

High-Speed CMOS Logic Octal Three-State Bus Transceiver, Inverting

Features

- Buffered Inputs
- Three-State Outputs
- Applications in Multiple-Data-Bus Architecture
- 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 'HC640 and 'HCT640 silicon-gate CMOS three-state bidirectional inverting and non-inverting buffers are intended for two-way asynchronous communication between data buses. They have high drive current outputs which enable high-speed operation when driving large bus capacitances. These circuits possess the low power dissipation of CMOS circuits, and have speeds comparable to low power Schottky TTL circuits. They can drive 15 LSTTL loads. The 'HC640 and 'HCT640 are inverting buffers.

The direction of data flow (A to B, B to A) is controlled by the DIR input.

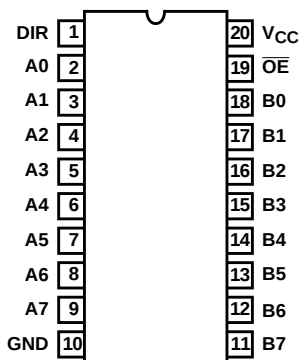
Outputs are enabled by a low on the Output Enable input ($\overline{OE}$); a high $\overline{OE}$ puts these devices in the high impedance mode.

Ordering Information

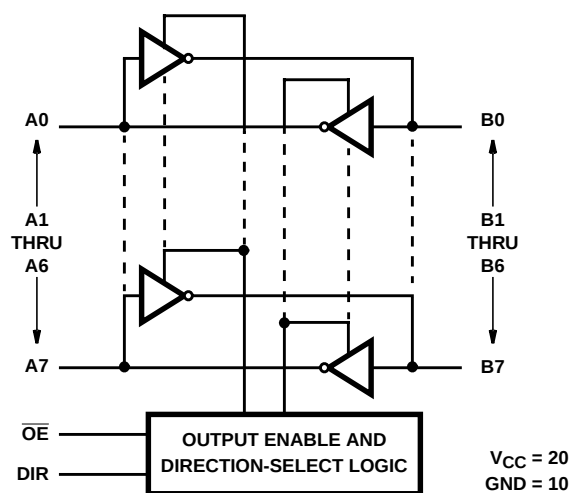
PART NUMBER	TEMP. RANGE (°C)	PACKAGE
CD54HC640F3A	-55 to 125	20 Ld CERDIP
CD54HCT640F3A	-55 to 125	20 Ld CERDIP
CD74HC640E	-55 to 125	20 Ld PDIP
CD74HC640M	-55 to 125	20 Ld SOIC
CD74HCT640E	-55 to 125	20 Ld PDIP
CD74HCT640M	-55 to 125	20 Ld SOIC

Pinout

CD54HC640, CD54HCT640
(CERDIP)
CD74HC640, CD74HCT640
(PDIP, SOIC)
TOP VIEW



Functional Diagram



TRUTH TABLE

CONTROL INPUTS		DATA PORT STATUS	
$\overline{OE}$	DIR	A_n	B_n
L	L	$\overline{O}$	I
H	H	Z	Z
H	L	Z	Z
L	H	I	$\overline{O}$

To prevent excess currents in the High-Z modes all I/O terminals should be terminated with 1k Ω to 1M Ω resistors.

H = High Level

L = Low Level

I = Input

$\overline{O}$ = Output (Inversion of Input Level)

Z = High Impedance

CD54HC640, CD74HC640, CD54HCT640, CD74HCT640

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 Drain Current, per Output, I_O	
For $-0.5V < V_O < V_{CC} + 0.5V$	$\pm 35mA$
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}	$\pm 50mA$

Thermal Information

Thermal Resistance (Typical, Note 1)	θ_{JA} ($^{\circ}C/W$)
E (PDIP) Package	69
M (SOIC) Package	58
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:

1. 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			
HC TYPES														
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		
-			-	-	-	-	-	-	-	-	V			
-			4.5	3.98	-	-	3.84	-	3.7	-	V			
-			6	5.48	-	-	5.34	-	5.2	-	V			
High Level Output Voltage TTL Loads	V _{OL}	V _{IH} or V _{IL}	-	-	-	-	-	-	-	-	-	V		
			-6	4.5	3.98	-	-	3.84	-	3.7	-	V		
			-7.8	6	5.48	-	-	5.34	-	5.2	-	V		
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 CMOS Loads	V _{OL}	V _{IH} or V _{IL}	-	-	-	-	-	-	-	-	-	V		
			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	-	-	±0.1	-	±1	-	±1	μA

CD54HC640, CD74HC640, CD54HCT640, CD74HCT640

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	
Quiescent Device Current	I _{CC}	V _{CC} or GND	0	6	-	-	8	-	80	-	160	μA
Three-State Leakage Current	I _{OZ}	V _{IL} or V _{IH}	V _O = V _{CC} or GND	6	-	-	±0.5	-	±5	-	±10	μA
HCT TYPES												
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} and 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
Three-State Leakage Current	I _{OZ}	V _{IL} or V _{IH}	V _O = V _{CC} or GND	5.5	-	-	±0.5	-	±5	-	±10	μA
Additional Quiescent Device Current Per Input Pin: 1 Unit Load	ΔI _{CC} (Note 2)	V _{CC} -2.1	-	4.5 to 5.5	-	100	360	-	450	-	490	μA

NOTE:

- 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
DIR	0.9
$\overline{OE}$, A	1.5
B	1.5

NOTE: Unit Load is ΔI_{CC} limit specified in DC Electrical Table, e.g., 360μA max at 25°C.

CD54HC640, CD74HC640, CD54HCT640, CD74HCT640

Switching Specifications $C_L = 50\text{pF}$, 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
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
HC TYPES											
Propagation Delay A to $\overline{B}$ B to $\overline{A}$	t _{PHL} , t _{PLH}	C _L = 50pF	2	-	-	90	-	115	-	135	ns
			4.5	-	-	18	-	23	-	27	ns
		C _L = 15pF	5	-	7	-	-	-	-	-	ns
		C _L = 50pF	6	-	-	15	-	20	-	23	ns
Output High-Z To High Level, To Low Level	t _{PHL} , t _{PLH}	C _L = 50pF	2	-	-	150	-	190	-	225	ns
			4.5	-	-	30	-	38	-	45	ns
		C _L = 15pF	5	-	12	-	-	-	-	-	ns
		C _L = 50pF	6	-	-	26	-	33	-	38	ns
Output High Level Output Low Level to High Z	t _{PHZ} , t _{PLZ}	C _L = 50pF	2	-	-	150	-	190	-	225	ns
			4.5	-	-	30	-	38	-	45	ns
		C _L = 15pF	5	-	12	-	-	-	-	-	ns
		C _L = 50pF	6	-	-	26	-	33	-	38	ns
Output Transition Time	t _{THL} , t _{TLH}	C _L = 50pF	2	-	-	60	-	75	-	90	ns
			4.5	-	-	12	-	15	-	18	ns
			6	-	-	10	-	13	-	15	ns
Input Capacitance	C _{IN}	C _L = 50pF	-	10	-	10	-	10	-	10	pF
Three-State Output Capacitance	C _O	-	-	-	-	20	-	20	-	20	pF
Power Dissipation Capacitance (Notes 3, 4)	C _{PD}	-	5	-	38	-	-	-	-	-	pF
HCT TYPES											
Propagation Delay A to $\overline{B}$ B to $\overline{A}$	t _{PHL} , t _{PLH}	C _L = 50pF	4.5	-	-	22	-	28	-	33	ns
		C _L = 15pF	5	-	9	-	-	-	-	-	ns
Output High-Z To High Level, To Low Level	t _{PHL} , t _{PLH}	C _L = 50pF	4.5	-	-	30	-	38	-	45	ns
		C _L = 15pF	5	-	12	-	-	-	-	-	ns
Output High Level Output Low Level to High Z	t _{PHZ} , t _{PLZ}	C _L = 50pF	4.5	-	-	30	-	38	-	45	ns
		C _L = 15pF	5	-	12	-	-	-	-	-	ns
Output Transition Time	t _{THL} , t _{TLH}	C _L = 50pF	4.5	-	-	12	-	15	-	18	ns
Input Capacitance	C _{IN}	C _L = 50pF	-	10	-	10	-	10	-	10	pF
Three-State Output Capacitance	C _O	-	-	-	-	20	-	20	-	20	pF
Power Dissipation Capacitance (Notes 3, 4)	C _{PD}	-	5	-	41	-	-	-	-	-	pF

NOTES:

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

Test Circuits and Waveforms

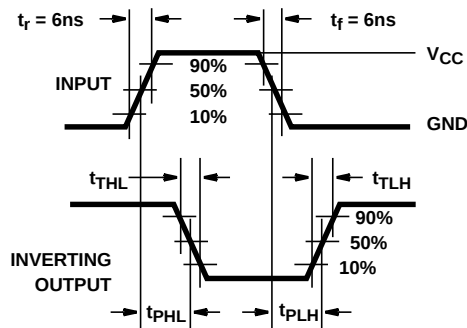


FIGURE 7. HC TRANSITION TIMES AND PROPAGATION DELAY TIMES, COMBINATION LOGIC

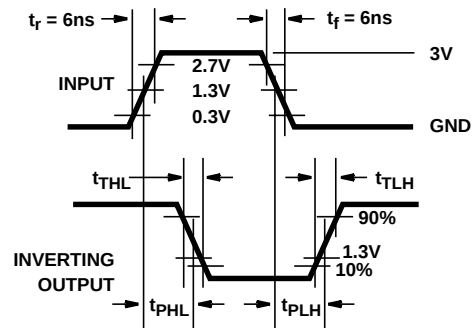


FIGURE 8. HCT TRANSITION TIMES AND PROPAGATION DELAY TIMES, COMBINATION LOGIC

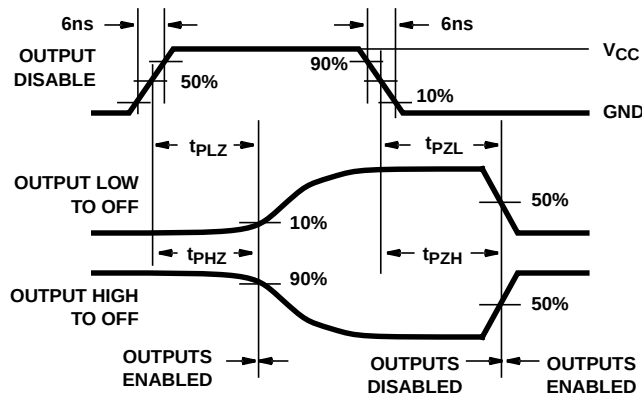


FIGURE 9. HC THREE-STATE PROPAGATION DELAY WAVEFORM

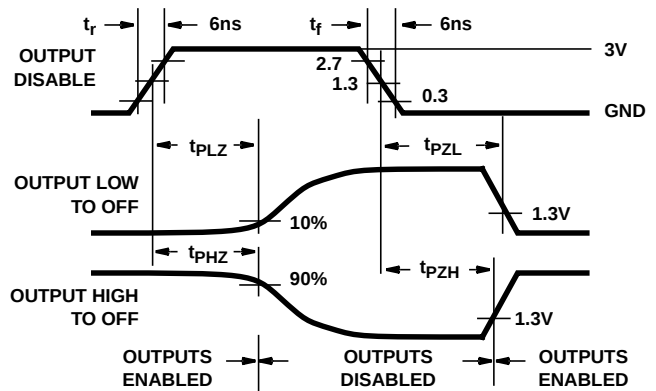
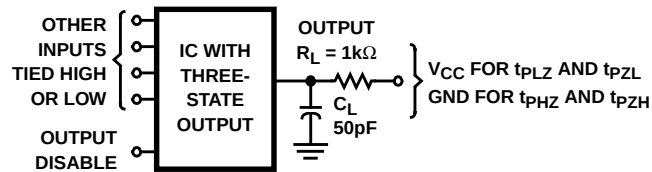


FIGURE 10. HCT THREE-STATE PROPAGATION DELAY WAVEFORM



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 11. HC AND HCT THREE-STATE PROPAGATION DELAY TEST CIRCUIT

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
5962-8974001RA	ACTIVE	CDIP	J	20	1	TBD	A42 SNPB	N / A for Pkg Type
CD54HC640F3A	ACTIVE	CDIP	J	20	1	TBD	A42 SNPB	N / A for Pkg Type
CD54HCT640F3A	ACTIVE	CDIP	J	20	1	TBD	A42 SNPB	N / A for Pkg Type
CD74HC640E	ACTIVE	PDIP	N	20	20	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
CD74HC640EE4	ACTIVE	PDIP	N	20	20	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
CD74HC640M	ACTIVE	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
CD74HC640ME4	ACTIVE	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
CD74HC640MG4	ACTIVE	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
CD74HCT640E	ACTIVE	PDIP	N	20	20	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
CD74HCT640EE4	ACTIVE	PDIP	N	20	20	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
CD74HCT640M	ACTIVE	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
CD74HCT640ME4	ACTIVE	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
CD74HCT640MG4	ACTIVE	SOIC	DW	20	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

⁽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.

OBSELETE: 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.

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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)

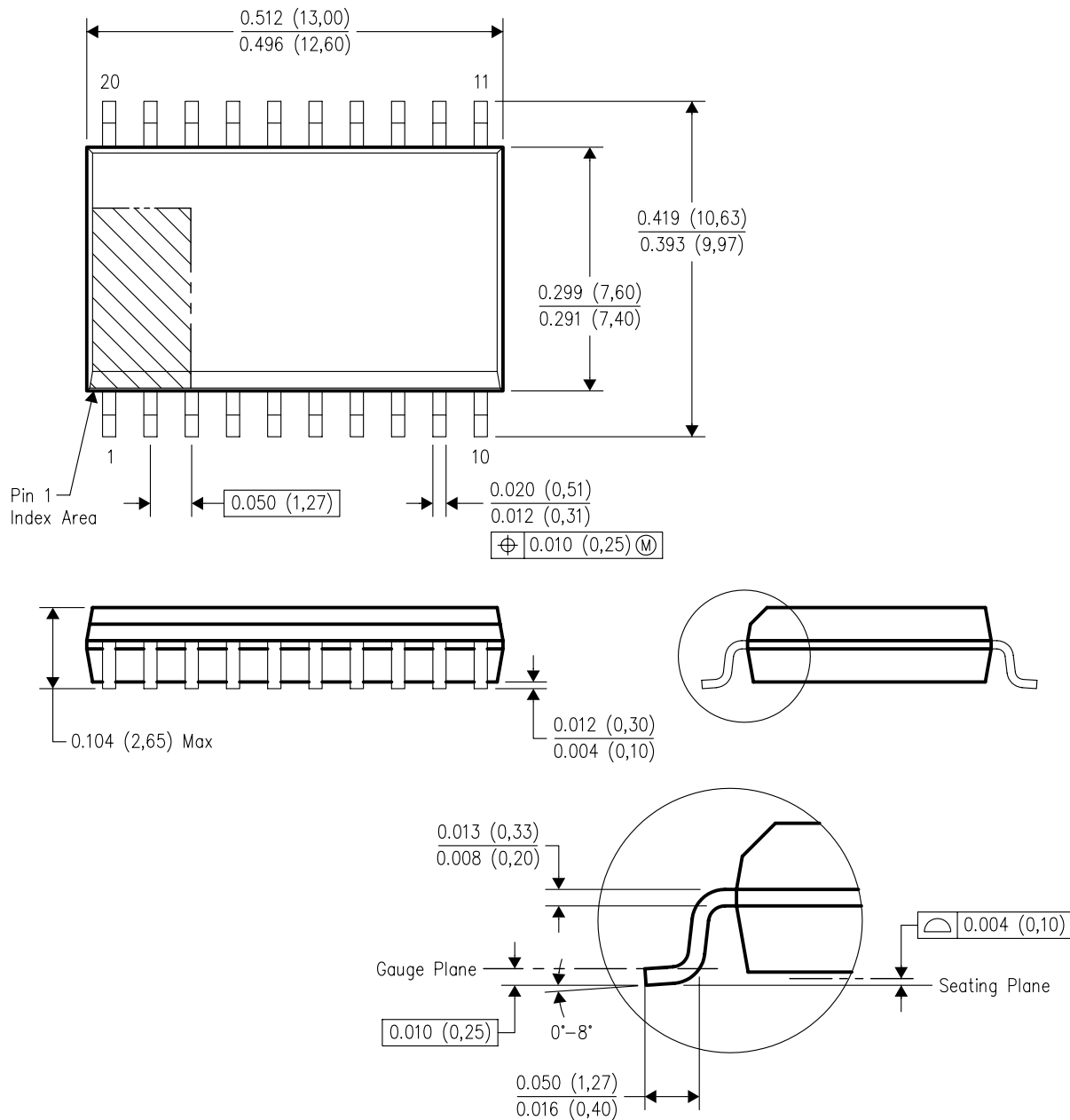


4040083/F 03/03

- 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.

DW (R-PDSO-G20)

PLASTIC SMALL-OUTLINE PACKAGE



4040000-4/F 06/2004

- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - Falls within JEDEC MS-013 variation AC.

N (R-PDIP-T**)

16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE



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



4040049/E 12/2002

NOTES:

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

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