

**High-Speed CMOS Logic  
Quad D-Type Flip-Flop, Three-State**

**Features**

- Three-State Buffered Outputs
- Gated Input and Output Enables
- Fanout (Over Temperature Range)
  - Standard Outputs . . . . . 10 LSTTL Loads
  - Bus Driver Outputs . . . . . 15 LSTTL Loads
- Wide Operating Temperature Range . . . -55°C to 125°C
- Balanced Propagation Delay and Transition Times
- Significant Power Reduction Compared to LSTTL Logic ICs
- HC Types
  - 2V to 6V Operation
  - High Noise Immunity:  $N_{IL} = 30\%$ ,  $N_{IH} = 30\%$  of  $V_{CC}$  at  $V_{CC} = 5V$
- HCT Types
  - 4.5V to 5.5V Operation
  - Direct LSTTL Input Logic Compatibility,  $V_{IL} = 0.8V$  (Max),  $V_{IH} = 2V$  (Min)
  - CMOS Input Compatibility,  $I_I \leq 1\mu A$  at  $V_{OL}$ ,  $V_{OH}$

**Description**

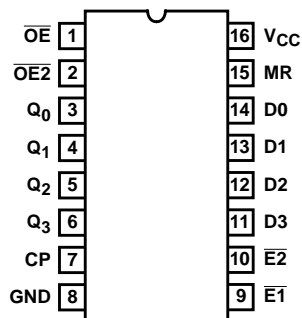
The 'HC173 and 'HCT173 high speed three-state quad D-type flip-flops are fabricated with silicon gate CMOS technology. They possess the low power consumption of standard CMOS Integrated circuits, and can operate at speeds comparable to the equivalent low power Schottky devices. The buffered outputs can drive 15 LSTTL loads. The large output drive capability and three-state feature make these parts ideally suited for interfacing with bus lines in bus oriented systems.

The four D-type flip-flops operate synchronously from a common clock. The outputs are in the three-state mode when either of the two output disable pins are at the logic "1" level. The input ENABLES allow the flip-flops to remain in their present states without having to disrupt the clock. If either of the 2 input ENABLES are taken to a logic "1" level, the Q outputs are fed back to the inputs, forcing the flip-flops to remain in the same state. Reset is enabled by taking the MASTER RESET (MR) input to a logic "1" level. The data outputs change state on the positive going edge of the clock.

The 'HCT173 logic family is functionally, as well as pin compatible with the standard LS logic family.

**Pinout**

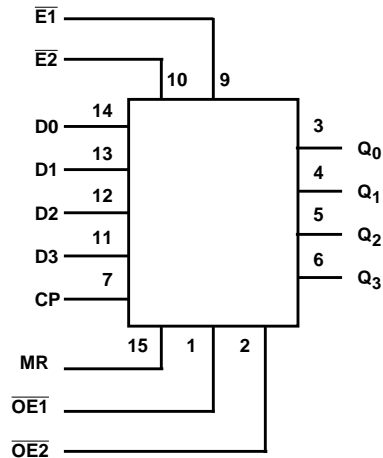
CD54HC173, CD54HCT173  
(CERDIP)  
CD74HC173  
(PDIP, SOIC, SOP, TSSOP)  
CD74HCT173  
(PDIP, SOIC)  
TOP VIEW



**Ordering Information**

PART NUMBER	TEMP. RANGE (°C)	PACKAGE
CD54HC173F3A	-55 to 125	16 Ld CERDIP
CD54HCT173F3A	-55 to 125	16 Ld CERDIP
CD74HC173E	-55 to 125	16 Ld PDIP
CD74HC173M	-55 to 125	16 Ld SOIC
CD74HC173MT	-55 to 125	16 Ld SOIC
CD74HC173M96	-55 to 125	16 Ld SOIC
CD74HC173NSR	-55 to 125	16 Ld SOP
CD74HC173PW	-55 to 125	16 Ld TSSOP
CD74HC173PWR	-55 to 125	16 Ld TSSOP
CD74HC173PWT	-55 to 125	16 Ld TSSOP
CD74HCT173E	-55 to 125	16 Ld PDIP
CD74HCT173M	-55 to 125	16 Ld SOIC
CD74HCT173MT	-55 to 125	16 Ld SOIC
CD74HCT173M96	-55 to 125	16 Ld SOIC

NOTE: When ordering, use the entire part number. The suffixes 96 and R denote tape and reel. The suffix T denotes a small-quantity reel of 250.

**Functional Diagram****TRUTH TABLE**

INPUTS				DATA	OUTPUT
MR	CP	DATA ENABLE			
		$\overline{E1}$	$\overline{E2}$	D	$Q_n$
H	X	X	X	X	L
L	L	X	X	X	$Q_0$
L	$\uparrow$	H	X	X	$Q_0$
L	$\uparrow$	X	H	X	$Q_0$
L	$\uparrow$	L	L	L	L
L	$\uparrow$	L	L	H	H

H= High Voltage Level

L = Low Voltage Level

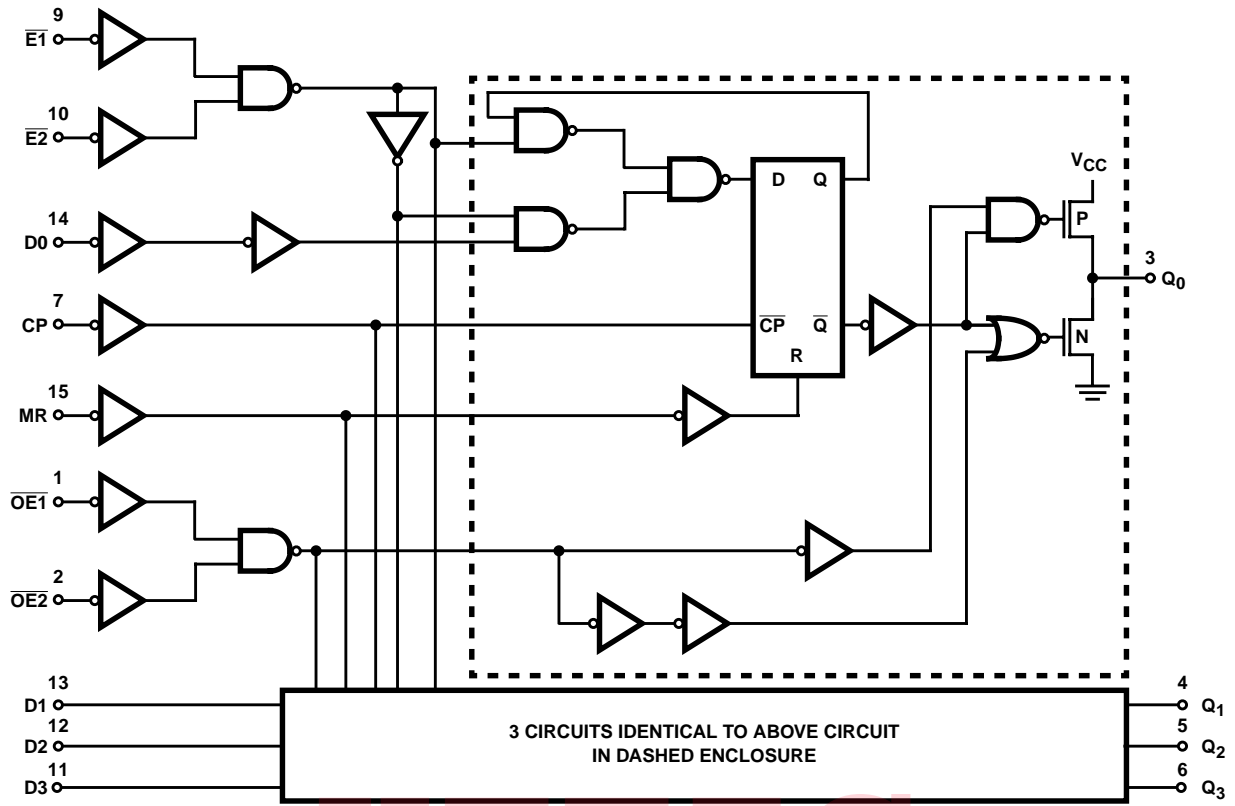
X= Irrelevant

 $\uparrow$ = Transition from Low to High Level $Q_0$ = Level Before the Indicated Steady-State Input Conditions Were Established

NOTE:

1. When either OE1 or OE2 (or both) is (are) high, the output is disabled to the high-impedance state, however, sequential operation of the flip-flops is not affected.

**Logic Diagram**



KTTIC

**Absolute Maximum Ratings**

DC Supply Voltage,  $V_{CC}$  ..... -0.5V to 7V  
 DC Input Diode Current,  $I_{IK}$   
 For  $V_I < -0.5V$  or  $V_I > V_{CC} + 0.5V$  .....  $\pm 20mA$   
 DC Output Diode Current,  $I_{OK}$   
 For  $V_O < -0.5V$  or  $V_O > V_{CC} + 0.5V$  .....  $\pm 20mA$   
 DC Output Source or Sink Current per Output Pin,  $I_O$   
 For  $V_O > -0.5V$  or  $V_O < V_{CC} + 0.5V$  .....  $\pm 25mA$   
 DC  $V_{CC}$  or Ground Current,  $I_{CC}$  .....  $\pm 70mA$

**Thermal Information**

Package Thermal Impedance,  $\theta_{JA}$  (see Note 2):  
 E (PDIP) Package .....  $67^{\circ}C/W$   
 M (SOIC) Package .....  $73^{\circ}C/W$   
 NS (SOP) Package .....  $64^{\circ}C/W$   
 PW (TSSOP) Package .....  $108^{\circ}C/W$   
 Maximum Junction Temperature .....  $150^{\circ}C$   
 Maximum Storage Temperature Range .....  $-65^{\circ}C$  to  $150^{\circ}C$   
 Maximum Lead Temperature (Soldering 10s) .....  $300^{\circ}C$   
 (SOIC - Lead Tips Only)

**Operating Conditions**

Temperature Range ( $T_A$ ) .....  $-55^{\circ}C$  to  $125^{\circ}C$   
 Supply Voltage Range,  $V_{CC}$   
 HC Types ..... 2V to 6V  
 HCT Types ..... 4.5V to 5.5V  
 DC Input or Output Voltage,  $V_I, V_O$  ..... 0V to  $V_{CC}$   
 Input Rise and Fall Time  
 2V ..... 1000ns (Max)  
 4.5V ..... 500ns (Max)  
 6V ..... 400ns (Max)

*CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.*

**NOTE:**

- The package thermal impedance is calculated in accordance with JESD 51-7.

**DC Electrical Specifications**

PARAMETER	SYMBOL	TEST CONDITIONS		$V_{CC}$ (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
		$V_I$ (V)	$I_O$ (mA)		MIN	TYP	MAX	MIN	MAX	MIN	MAX	
<b>HC TYPES</b>												
High Level Input Voltage	$V_{IH}$	-	-	2	1.5	-	-	1.5	-	1.5	-	V
				4.5	3.15	-	-	3.15	-	3.15	-	V
				6	4.2	-	-	4.2	-	4.2	-	V
Low Level Input Voltage	$V_{IL}$	-	-	2	-	-	0.5	-	0.5	-	0.5	V
				4.5	-	-	1.35	-	1.35	-	1.35	V
				6	-	-	1.8	-	1.8	-	1.8	V
High Level Output Voltage CMOS Loads	$V_{OH}$	$V_{IH}$ or $V_{IL}$	-0.02	2	1.9	-	-	1.9	-	1.9	-	V
			-0.02	4.5	4.4	-	-	4.4	-	4.4	-	V
			-0.02	6	5.9	-	-	5.9	-	5.9	-	V
High Level Output Voltage TTL Loads	$V_{OH}$	$V_{IH}$ or $V_{IL}$	-6	4.5	3.98	-	-	3.84	-	3.7	-	V
			-7.8	6	5.48	-	-	5.34	-	5.2	-	V
Low Level Output Voltage CMOS Loads	$V_{OL}$	$V_{IH}$ or $V_{IL}$	0.02	2	-	-	0.1	-	0.1	-	0.1	V
			0.02	4.5	-	-	0.1	-	0.1	-	0.1	V
			0.02	6	-	-	0.1	-	0.1	-	0.1	V
Low Level Output Voltage TTL Loads	$V_{OL}$	$V_{IH}$ or $V_{IL}$	6	4.5	-	-	0.26	-	0.33	-	0.4	V
			7.8	6	-	-	0.26	-	0.33	-	0.4	V
Input Leakage Current	$I_I$	$V_{CC}$ or GND	-	6	-	-	$\pm 0.1$	-	$\pm 1$	-	$\pm 1$	$\mu A$
Quiescent Device Current	$I_{CC}$	$V_{CC}$ or GND	0	6	-	-	8	-	80	-	160	$\mu A$

## DC Electrical Specifications (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS		$V_{CC}$ (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
		$V_I$ (V)	$I_O$ (mA)		MIN	TYP	MAX	MIN	MAX	MIN	MAX	
Three-State Leakage Current	$I_{OZ}$	$V_{IL}$ or $V_{IH}$	-	6	-	-	±0.5	-	±0.5	-	±10	μA
<b>HCT TYPES</b>												
High Level Input Voltage	$V_{IH}$	-	-	4.5 to 5.5	2	-	-	2	-	2	-	V
Low Level Input Voltage	$V_{IL}$	-	-	4.5 to 5.5	-	-	0.8	-	0.8	-	0.8	V
High Level Output Voltage CMOS Loads	$V_{OH}$	$V_{IH}$ or $V_{IL}$	-0.02	4.5	4.4	-	-	4.4	-	4.4	-	V
High Level Output Voltage TTL Loads			-6	4.5	3.98	-	-	3.84	-	3.7	-	V
Low Level Output Voltage CMOS Loads	$V_{OL}$	$V_{IH}$ or $V_{IL}$	0.02	4.5	-	-	0.1	-	0.1	-	0.1	V
Low Level Output Voltage TTL Loads			6	4.5	-	-	0.26	-	0.33	-	0.4	V
Input Leakage Current	$I_I$	$V_{CC}$ to GND	0	5.5	-	-	±0.1	-	±1	-	±1	μA
Quiescent Device Current	$I_{CC}$	$V_{CC}$ or GND	0	5.5	-	-	8	-	80	-	160	μA
Additional Quiescent Device Current Per Input Pin: 1 Unit Load	$\Delta I_{CC}$ (Note 3)	$V_{CC}$ -2.1	-	4.5 to 5.5	-	100	360	-	450	-	490	μA
Three-State Leakage Current	$I_{OZ}$	$V_{IL}$ or $V_{IH}$	-	5.5	-	-	±0.5	-	±5.0	-	±10	μA

## NOTE:

3. For dual-supply systems theoretical worst case ( $V_I = 2.4V$ ,  $V_{CC} = 5.5V$ ) specification is 1.8mA.

## HCT Input Loading Table

INPUT	UNIT LOADS
D0-D3	0.15
$\bar{E}1$ and $\bar{E}2$	0.15
CP	0.25
MR	0.2
$\bar{OE}1$ and $\bar{OE}2$	0.5

NOTE: Unit Load is  $\Delta I_{CC}$  limit specified in DC Electrical Specifications table, e.g., 360μA max at 25°C.

**Switching Specifications** Input  $t_r, t_f = 6\text{ns}$ 

PARAMETER	SYMBOL	TEST CONDITIONS	$V_{CC}$ (V)	25°C		-40°C TO 85°C	-55°C TO 125°C	UNITS
				TYP	MAX	MAX	MAX	
<b>HC TYPES</b>								
Propagation Delay, Clock to Output	$t_{PLH}, t_{PHL}$	$C_L = 50\text{pF}$	2	-	200	250	300	ns
			4.5	-	40	50	60	ns
		$C_L = 15\text{pF}$	5	17	-	-	-	ns
		$C_L = 50\text{pF}$	6	-	34	43	51	ns
Propagation Delay, MR to Output	$t_{PHL}$	$C_L = 50\text{pF}$	2	-	175	220	265	ns
			4.5	-	35	44	53	ns
		$C_L = 15\text{pF}$	5	12	-	-	-	ns
		$C_L = 50\text{pF}$	6	-	30	37	45	ns
Propagation Delay Output Enable to Q (Figure 6)	$t_{PLZ}, t_{PHZ}$ $t_{PZL}, t_{PZH}$	$C_L = 50\text{pF}$	2	-	150	190	225	ns
		$C_L = 50\text{pF}$	4.5	-	30	38	45	ns
		$C_L = 15\text{pF}$	5	12	-	-	-	ns
		$C_L = 50\text{pF}$	6	-	26	33	38	ns
Output Transition Times	$t_{TLH}, t_{THL}$	$C_L = 50\text{pF}$	2	-	60	75	90	ns
			4.5	-	12	15	18	ns
			6	-	10	13	15	ns
Maximum Clock Frequency	$f_{MAX}$	$C_L = 15\text{pF}$	5	60	-	-	-	MHz
Input Capacitance	$C_{IN}$	-	-	-	10	10	10	pF
Three-State Output Capacitance	$C_O$	-	-	-	10	10	10	pF
Power Dissipation Capacitance (Notes 4, 5)	$C_{PD}$	-	5	29	-	-	-	pF
<b>HCT TYPES</b>								
Propagation Delay, Clock to Output	$t_{PLH}, t_{PHL}$	$C_L = 50\text{pF}$	4.5	-	40	50	60	ns
		$C_L = 15\text{pF}$	5	17	-	-	-	ns
Propagation Delay, MR to Output	$t_{PHL}$	$C_L = 50\text{pF}$	4.5	-	44	55	66	ns
		$C_L = 15\text{pF}$	5	18	-	-	-	ns
Propagation Delay Output Enable to Q (Figure 6)	$t_{PZL}, t_{PZH}$	$C_L = 50\text{pF}$	2	-	150	190	225	ns
		$C_L = 50\text{pF}$	4.5	-	30	38	45	ns
		$C_L = 15\text{pF}$	5	14	-	-	-	ns
		$C_L = 50\text{pF}$	6	-	26	33	38	ns
Output Transition Times	$t_{TLH}, t_{THL}$	$C_L = 50\text{pF}$	4.5	-	15	19	22	ns
Maximum Clock Frequency	$f_{MAX}$	$C_L = 15\text{pF}$	5	60	-	-	-	MHz
Input Capacitance	$C_{IN}$	-	-	-	10	10	10	pF
Power Dissipation Capacitance (Notes 4, 5)	$C_{PD}$	-	5	34	-	-	-	pF

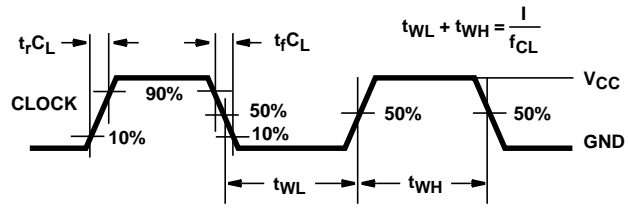
## NOTES:

- $C_{PD}$  is used to determine the dynamic power consumption, per package.
- $P_D = V_{CC}^2 f_i + \sum (C_L V_{CC}^2 + f_O)$  where  $f_i$  = Input Frequency,  $f_O$  = Output Frequency,  $C_L$  = Output Load Capacitance,  $V_{CC}$  = Supply Voltage.

**Prerequisite For Switching Specifications**

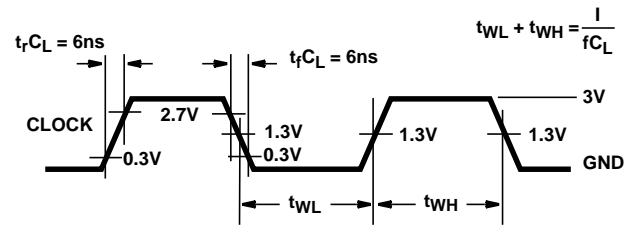
PARAMETER	SYMBOL	V <sub>CC</sub> (V)	25°C		-40°C TO 85°C		-55°C TO 125°C		UNITS
			MIN	MAX	MIN	MAX	MIN	MAX	
<b>HC TYPES</b>									
Maximum Clock Frequency	f <sub>MAX</sub>	2	6	-	5	-	4	-	MHz
		4.5	30	-	24	-	20	-	MHz
		6	35	-	28	-	24	-	MHz
MR Pulse Width	t <sub>w</sub>	2	80	-	100	-	120	-	ns
		4.5	16	-	20	-	24	-	ns
		6	14	-	17	-	20	-	ns
Clock Pulse Width	t <sub>w</sub>	2	80	-	100	-	120	-	ns
		4.5	16	-	20	-	24	-	ns
		6	14	-	17	-	20	-	ns
Set-up Time, Data to Clock and $\bar{E}$ to Clock	t <sub>SU</sub>	2	60	-	75	-	90	-	ns
		4.5	12	-	15	-	18	-	ns
		6	10	-	13	-	15	-	ns
Hold Time, Data to Clock	t <sub>H</sub>	2	3	-	3	-	3	-	ns
		4.5	3	-	3	-	3	-	ns
		6	3	-	3	-	3	-	ns
Hold Time, $\bar{E}$ to Clock	t <sub>H</sub>	2	0	-	0	-	0	-	ns
		4.5	0	-	0	-	0	-	ns
		6	0	-	0	-	0	-	ns
Removal Time, MR to Clock	t <sub>REM</sub>	2	60	-	75	-	90	-	ns
		4.5	12	-	15	-	18	-	ns
		6	10	-	13	-	15	-	ns
<b>HCT TYPES</b>									
Maximum Clock Frequency	f <sub>MAX</sub>	4.5	20	-	16	-	13	-	MHz
MR Pulse Width	t <sub>w</sub>	4.5	15	-	19	-	22	-	ns
Clock Pulse Width	t <sub>w</sub>	4.5	25	-	31	-	38	-	ns
Set-up Time, $\bar{E}$ to Clock	t <sub>SU</sub>	4.5	12	-	15	-	18	-	ns
Set-up Time, Data to Clock	t <sub>SU</sub>	4.5	18	-	23	-	27	-	ns
Hold Time, Data to Clock	t <sub>H</sub>	4.5	0	-	0	-	0	-	ns
Hold Time, $\bar{E}$ to Clock	t <sub>H</sub>	4.5	0	-	0	-	0	-	ns
Removal Time, MR to Clock	t <sub>REM</sub>	4.5	12	-	15	-	18	-	ns

**Test Circuits and Waveforms**



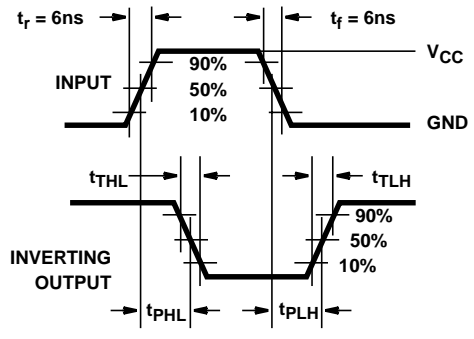
NOTE: Outputs should be switching from 10% V<sub>CC</sub> to 90% V<sub>CC</sub> in accordance with device truth table. For f<sub>MAX</sub>, input duty cycle = 50%.

**FIGURE 1. HC CLOCK PULSE RISE AND FALL TIMES AND PULSE WIDTH**

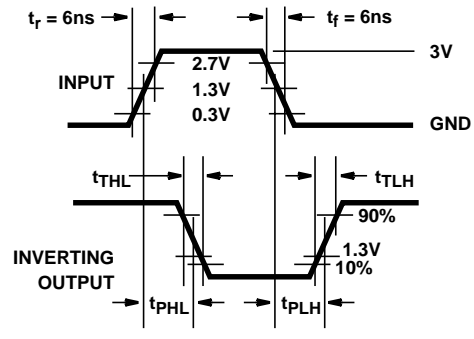


NOTE: Outputs should be switching from 10% V<sub>CC</sub> to 90% V<sub>CC</sub> in accordance with device truth table. For f<sub>MAX</sub>, input duty cycle = 50%.

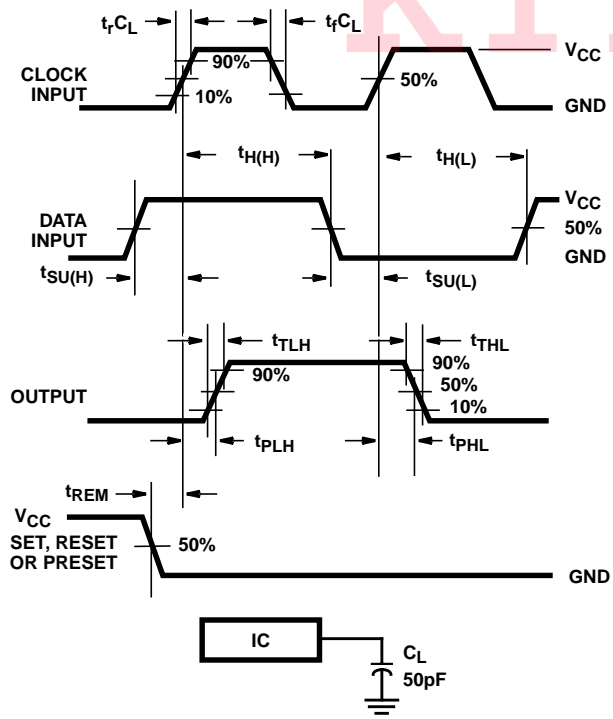
**FIGURE 2. HCT CLOCK PULSE RISE AND FALL TIMES AND PULSE WIDTH**



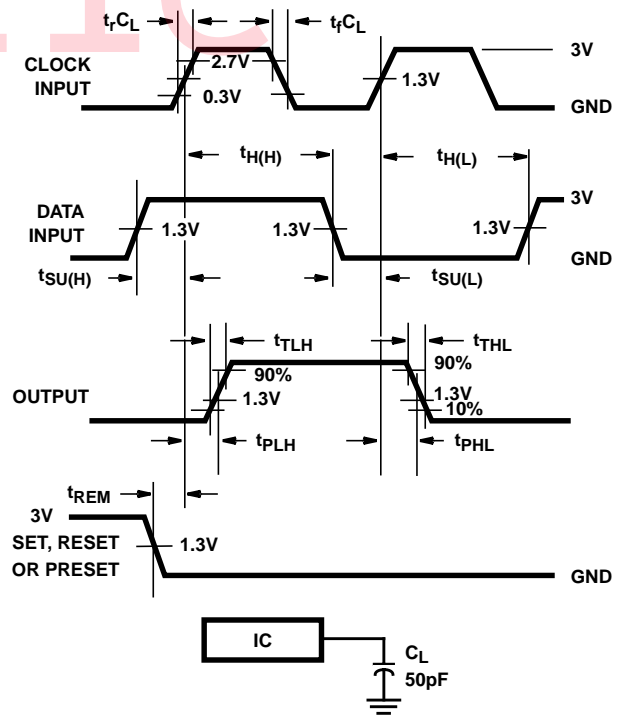
**FIGURE 3. HC AND HCU TRANSITION TIMES AND PROPAGATION DELAY TIMES, COMBINATION LOGIC**



**FIGURE 4. HCT TRANSITION TIMES AND PROPAGATION DELAY TIMES, COMBINATION LOGIC**



**FIGURE 5. HC SETUP TIMES, HOLD TIMES, REMOVAL TIME, AND PROPAGATION DELAY TIMES FOR EDGE TRIGGERED SEQUENTIAL LOGIC CIRCUITS**



**FIGURE 6. HCT SETUP TIMES, HOLD TIMES, REMOVAL TIME, AND PROPAGATION DELAY TIMES FOR EDGE TRIGGERED SEQUENTIAL LOGIC CIRCUITS**



**Test Circuits and Waveforms (Continued)**

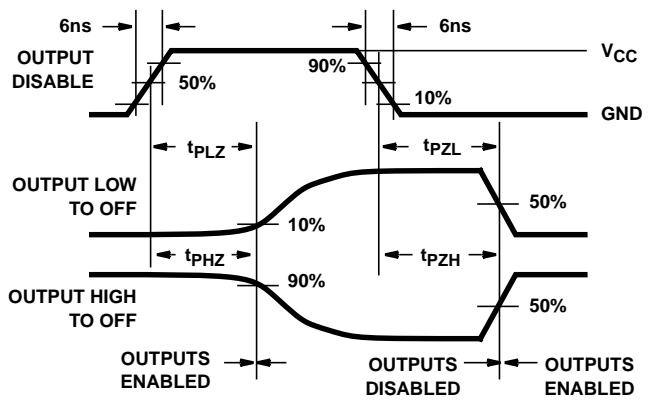


FIGURE 7. HC THREE-STATE PROPAGATION DELAY WAVEFORM

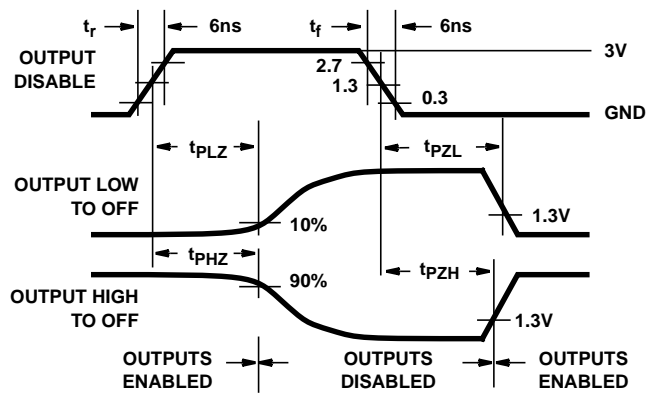
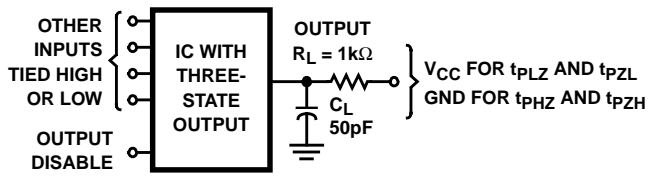


FIGURE 8. HCT THREE-STATE PROPAGATION DELAY WAVEFORM



NOTE: Open drain waveforms  $t_{PLZ}$  and  $t_{PZL}$  are the same as those for three-state shown on the left. The test circuit is Output  $R_L = 1k\Omega$  to  $V_{CC}$ ,  $C_L = 50pF$ .

FIGURE 9. HC AND HCT THREE-STATE PROPAGATION DELAY TEST CIRCUIT

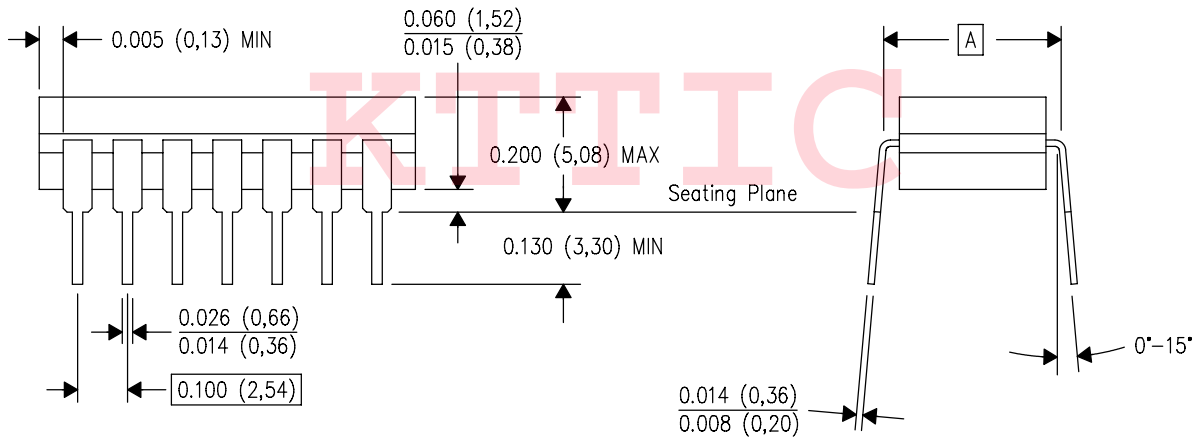


J (R-GDIP-T\*\*)   
 14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



DIM \ PINS **	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)



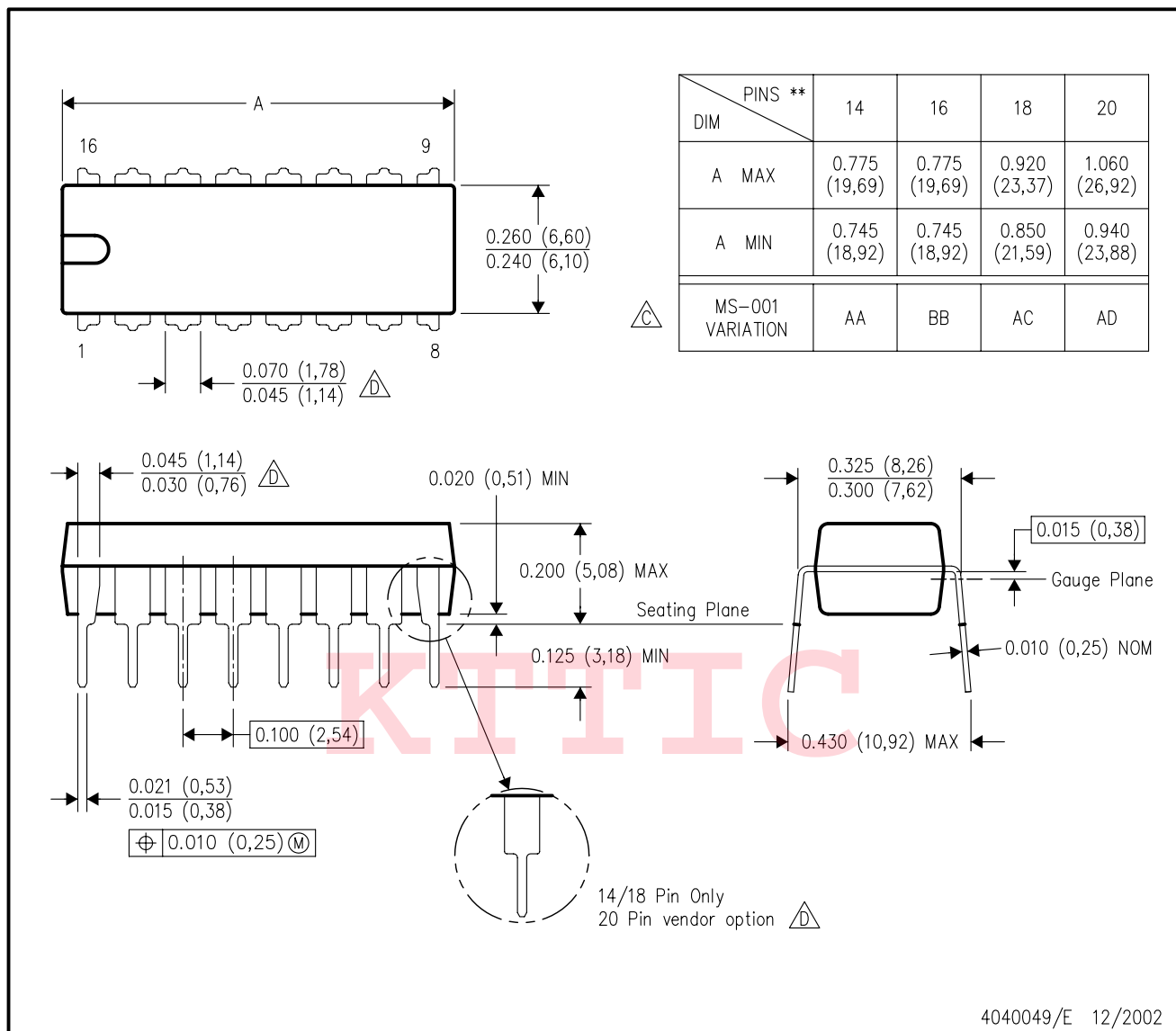
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- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package is hermetically sealed with a ceramic lid using glass frit.
  - D. Index point is provided on cap for terminal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

N (R-PDIP-T\*\*)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN

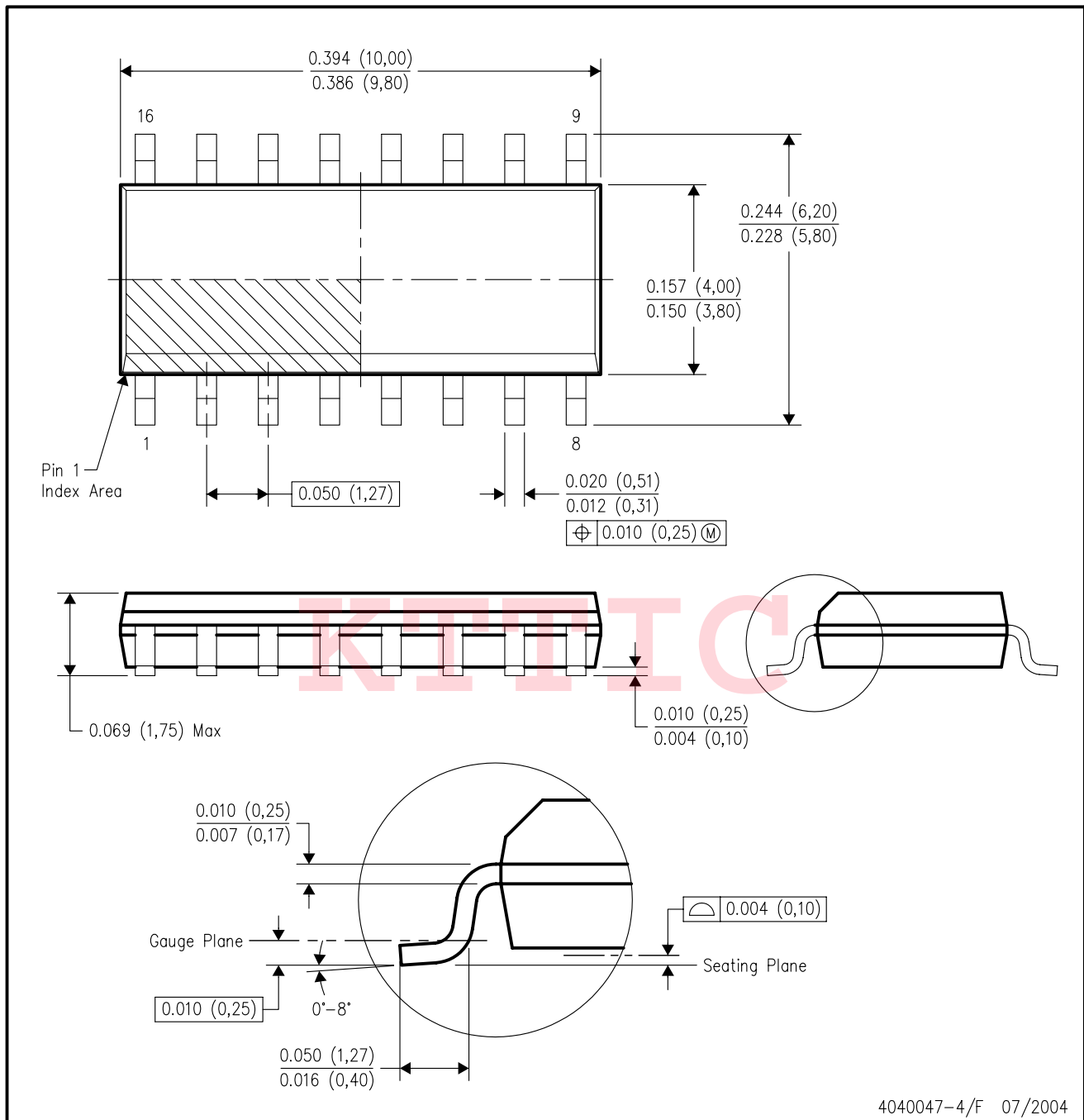


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- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
  - D. The 20 pin end lead shoulder width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

D (R-PDSO-G16)

PLASTIC SMALL-OUTLINE PACKAGE



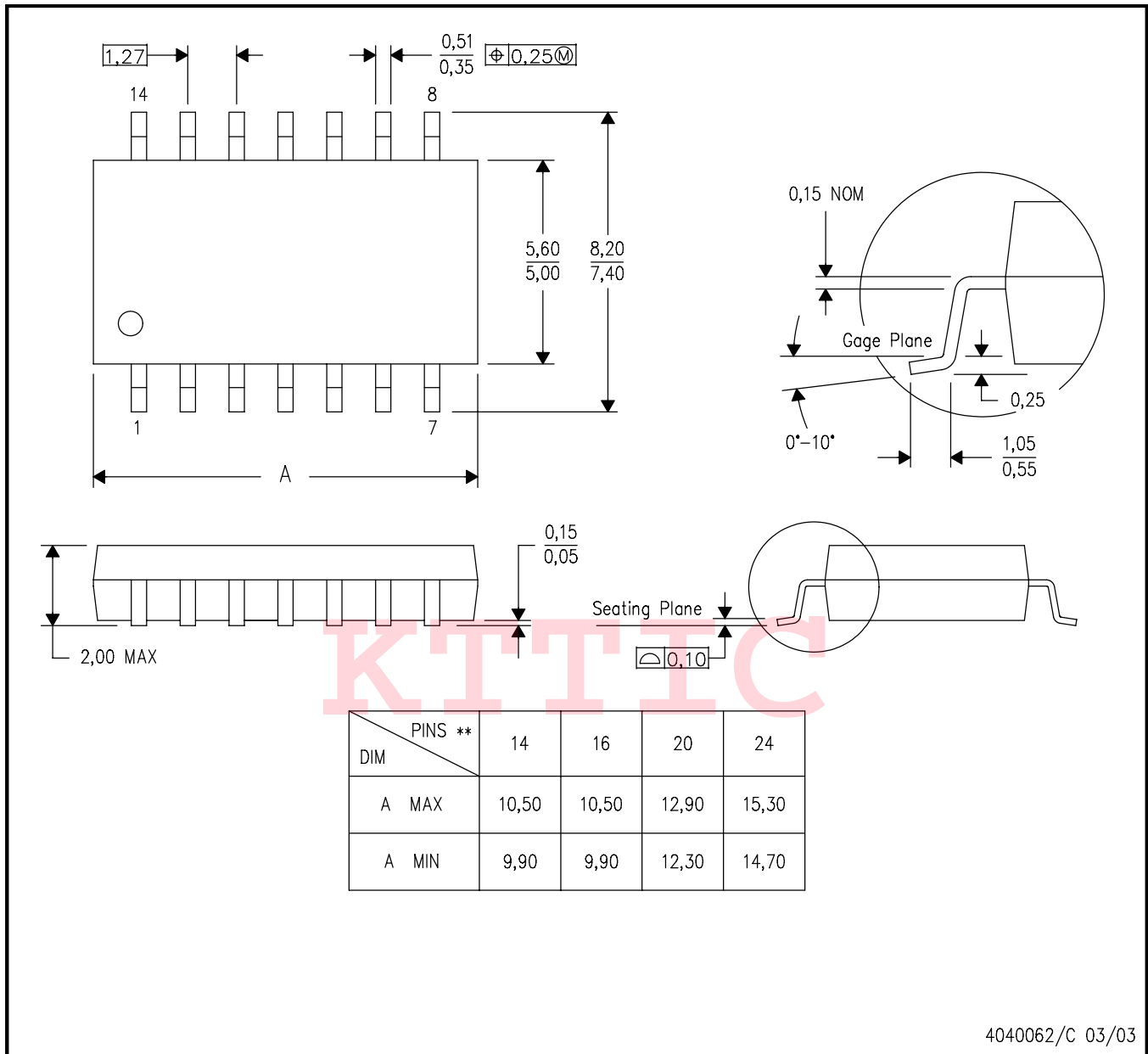
- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - D. Falls within JEDEC MS-012 variation AC.

**MECHANICAL DATA**

**NS (R-PDSO-G\*\*)**

**PLASTIC SMALL-OUTLINE PACKAGE**

**14-PINS SHOWN**

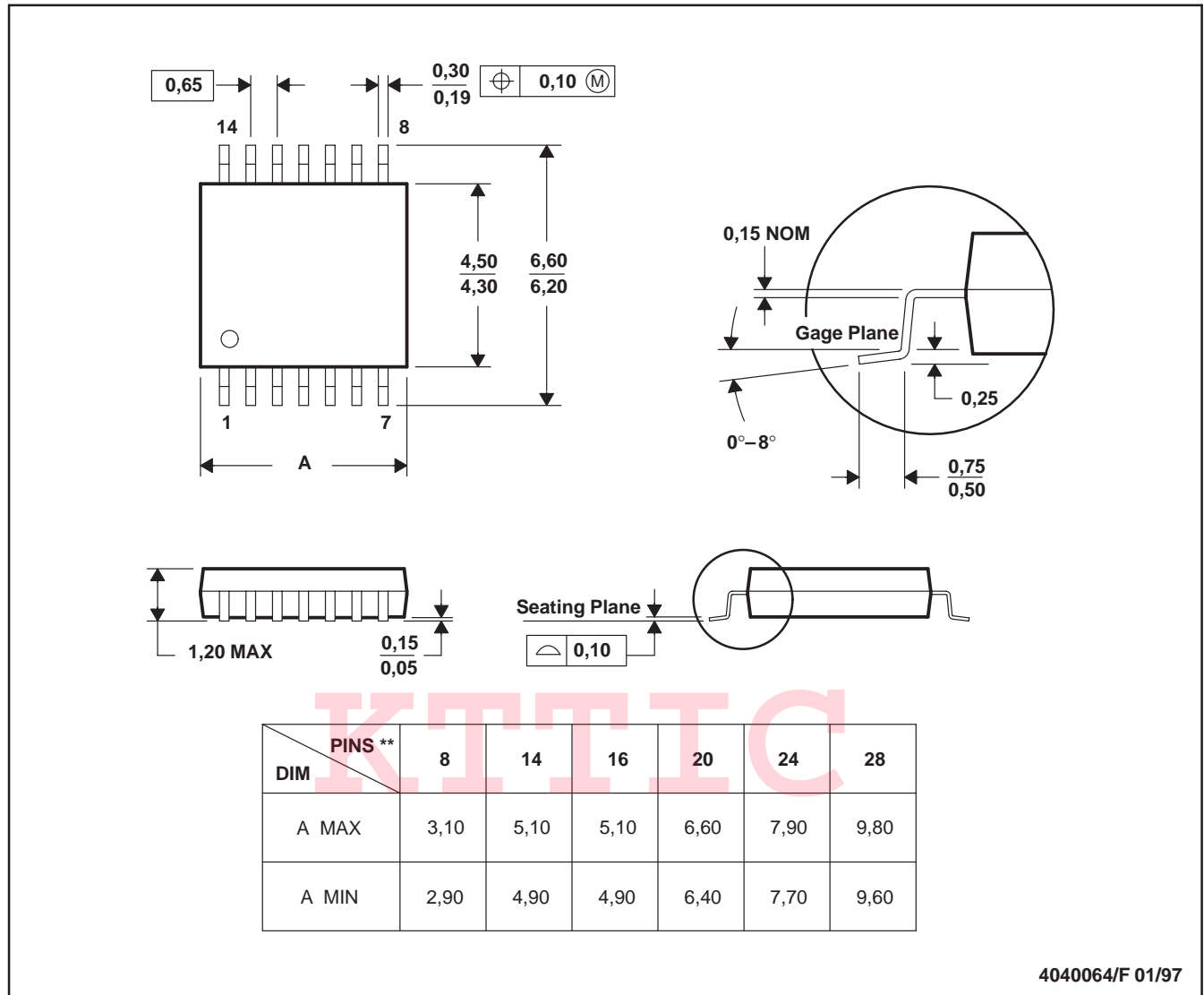


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

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

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Mailing Address: Texas Instruments  
 Post Office Box 655303 Dallas, Texas 75265

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