Data sheet acquired from Harris Semiconductor
SCHS240A

September 1998 - Revised May 2000

8-Bit Serial-In/Parallel-Out Shift Register

Features

- **Buffered Inputs**
- **Typical Propagation Delay**
  - **6ns at V_{CC} = 5V, T_A = 25^{o}C, C_L = 50pF**
- **Exceeds 2kV ESD Protection MIL-STD-883, Method 3015**
- **SCR-Latchup-Resistant CMOS Process and Circuit Design**
- **Speed of Bipolar FAST™/AS/S with Significantly Reduced Power Consumption**
- **Balanced Propagation Delays**
- **AC Types Feature 1.5V to 5.5V Operation and Balanced Noise Immunity at 30% of the Supply**
- **±24mA Output Drive Current**
  - **Fanout to 15 FAST™ ICs**
  - **Drives 50Ω Transmission Lines**

Description

The ’AC164 and ’ACT164 are 8-bit serial-in/parallel-out shift registers with asynchronous reset that utilize Advanced CMOS Logic technology. Data is shifted on the positive edge of the clock (CP). A LOW on the Master Reset ($\overline{MR}$) pin resets the shift register and all outputs go to the LOW state regardless of the input conditions. Two Serial Data inputs (DS1 and DS2) are provided; either one can be used as a Data Enable control.

Ordering Information

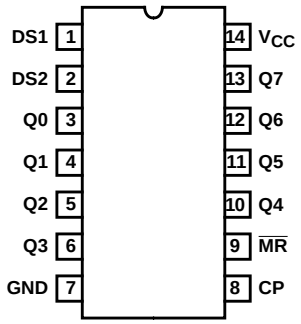
PART NUMBER	TEMP. RANGE (^{o}C)	PACKAGE
CD54AC164F3A	-55 to 125	14 Ld CERDIP
CD74AC164E	-55 to 125	14 Ld PDIP
CD74AC164M	-55 to 125	14 Ld SOIC
CD54ACT164F3A	-55 to 125	14 Ld CERDIP
CD74ACT164E	-55 to 125	14 Ld PDIP
CD74ACT164M	-55 to 125	14 Ld SOIC

NOTES:

1. When ordering, use the entire part number. Add the suffix 96 to obtain the variant in the tape and reel.
2. Wafer and die for this part number is available which meets all electrical specifications. Please contact your local TI sales office or customer service for ordering information.

Pinout

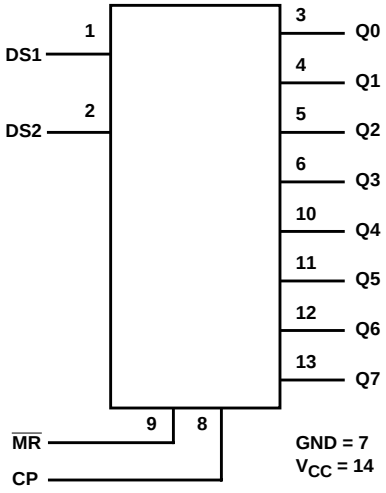
CD54AC164, CD54ACT164
(CERDIP)
CD74AC164, CD74ACT164
(PDIP, SOIC)
TOP VIEW



CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper IC Handling Procedures.

FAST™ is a Trademark of Fairchild Semiconductor.

Functional Diagram



MODE SELECT - TRUTH TABLE

OPERATING MODE	INPUTS				OUTPUTS	
	$\overline{MR}$	CP	DS1	DS2	Q0	Q1 - Q7
RESET (CLEAR)	**L**	**X**	**X**	**X**	**L**	**L - L**
SHIFT	H	↑	l	l	L	q0 - q6
	H	↑	l	h	L	q0 - q6
	H	↑	h	l	L	q0 - q6
	H	↑	h	h	H	q0 - q6

H = HIGH voltage level steady state.
L = LOW voltage level steady state.
h = HIGH voltage level one setup time prior to the LOW-to_HIGH clock transition.
l = LOW voltage level one setup time prior to the LOW-to-HIGH clock transition.
X = Don't care.
q = Lowercase letters indicate the state of the referenced output prior to the LOW-to-HIGH clock transition.
↑ = LOW-to-HIGH clock transition.

Absolute Maximum Ratings

DC Supply Voltage, V_{CC} . . . . . -0.5V to 6V
DC Input Diode Current, I_{IK}
For V_I < -0.5V or V_I > V_{CC} + 0.5V . . . . . ±20mA
DC Output Diode Current, I_{OK}
For V_O < -0.5V or V_O > V_{CC} + 0.5V . . . . . ±50mA
DC Output Source or Sink Current per Output Pin, I_O
For V_O > -0.5V or V_O < V_{CC} + 0.5V . . . . . ±50mA
DC V_{CC} or Ground Current, $I_{CC\ or}$ I_{GND} (Note 3) . . . . . ±100mA

Operating Conditions

Temperature Range, T_A . . . . . -55°C to 125°C
Supply Voltage Range, V_{CC} (Note 4)
AC Types. . . . . 1.5V to 5.5V
ACT Types . . . . . 4.5V to 5.5V
DC Input or Output Voltage, V_I, V_O . . . . . 0V to V_{CC}
Input Rise and Fall Slew Rate, dt/dv
AC Types, 1.5V to 3V . . . . . 50ns (Max)
AC Types, 3.6V to 5.5V. . . . . 20ns (Max)
ACT Types, 4.5V to 5.5V. . . . . 10ns (Max)

Thermal Information

Thermal Resistance (Typical, Note 5) θ_{JA} (°C/W)
PDIP Package 90
SOIC Package 175
Maximum Junction Temperature (Plastic Package) . . . . . 150°C
Maximum Storage Temperature Range . . . . . -65°C to 150°C
Maximum Lead Temperature (Soldering 10s) . . . . . 300°C
(SOIC - Lead Tips Only)

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.

NOTES:

3. For up to 4 outputs per device, add ±25mA for each additional output.
4. Unless otherwise specified, all voltages are referenced to ground.
5. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

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	MAX	MIN	MAX	MIN	MAX	
AC TYPES											
High Level Input Voltage	V_{IH}	-	-	1.5	1.2	-	1.2	-	1.2	-	V
				3	2.1	-	2.1	-	2.1	-	V
				5.5	3.85	-	3.85	-	3.85	-	V
Low Level Input Voltage	V_{IL}	-	-	1.5	-	0.3	-	0.3	-	0.3	V
				3	-	0.9	-	0.9	-	0.9	V
				5.5	-	1.65	-	1.65	-	1.65	V
High Level Output Voltage	V_{OH}	V_{IH} or V_{IL}	-0.05	1.5	1.4	-	1.4	-	1.4	-	V
			-0.05	3	2.9	-	2.9	-	2.9	-	V
			-0.05	4.5	4.4	-	4.4	-	4.4	-	V
			-4	3	2.58	-	2.48	-	2.4	-	V
			-24	4.5	3.94	-	3.8	-	3.7	-	V
			-75 (Note 6, 7)	5.5	-	-	3.85	-	-	-	V
			-50 (Note 6, 7)	5.5	-	-	-	-	3.85	-	V

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	MAX	MIN	MAX	MIN	MAX	
Low Level Output Voltage	V_{OL}	V_{IH} or V_{IL}	0.05	1.5	-	0.1	-	0.1	-	0.1	V
			0.05	3	-	0.1	-	0.1	-	0.1	V
			0.05	4.5	-	0.1	-	0.1	-	0.1	V
			12	3	-	0.36	-	0.44	-	0.5	V
			24	4.5	-	0.36	-	0.44	-	0.5	V
			75 (Note 6, 7)	5.5	-	-	-	1.65	-	-	V
			50 (Note 6, 7)	5.5	-	-	-	-	-	1.65	V
Input Leakage Current	I_I	V_{CC} or GND	-	5.5	-	±0.1	-	±1	-	±1	µA
Quiescent Supply Current MSI	I_{CC}	V_{CC} or GND	0	5.5	-	8	-	80	-	160	µA
ACT 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	V_{OH}	V_{IH} or V_{IL}	-0.05	4.5	4.4	-	4.4	-	4.4	-	V
			-24	4.5	3.94	-	3.8	-	3.7	-	V
			-75 (Note 6, 7)	5.5	-	-	3.85	-	-	-	V
			-50 (Note 6, 7)	5.5	-	-	-	-	3.85	-	V
Low Level Output Voltage	V_{OL}	V_{IH} or V_{IL}	0.05	4.5	-	0.1	-	0.1	-	0.1	V
			24	4.5	-	0.36	-	0.44	-	0.5	V
			75 (Note 6, 7)	5.5	-	-	-	1.65	-	-	V
			50 (Note 6, 7)	5.5	-	-	-	-	-	1.65	V
Input Leakage Current	I_I	V_{CC} or GND	-	5.5	-	±0.1	-	±1	-	±1	µA
Quiescent Supply Current MSI	I_{CC}	V_{CC} or GND	0	5.5	-	8	-	80	-	160	µA
Additional Supply Current per Input Pin TTL Inputs High 1 Unit Load	ΔI_{CC}	V_{CC} -2.1	-	4.5 to 5.5	-	2.4	-	2.8	-	3	mA

NOTES:

6. Test one output at a time for a 1-second maximum duration. Measurement is made by forcing current and measuring voltage to minimize power dissipation.
7. Test verifies a minimum 50Ω transmission-line-drive capability at 85°C, 75Ω at 125°C.

ACT Input Load Table

INPUT	UNIT LOAD
DS1, DS2	0.5
$\overline{MR}$	0.74
CP	0.71

NOTE: Unit load is ΔI_{CC} limit specified in DC Electrical Specifications Table, e.g., 2.4mA max at 25°C.

Prerequisite For Switching Function

PARAMETER	SYMBOL	V_{CC} (V)	-40°C TO 85°C		-55°C TO 125°C		UNITS
			MIN	MAX	MIN	MAX	
AC TYPES							
Max. Clock Frequency	f_{MAX}	1.5	7	-	6	-	MHz
		3.3 (Note 9)	62	-	54	-	MHz
		5 (Note 10)	86	-	75	-	MHz
$\overline{MR}$ Pulse Width	t_W	1.5	49	-	56	-	ns
		3.3	5.5	-	6.3	-	ns
		5	3.9	-	4.5	-	ns
CP Pulse Width	t_W	1.5	73	-	84	-	ns
		3.3	8.2	-	9.4	-	ns
		5	5.9	-	6.7	-	ns
Set-up Time	t_{SU}	1.5	27	-	31	-	ns
		3.3	3.1	-	3.5	-	ns
		5	2.2	-	2.5	-	ns
Hold Time	t_H	1.5	27	-	31	-	ns
		3.3	3.1	-	3.5	-	ns
		5	2.2	-	2.5	-	ns
$\overline{MR}$ to CP Removal Time	t_{REM}	1.5	1	-	1	-	ns
		3.3	1	-	1	-	ns
		5	1	-	1	-	ns
ACT TYPES							
Max. Clock Frequency	f_{MAX}	5 (Note 10)	80	-	70	-	MHz
$\overline{MR}$ Pulse Width	t_W	5	3.9	-	4.5	-	ns
CP Pulse Width	t_W	5	6.2	-	7.1	-	ns
Set-up Time	t_{SU}	5	2.2	-	2.5	-	ns
Hold Time	t_H	5	2.6	-	3	-	ns
$\overline{MR}$ to CP Removal Time	t_{REM}	5	0	-	0	-	ns

Switching Specifications Input t_r, t_f = 3ns, C_L = 50pF (Worst Case)

PARAMETER	SYMBOL	V_{CC} (V)	-40°C TO 85°C			-55°C TO 125°C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
AC TYPES									
Propagation Delay, CP to Qn	t_{PLH}, t_{PHL}	1.5	-	-	143	-	-	157	ns
		3.3 (Note 9)	4.5	-	15.9	4.4	-	17.5	ns
		5 (Note 10)	3.2	-	11.4	3.1	-	12.5	ns

Switching Specifications Input t_r, t_f = 3ns, C_L = 50pF (Worst Case) **(Continued)**

PARAMETER	SYMBOL	V_{CC} (V)	-40°C TO 85°C			-55°C TO 125°C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Propagation Delay, $\overline{MR}$ to Qn	t_{PLH}, t_{PHL}	1.5	-	-	158	-	-	174	ns
		3.3	5	-	17.7	4.9	-	19.5	ns
		5	3.6	-	12.6	3.5	-	13.9	ns
Input Capacitance	C_I	-	-	-	10	-	-	10	pF
Power Dissipation Capacitance	C_{PD} (Note 11)	-	-	150	-	-	150	-	pF
ACT TYPES									
Propagation Delay, CP to Qn	t_{PLH}, t_{PHL}	5 (Note 10)	3.8	-	13.5	3.7	-	14.9	ns
Propagation Delay, $\overline{MR}$ to Qn	t_{PLH}, t_{PHL}	5	4.1	-	14.4	4	-	15.8	ns
Input Capacitance	C_I	-	-	-	10	-	-	10	pF
Power Dissipation Capacitance	C_{PD} (Note 11)	-	-	150	-	-	150	-	pF

NOTES:

8. Limits tested at 100%.
9. 3.3V Min at 3.6V, Max at 3V.
10. 5V Min at 5.5V, Max at 4.5V.
11. C_{PD} is used to determine the dynamic power consumption per device. $P_D = C_{PD} V_{CC}^2 f_i \Sigma (C_L V_{CC}^2 f_o) + V_{CC} \Delta I_{CC}$, where f_i = input frequency, f_o = output frequency, C_L = output load capacitance, V_{CC} = supply voltage.

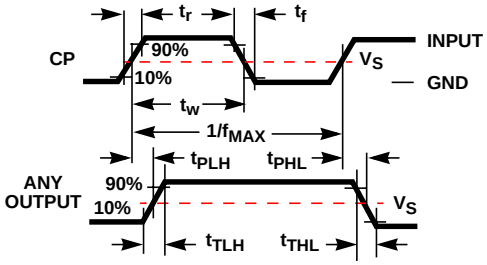


FIGURE 1.

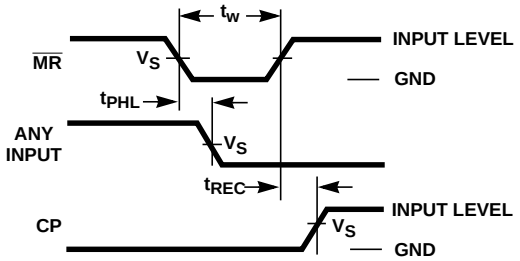


FIGURE 2.

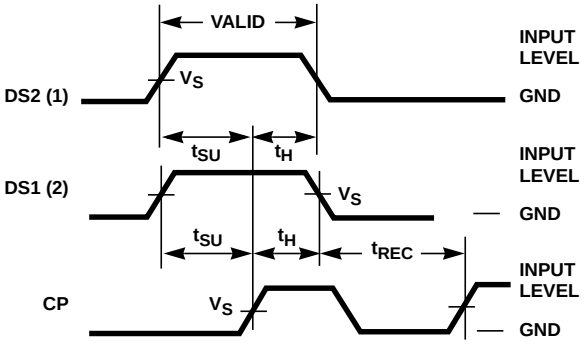


FIGURE 3.

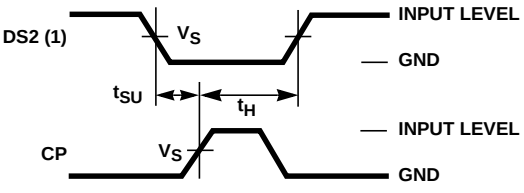
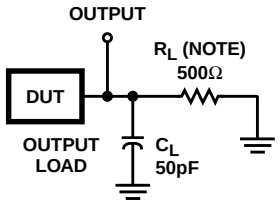


FIGURE 4.



NOTE: For AC Series Only: When V_{CC} = 1.5V, R_L = 1kΩ.

	AC	ACT
Input Level	V_{CC}	3V
Input Switching Voltage, V_S	0.5 V_{CC}	1.5V
Output Switching Voltage, V_S	0.5 V_{CC}	0.5 V_{CC}

FIGURE 5. PROPAGATION DELAY TIMES

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
CD54AC164F3A	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	CD54AC164F3A	Samples
CD54ACT164F3A	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	CD54ACT164F3A	Samples
CD74AC164E	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74AC164E	Samples
CD74AC164EE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74AC164E	Samples
CD74AC164M	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	AC164M	Samples
CD74AC164M96	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	AC164M	Samples
CD74AC164M96E4	ACTIVE	SOIC	D	14		TBD	Call TI	Call TI	-55 to 125	AC164M	Samples
CD74AC164M96G4	ACTIVE	SOIC	D	14		TBD	Call TI	Call TI	-55 to 125	AC164M	Samples
CD74AC164ME4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	AC164M	Samples
CD74AC164MG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	AC164M	Samples
CD74ACT164E	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74ACT164E	Samples
CD74ACT164EE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74ACT164E	Samples
CD74ACT164M	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	ACT164M	Samples
CD74ACT164M96	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	ACT164M	Samples
CD74ACT164M96E4	ACTIVE	SOIC	D	14		TBD	Call TI	Call TI	-55 to 125	ACT164M	Samples
CD74ACT164M96G4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	ACT164M	Samples
CD74ACT164ME4	ACTIVE	SOIC	D	14		TBD	Call TI	Call TI	-55 to 125	ACT164M	Samples
CD74ACT164MG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	ACT164M	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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

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

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

OTHER QUALIFIED VERSIONS OF CD54AC164, CD54ACT164, CD74AC164, CD74ACT164 :

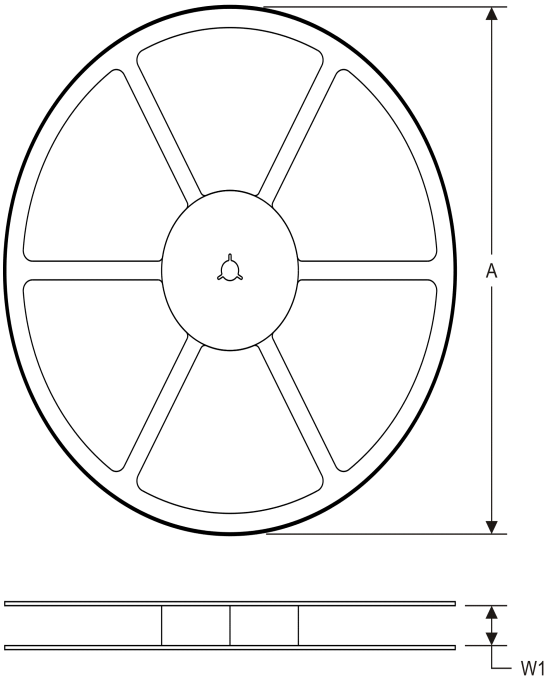
- Catalog: CD74AC164, CD74ACT164
- Military: CD54AC164, CD54ACT164

NOTE: Qualified Version Definitions:

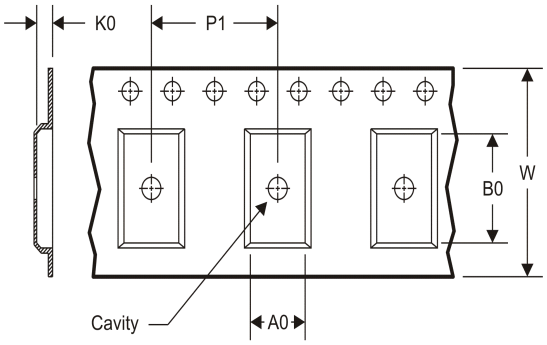
- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



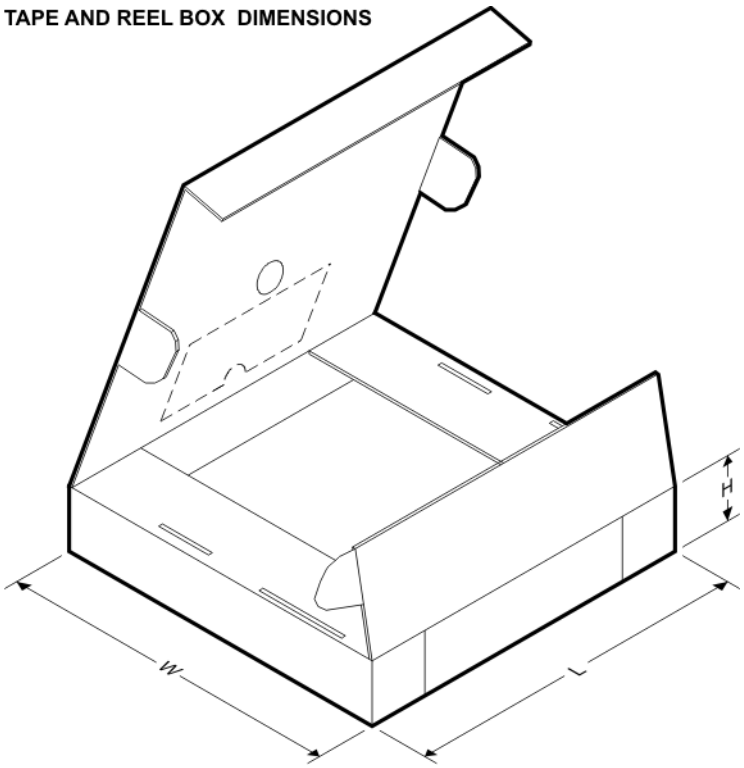
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

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
CD74AC164M96	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
CD74ACT164M96	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



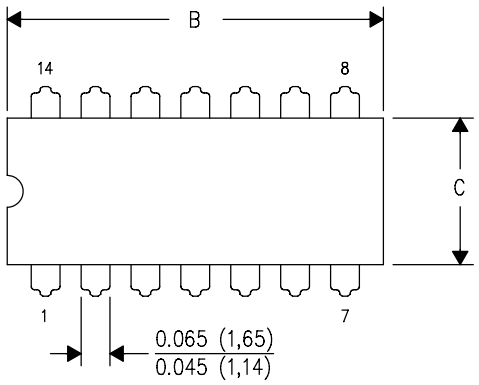
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CD74AC164M96	SOIC	D	14	2500	367.0	367.0	38.0
CD74ACT164M96	SOIC	D	14	2500	367.0	367.0	38.0

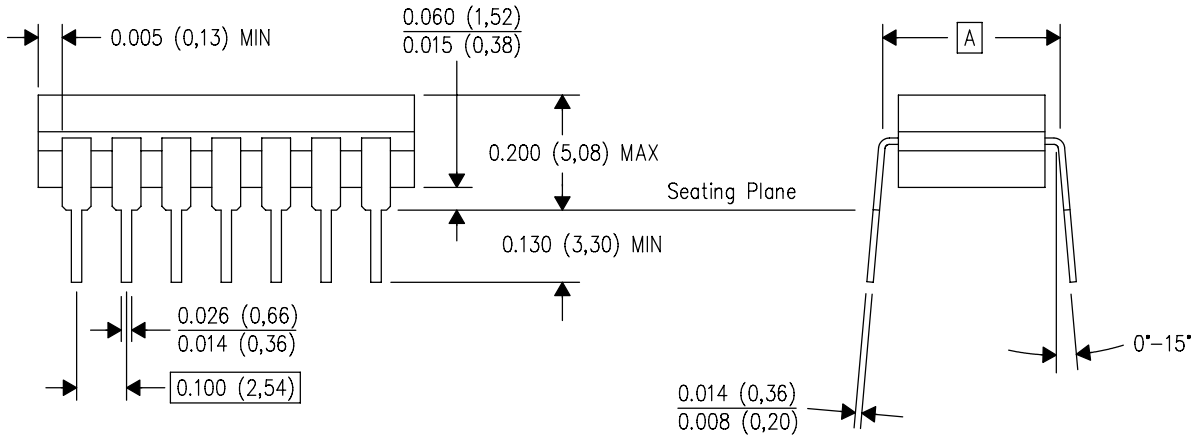
J (R–GDIP–T**)

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)



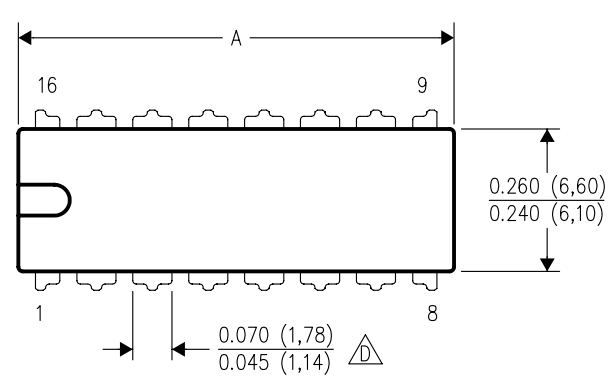
4040083/F 03/03

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.

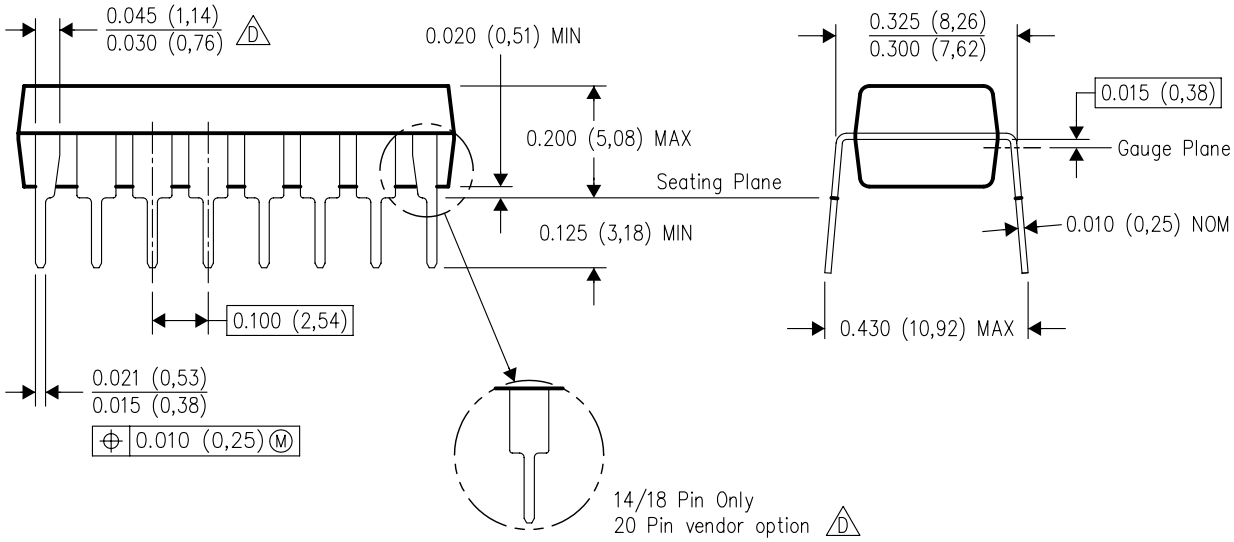
N (R–PDIP–T**)

PLASTIC DUAL–IN–LINE PACKAGE

16 PINS SHOWN



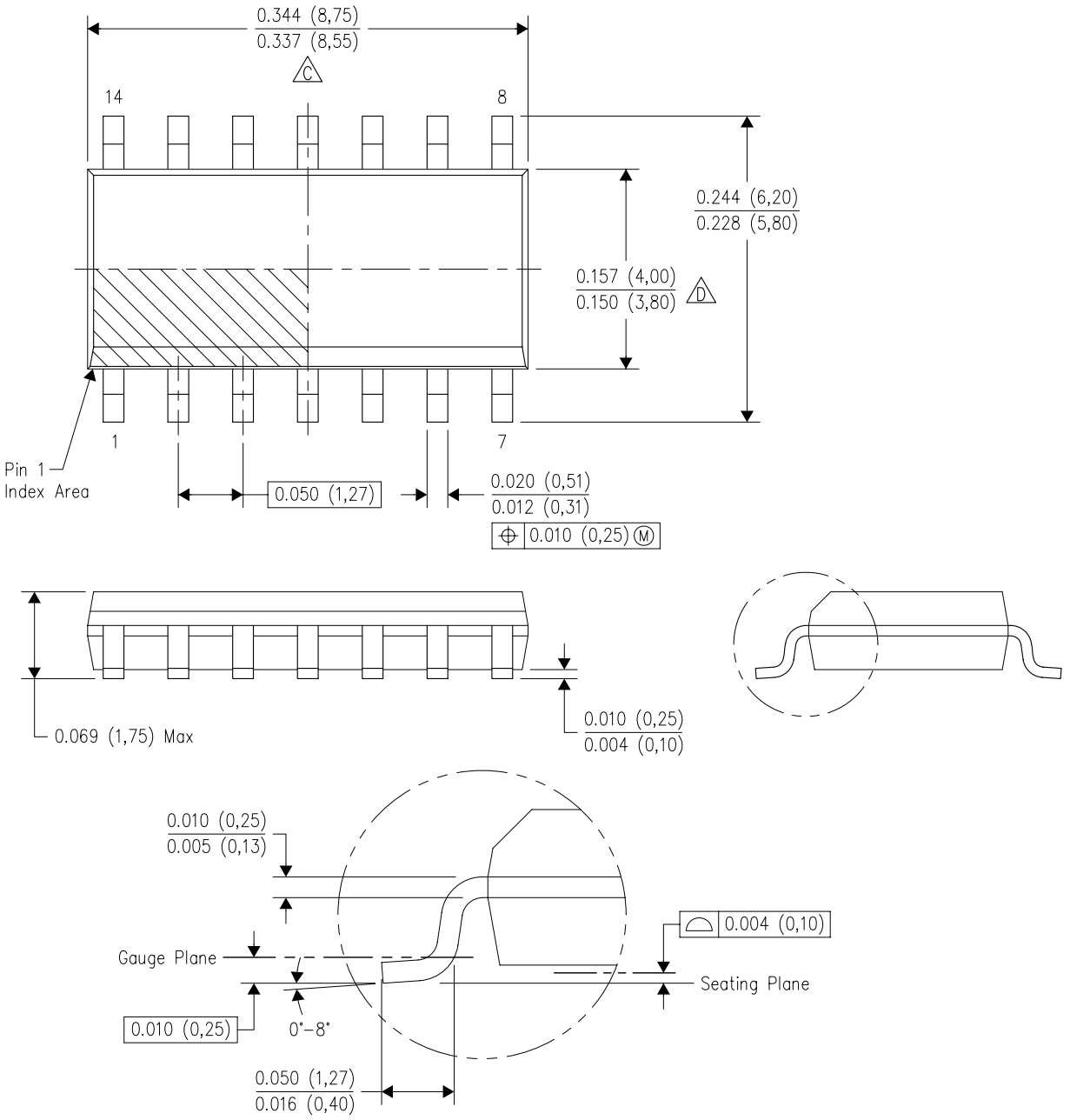
DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS–001 VARIATION (C)	AA	BB	AC	AD



4040049/E 12/2002

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
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.

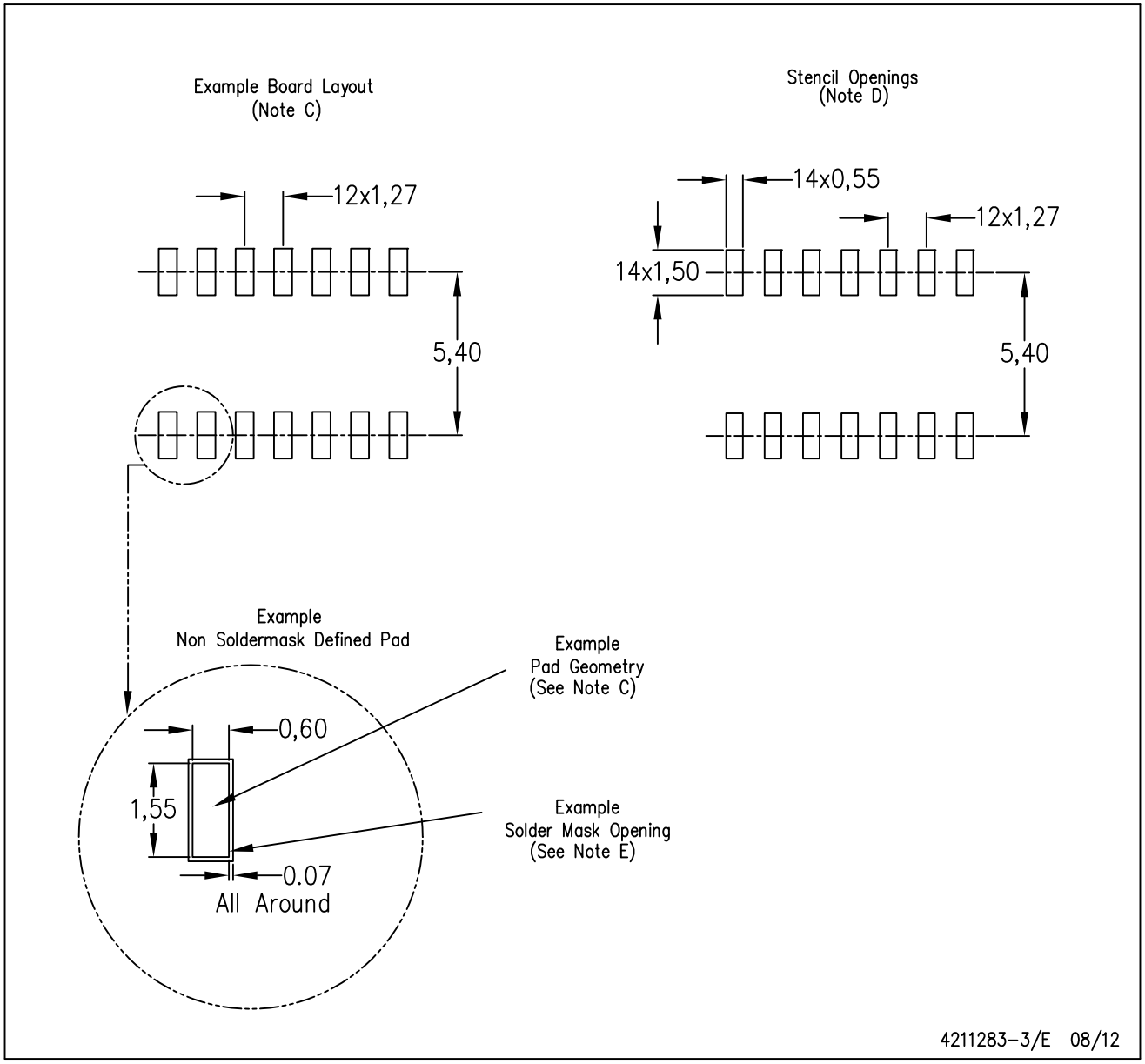
D (R–PDSO–G14) PLASTIC SMALL OUTLINE



4040047–5/M 06/11

NOTES:
A. All linear dimensions are in inches (millimeters).
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 0.006 (0,15) each side.
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 AB.

D (R–PDSO–G14) 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.

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