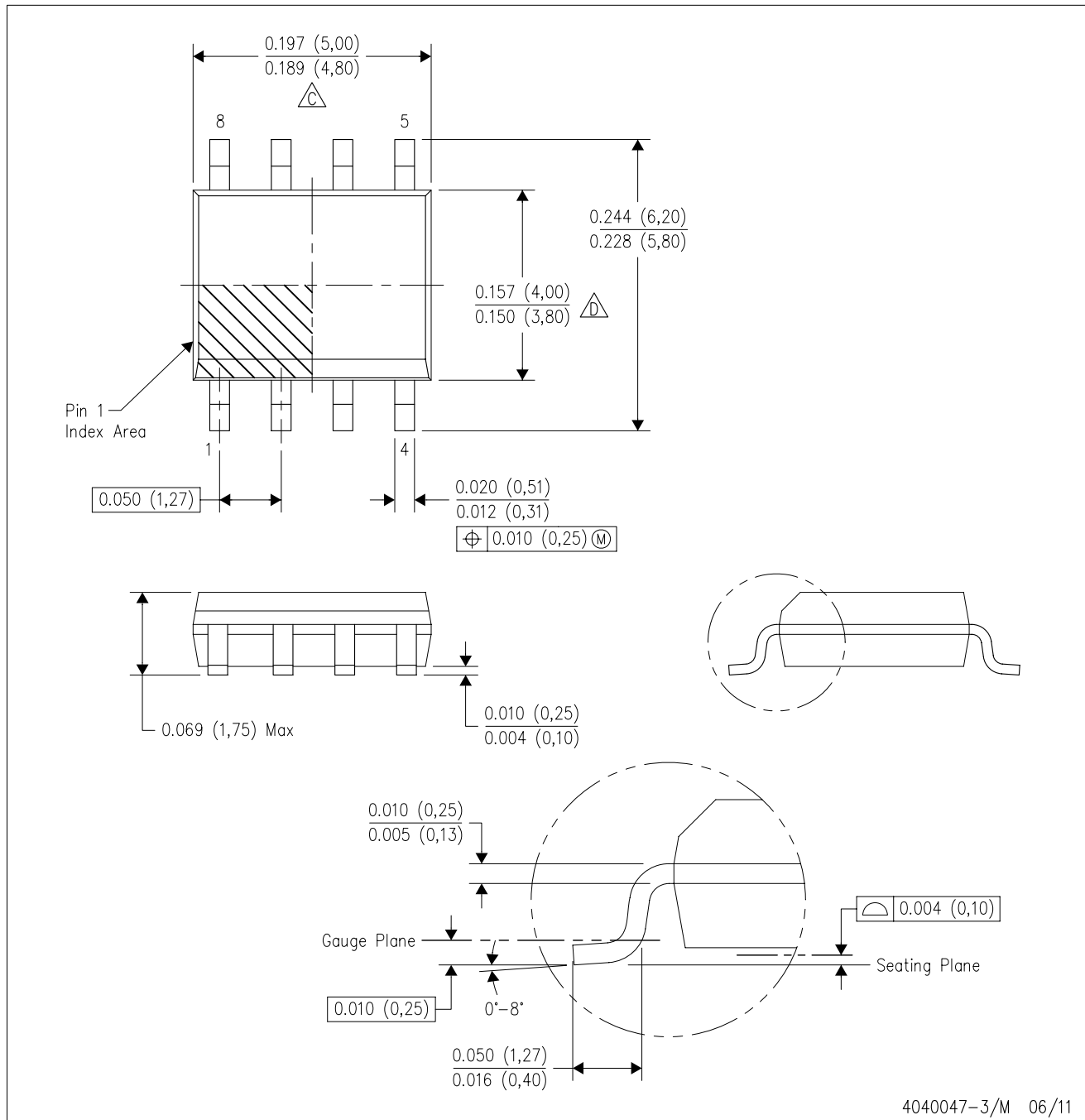
PLASTIC DUAL-IN-LINE PACKAGE



- 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.

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



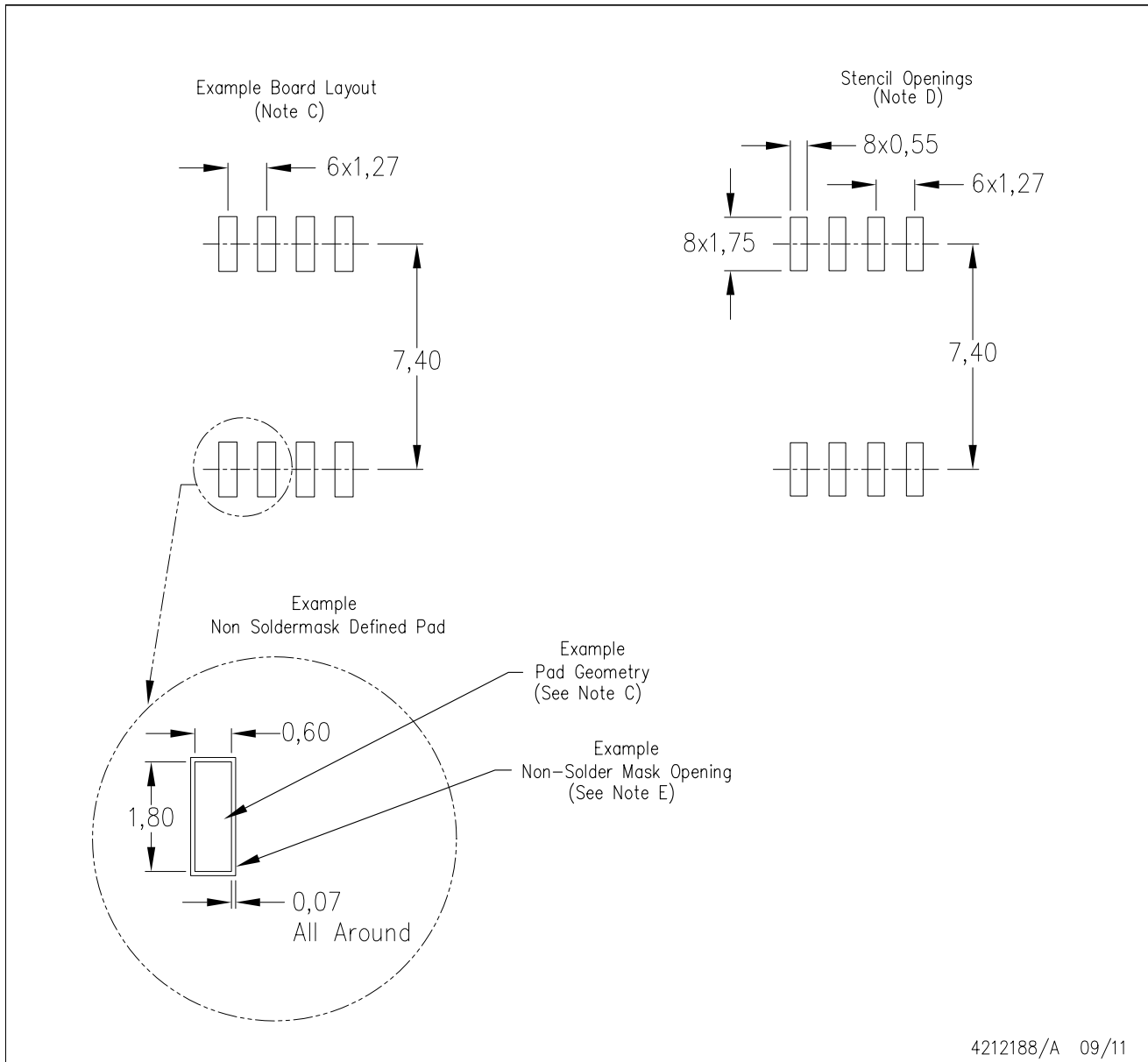
4211283-2/E 08/12

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



PS (R-PDSO-G8)

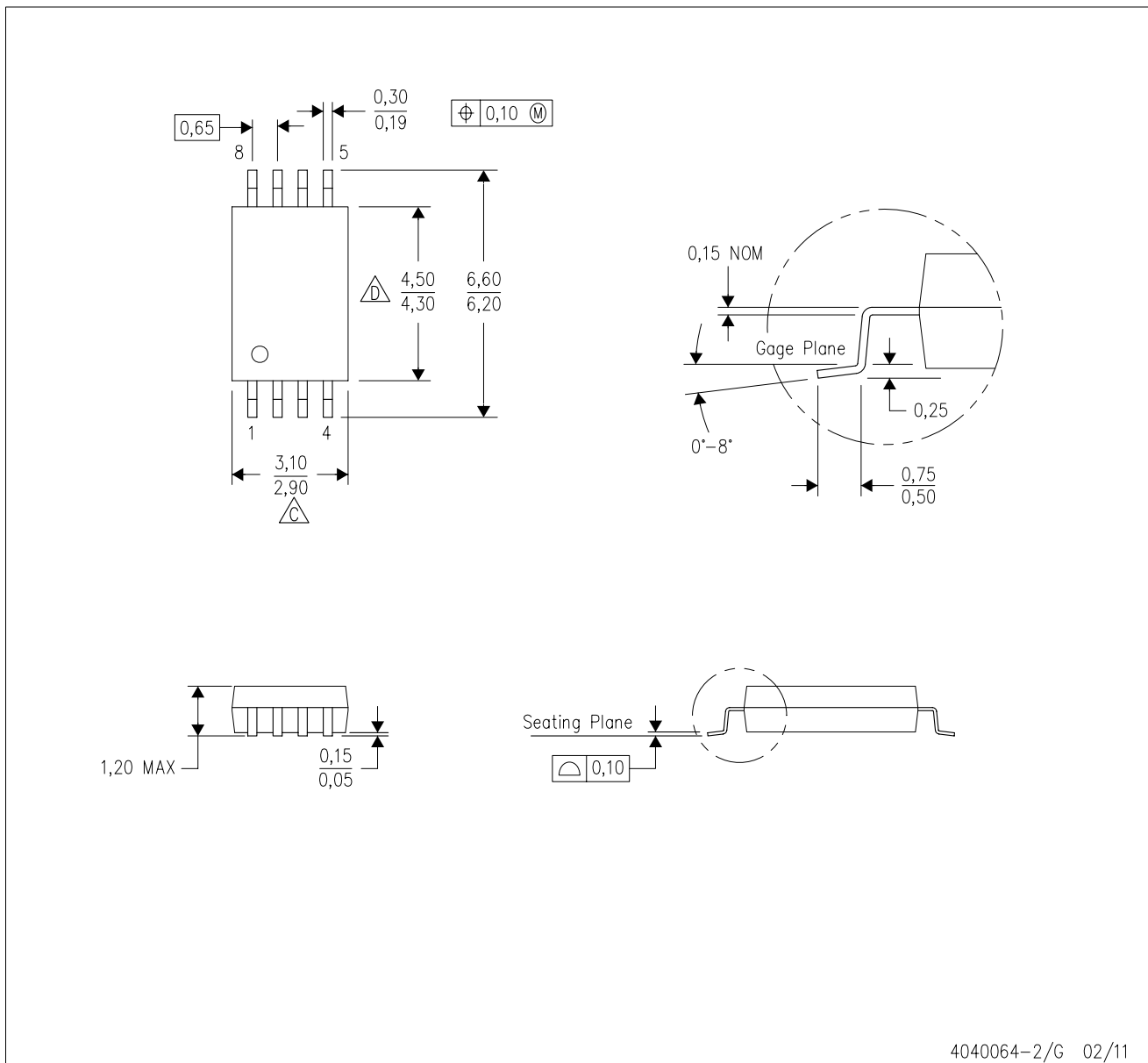
PLASTIC SMALL OUTLINE



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

PW (R-PDSO-G8)

PLASTIC SMALL OUTLINE



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

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve 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. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)