

CD4026B, CD4033B Types

CMOS Decade Counters/Dividers

High-Voltage Types (20-Volt Rating)

With Decoded 7-Segment Display Outputs and:

Display Enable – CD4026B

Ripple Blanking – CD4033B

■ CD4026B and CD4033B each consist of a 5-stage Johnson decade counter and an output decoder which converts the Johnson code to a 7-segment decoded output for driving one stage in a numerical display.

These devices are particularly advantageous in display applications where low power dissipation and/or low package count are important.

Inputs common to both types are CLOCK, RESET, & CLOCK INHIBIT; common outputs are CARRY OUT and the seven decoded outputs (a, b, c, d, e, f, g). Additional inputs and outputs for the CD4026B include DISPLAY ENABLE input and DISPLAY ENABLE and UNGATED "C" SEGMENT" outputs. Signals peculiar to the CD4033B are RIPPLE-BLANKING INPUT AND LAMP TEST INPUT and a RIPPLE-BLANKING OUTPUT.

A high RESET signal clears the decade counter to its zero count. The counter is advanced one count at the positive clock signal transition if the CLOCK INHIBIT signal is low. Counter advancement via the clock line is inhibited when the CLOCK INHIBIT signal is high. The CLOCK INHIBIT signal can be used as a negative-edge clock if the clock line is held high. Antilock gating is provided on the JOHNSON counter, thus assuring proper counting sequence. The CARRY-OUT (C_{out}) signal completes one cycle every ten CLOCK INPUT cycles and is used to clock the succeeding decade directly in a multi-decade counting chain. The seven decoded outputs (a, b, c, d, e, f, g) illuminate the proper segments in a seven

Features:

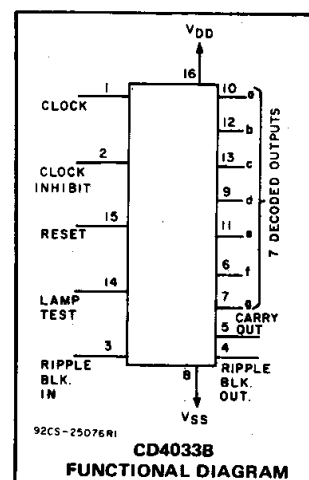
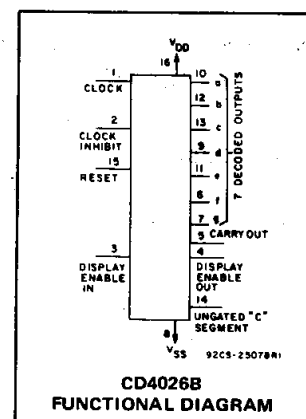
- Counter and 7-segment decoding in one package
- Easily interfaced with 7-segment display types
- Fully static counter operation: DC to 6 MHz (typ.) at $V_{DD}=10\text{ V}$
- Ideal for low-power displays
- Display enable output (CD4026B)
- "Ripple blanking" and lamp test (CD4033B)
- 100% tested for quiescent current at 20 V
- Standardized, symmetrical output characteristics

- 5-V, 10-V, and 15-V parametric ratings
- Schmitt-triggered clock inputs
- Meets all requirements of JEDEC Tentative Standard No. 13B, "Standard Specifications for Description of 'B' Series CMOS Devices"

Applications

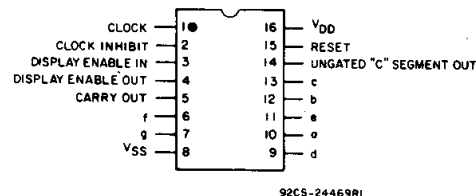
- Decade counting 7-segment decimal display
- Frequency division 7-segment decimal displays
- Clocks, watches, timers (e.g. $\div 60$, $\div 60$, $\div 12$ counter/display)
- Counter/display driver for meter applications

segment display device used for representing the decimal numbers 0 to 9. The 7-segment outputs go high on selection in the CD4033B; in the CD4026B these outputs go high only when the DISPLAY ENABLE IN is high.



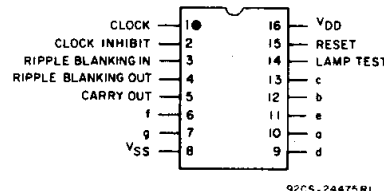
TERMINAL DIAGRAMS

Top View



CD4026B

Top View



CD4033B

MAXIMUM RATINGS, Absolute-Maximum Values:

DC SUPPLY-VOLTAGE RANGE, (V_{DD})

Voltages referenced to V_{SS} Terminal) -0.5V to +20V

INPUT VOLTAGE RANGE, ALL INPUTS -0.5V to $V_{DD} + 0.5\text{V}$

DC INPUT CURRENT, ANY ONE INPUT $\pm 10\text{mA}$

POWER DISSIPATION PER PACKAGE (P_D):

For $T_A = -55^\circ\text{C}$ to $+100^\circ\text{C}$ 500mW

For $T_A = +100^\circ\text{C}$ to $+125^\circ\text{C}$ Derate Linearly at 12mW/ $^\circ\text{C}$ to 200mW

DEVICE DISSIPATION PER OUTPUT TRANSISTOR

FOR $T_A = \text{FULL PACKAGE-TEMPERATURE RANGE (All Package Types)}$ 100mW

OPERATING-TEMPERATURE RANGE (T_A) -55°C to $+125^\circ\text{C}$

STORAGE TEMPERATURE RANGE (T_{stg}) -65°C to $+150^\circ\text{C}$

LEAD TEMPERATURE (DURING SOLDERING):

At distance 1/16 $\pm$ 1/32 inch (1.59 $\pm$ 0.79mm) from case for 10s max $+265^\circ\text{C}$

CD4026B, CD4033B Types

RECOMMENDED OPERATING CONDITIONS

For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges:

CHARACTERISTIC	V _{DD} (V)	LIMITS		UNITS
		MIN.	MAX.	
Supply-Voltage Range (For T _A = Full Package Temperature Range)		3	18	V
Clock Input Frequency, f _{CL}	5 10 15	— — —	2.5 5.5 8	MHz
Clock Pulse Width, t _{WCL}	5 10 15	220 100 80	— — —	ns
Clock Rise and Fall Time, t _{CL} , t _{FCL}	5 10 15	— — —	Unlimited	
Clock Inhibit Set Up Time, t _{SU}	5 10 15	200 50 30	— — —	
Reset Pulse Width, t _W	5 10 15	200 100 50	— — —	
Reset Removal Time	5 10 15	30 15 10	— — —	

CD4026B

When the DISPLAY ENABLE IN is low the seven decoded outputs are forced low regardless of the state of the counter. Activation of the display only when required results in significant power savings. This system also facilitates implementation of display-character multiplexing.

The CARRY OUT and UNGATED "C-SEGMENT" signals are not gated by the DISPLAY ENABLE and therefore are available continuously. This feature is a requirement in implementation of certain divider functions such as divide-by-60 and divide-by-12.

CD4033B

The CD4033B has provisions for automatic blanking of the non-significant zeros in a multi-digit decimal number which results in an easily readable display consistent with normal writing practice. For example, the number 0050.0700 in an eight digit display would be displayed as 50.07. Zero suppression on the integer side is obtained by connecting the RBI terminal of the CD4033B associated with the most significant digit in the display to a low-level voltage and connecting the RBO terminal of that stage to the RBI terminal of the CD4033B in the next-lower significant position in the display. This procedure is continued for each succeeding CD4033B on the integer side of the display.

On the fraction side of the display the RBI of the CD4033B associated with the least significant bit is connected to a low-level voltage and the RBO of that CD4033B is connected to the RBI terminal of the CD4033B in the next more-significant-bit position. Again, this procedure is continued for all CD4033B's on the fraction side of the display.

In a purely fractional number the zero immediately preceding the decimal point can be displayed by connecting the RBI of that stage to a high level voltage (instead of to the RBO of the next more-significant-stage). For example: optional zero → 0.7346. Likewise, the zero in a number such as 763.0 can be displayed by connecting the RBI of the CD4033B associated with it to a high-level voltage.

Ripple blanking of non-significant zeros provides an appreciable savings in display power.

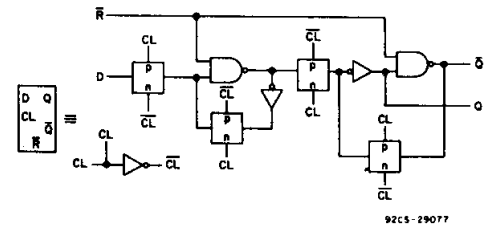
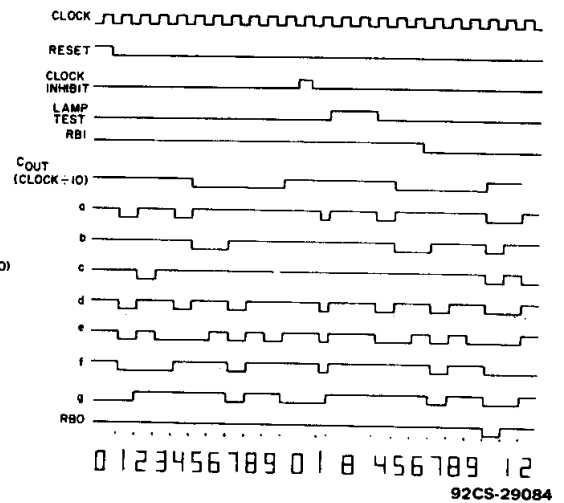
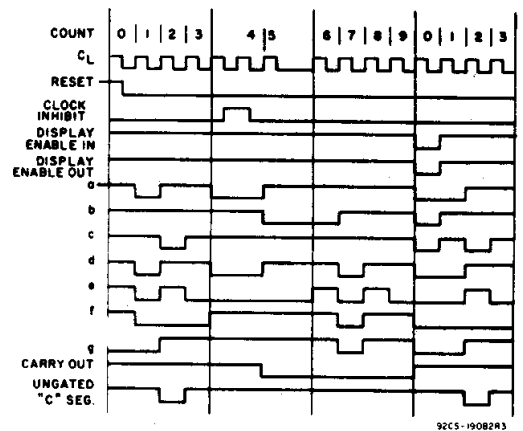
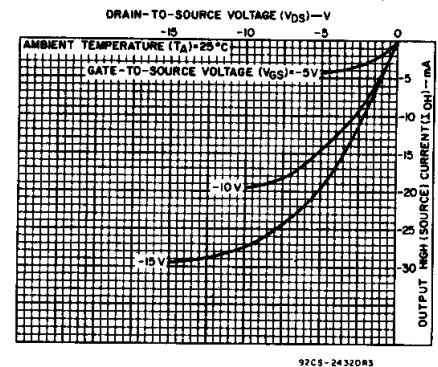
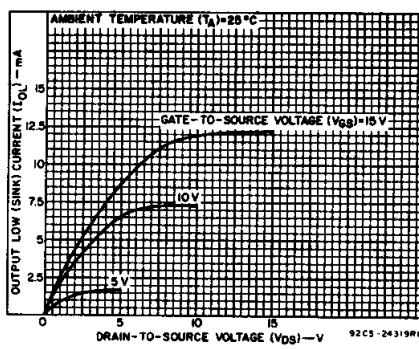
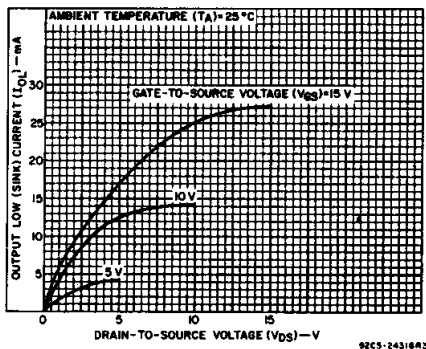
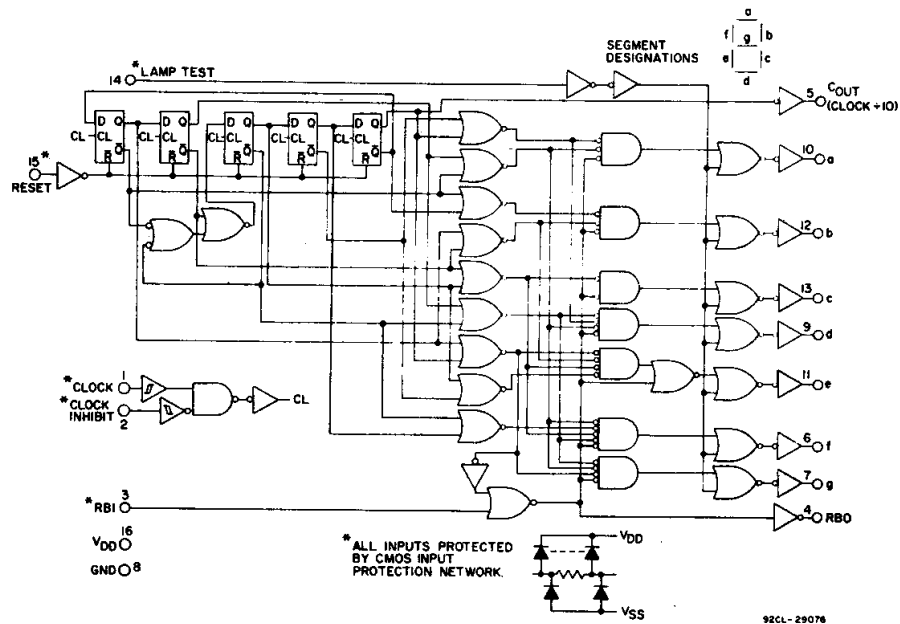
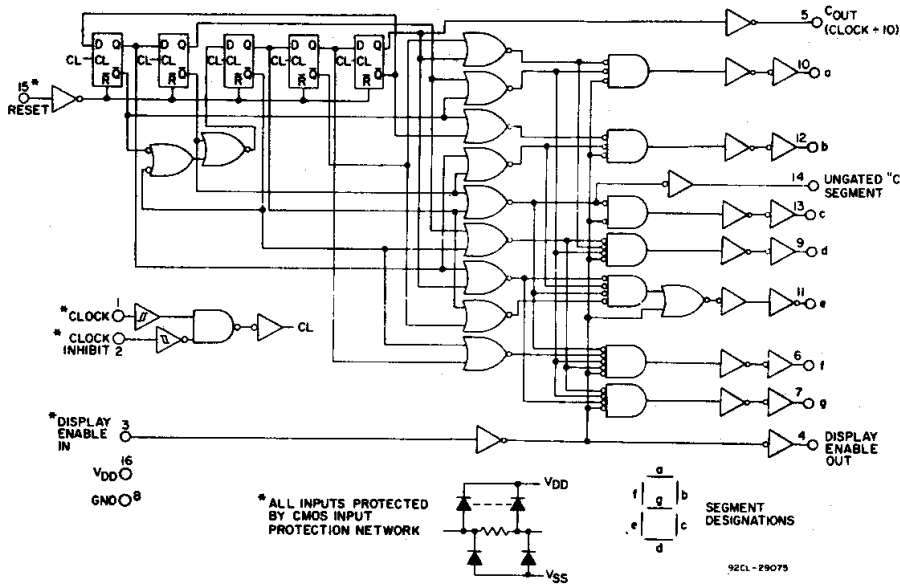
The CD4033B has a LAMP TEST input which, when connected to a high-level voltage, overrides normal decoder operation and enables a check to be made on possible display malfunctions by putting the seven outputs in the high state.

The CD4026B- and CD4033B-series types are supplied in 16-lead dual-in-line plastic packages (E suffix), 16-lead small-outline packages (NSR suffix), and 16-lead thin shrink small-outline packages (PW and PWR suffixes).

STATIC ELECTRICAL CHARACTERISTICS

CHARACTER- ISTIC	CONDITIONS			LIMITS AT INDICATED TEMPERATURES (°C)							UNITS
	V _O (V)	V _{IN} (V)	V _{DD} (V)					+25			
				−55	−40	+85	+125	Min.	Typ.	Max.	
Quiescent Device Current, I _{DD} Max.	—	0,5	5	5	5	150	150	—	0.04	5	μA
	—	0,10	10	10	10	300	300	—	0.04	10	
	—	0,15	15	20	20	600	600	—	0.04	20	
	—	0,20	20	100	100	3000	3000	—	0.08	100	
Output Low (Sink) Current I _{OL} Min.	0.4	0,5	5	0.64	0.61	0.42	0.36	0.51	1	—	mA
	0.5	0,10	10	1.6	1.5	1.1	0.9	1.3	2.6	—	
	1.5	0,15	15	4.2	4	2.8	2.4	3.4	6.8	—	
Output High (Source) Current, I _{OH} Min.	4.6	0,5	5	−0.64	−0.61	−0.42	−0.36	−0.51	−1	—	mA
	2.5	0,5	5	−2	−1.8	−1.3	−1.15	−1.6	−3.2	—	
	9.5	0,10	10	−1.6	−1.5	−1.1	−0.9	−1.3	−2.6	—	
	13.5	0,15	15	−4.2	−4	−2.8	−2.4	−3.4	−6.8	—	
Output Voltage: Low-Level, V _{OL} Max.	—	0,5	5	0.05				—	0	0.05	V
	—	0,10	10	0.05				—	0	0.05	
	—	0,15	15	0.05				—	0	0.05	
Output Voltage: High-Level, V _{OH} Min.	—	0,5	5	4.95				4.95	5	—	V
	—	0,10	10	9.95				9.95	10	—	
	—	0,15	15	14.95				14.95	15	—	
Input Low Voltage, V _{IL} Max.	0.5, 4,5	—	5	1.5				—	—	1.5	V
	1, 9	—	10	3				—	—	3	
	1.5,13.5	—	15	4				—	—	4	
Input High Voltage, V _{IH} Min.	0.5, 4,5	—	5	3.5				3.5	—	—	V
	1, 9	—	10	7				7	—	—	
	1.5,13.5	—	15	11				11	—	—	
Input Current I _{IN} Max.	—	0,18	18	±0.1	±0.1	±1	±1	—	±10 ^{−5}	±0.1	μA

CD4026B, CD4033B Types



CD4026B, CD4033B Types

DYNAMIC ELECTRICAL CHARACTERISTICS at $T_A = 25^\circ\text{C}$, Input $t_r, t_f = 20\text{ ns}$,
 $C_L = 50\text{ pF}$, $R_L = 200\text{ k}\Omega$

CHARACTERISTIC	TEST CONDITIONS	LIMITS				UNITS
		VDD (V)	Min.	Typ.	Max.	
CLOCKED OPERATION						
Propagation Delay Time; Carry-Out Line t_{PLH}, t_{PHL}		5	—	250	500	ns
		10	—	100	200	
		15	—	75	150	
Decode Outlines		5	—	350	700	ns
		10	—	125	250	
		15	—	90	180	
Transition Time; Carry-Out Line t_{THL}, t_{TLH}		5	—	100	200	ns
		10	—	50	100	
		15	—	25	50	
Maximum Clock Input Frequency, f_{CL}^{Δ}		5	2.5	5	—	MHz
		10	5.5	11	—	
		15	8	16	—	
Min. Clock Pulse Width, t_W		5	—	110	220	ns
		10	—	50	100	
		15	—	40	80	
Clock and Clock Inhibit Rise or Fall Time; t_{rCL}, t_{fCL}		5	Unlimited			ns
		10				
		15				
Average Input Capacitance, C_{IN}	Any Input	—	5	7	pF	
RESET OPERATION						
Propagation Delay Time; To Carry-Out Line, t_{PLH}		5	—	275	550	ns
		10	—	120	240	
		15	—	80	160	
To Decode Out Lines, t_{PHL}, t_{PLH}		5	—	300	600	ns
		10	—	125	250	
		15	—	90	180	
Min. Reset Pulse Width, t_W		5	—	100	120	ns
		10	—	50	100	
		15	—	25	50	
Min. Reset Removal Time		5	—	0	30	ns
		10	—	0	15	
		15	—	0	10	

Δ Measured with respect to carry-out line.

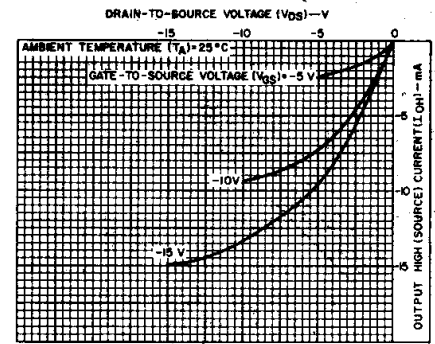


Fig. 9 — Minimum p-channel output high (source) current characteristics.

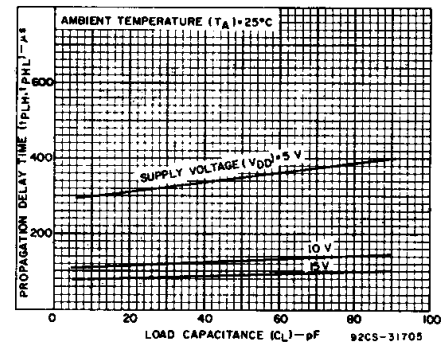


Fig. 10 — Typical propagation delay time as a function of load capacitance for decoded outputs.

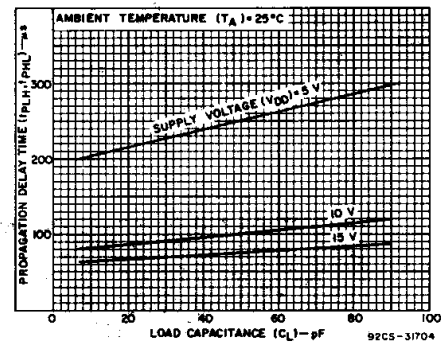


Fig. 11 — Typical propagation delay time as a function of load capacitance for carry-out outputs.

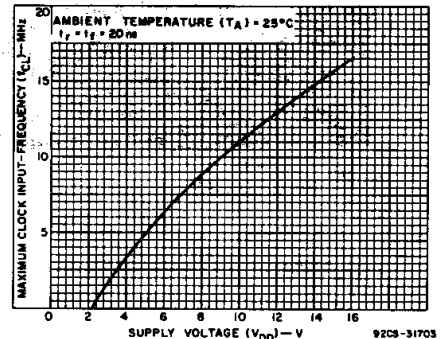


Fig. 12 — Typical maximum clock input frequency as a function of supply voltage.

CD4026B, CD4033B Types

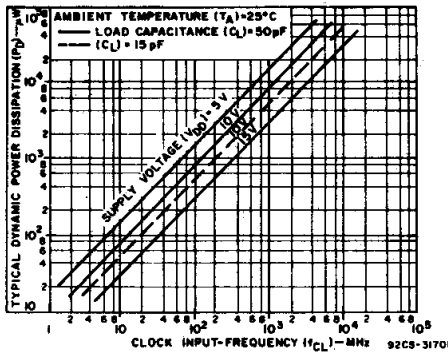


Fig. 13 - Typical power dissipation as a function of clock input frequency.

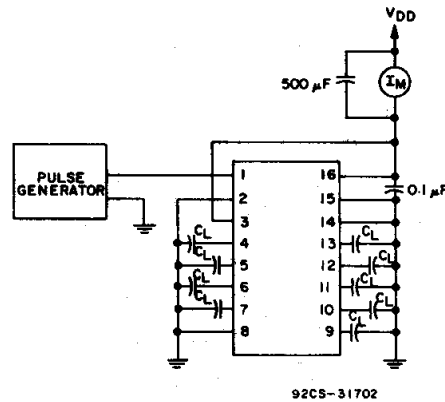


Fig. 14 - Dynamic power dissipation test circuit for CD4033B.

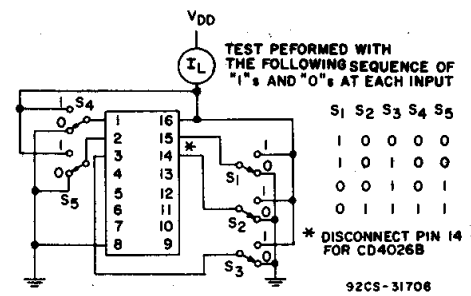


Fig. 15 - Quiescent device current.

INTERFACING THE CD4026B AND CD4033B WITH COMMERCIALY AVAILABLE LIGHT EMITTING DIODE DISPLAYS

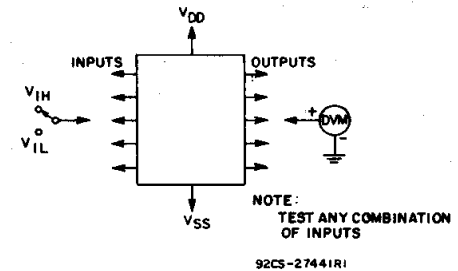
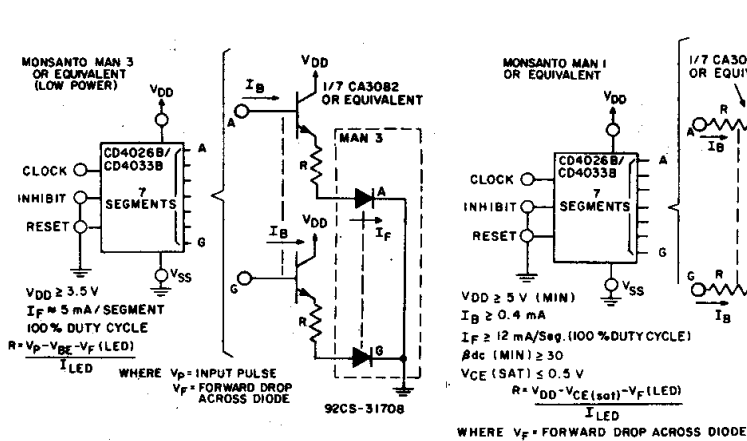


Fig. 16 - Input voltage.

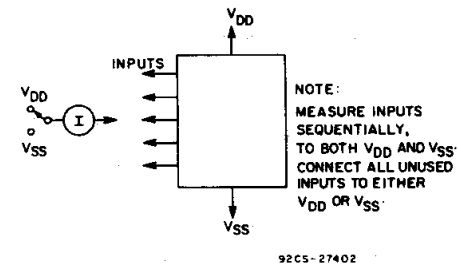
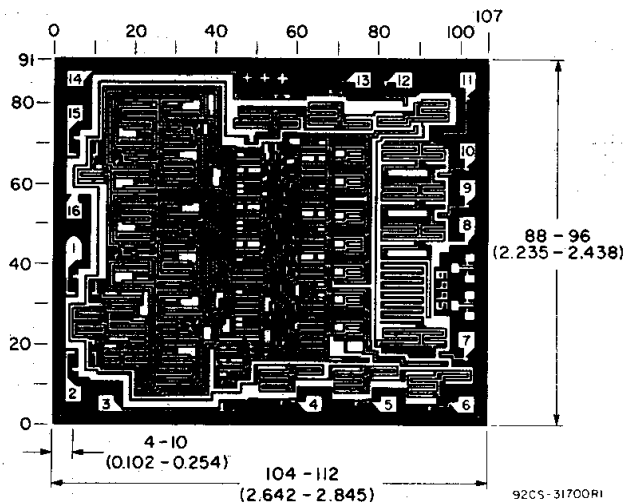
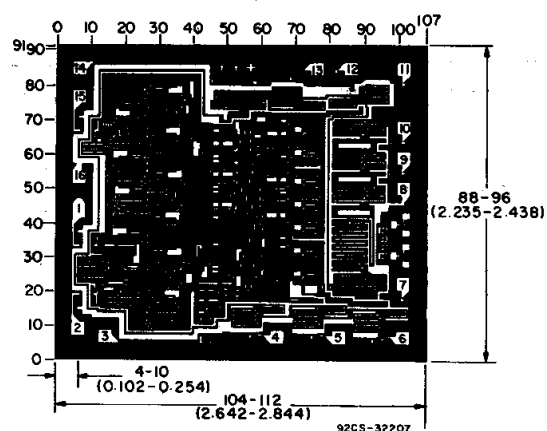


Fig. 17 - Input current.



Chip dimensions and pad layout for CD4026B

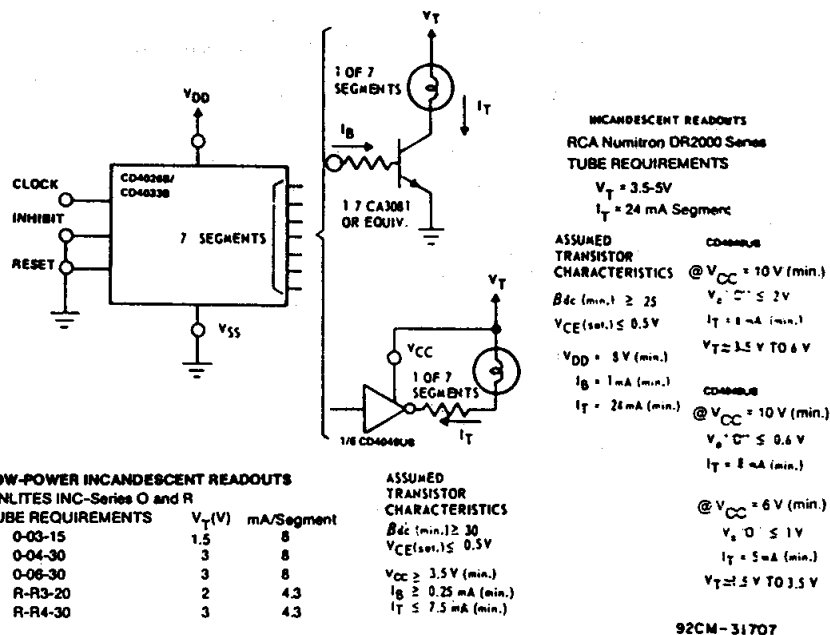
Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid graduations are in mils (10^{-3} inch).



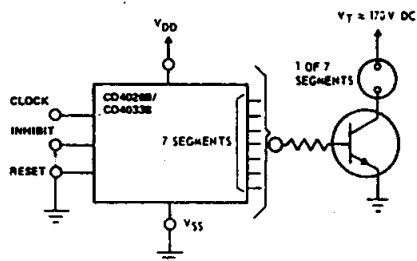
Chip dimensions and pad layout for CD4033B

CD4026B, CD4033B Types

INTERFACING THE CD4026B AND CD4033B WITH COMMERCIALLY AVAILABLE 7-SEGMENT DISPLAY DEVICES*



* The interfacing buffers shown, while a necessity with the CD4026A and CD4033A, are not required when using the "B" devices; the "B" outputs (≈ 10 times the "A" outputs) can drive most display devices directly especially at voltages above 10 V.



NEON READOUT (NIXIE TUBE*)

1. Alco Electronics - MG19
2. Burroughs - B5971, B7971, B8971

TUBE REQUIREMENTS	V_T (Vdc)	mA Segment
Alco MG19	180	0.5
Burroughs B5971	170	3
Burroughs B7971, B8971	170	6

* (Trademark) Burroughs Corp.

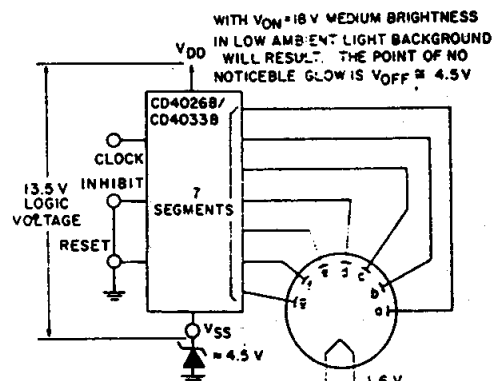
TRANSISTOR CHARACTERISTICS

Leakage with transistor cutoff - 0.05 mA

$V_{(BR)CER} > V_T$

$\beta_{dc} (\min.) > 30$

92CS-31710



LOW VOLTAGE VACUUM FLUORESCENT READOUTS

1. Tung-Sol DIGIVAC S/G; Type DT1704A or DT1705C
2. Nippon Electric (NEC); Type DG12E or LD51S

TUBE REQUIREMENTS: 100 to 300 μA /segment
at tube voltages of 12 V to 25 V depending on
required brightness Filament requirement 45 mA
at 1.6 V, ac or dc.

* (Trademark) Wagner Electric Co.

92CS-31711

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
CD4026BE	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4026BE
CD4026BE.A	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4026BE
CD4026BEE4	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4026BE
CD4026BNSR	Active	Production	SOP (NS) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4026B
CD4026BNSR.A	Active	Production	SOP (NS) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4026B
CD4026BPW	Obsolete	Production	TSSOP (PW) 16	-	-	Call TI	Call TI	-55 to 125	CM026B
CD4026BPWR	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM026B
CD4026BPWR.A	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM026B
CD4033BE	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4033BE
CD4033BE.A	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4033BE
CD4033BPW	Obsolete	Production	TSSOP (PW) 16	-	-	Call TI	Call TI	-55 to 125	CM033B

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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.

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
CD4026BNSR	SOP	NS	16	2000	330.0	16.4	8.1	10.4	2.5	12.0	16.0	Q1
CD4026BPWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CD4026BNSR	SOP	NS	16	2000	353.0	353.0	32.0
CD4026BPWR	TSSOP	PW	16	2000	353.0	353.0	32.0

TUBE


*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
CD4026BE	N	PDIP	16	25	506	13.97	11230	4.32
CD4026BE	N	PDIP	16	25	506	13.97	11230	4.32
CD4026BE.A	N	PDIP	16	25	506	13.97	11230	4.32
CD4026BE.A	N	PDIP	16	25	506	13.97	11230	4.32
CD4026BEE4	N	PDIP	16	25	506	13.97	11230	4.32
CD4026BEE4	N	PDIP	16	25	506	13.97	11230	4.32
CD4033BE	N	PDIP	16	25	506	13.97	11230	4.32
CD4033BE	N	PDIP	16	25	506	13.97	11230	4.32
CD4033BE.A	N	PDIP	16	25	506	13.97	11230	4.32
CD4033BE.A	N	PDIP	16	25	506	13.97	11230	4.32

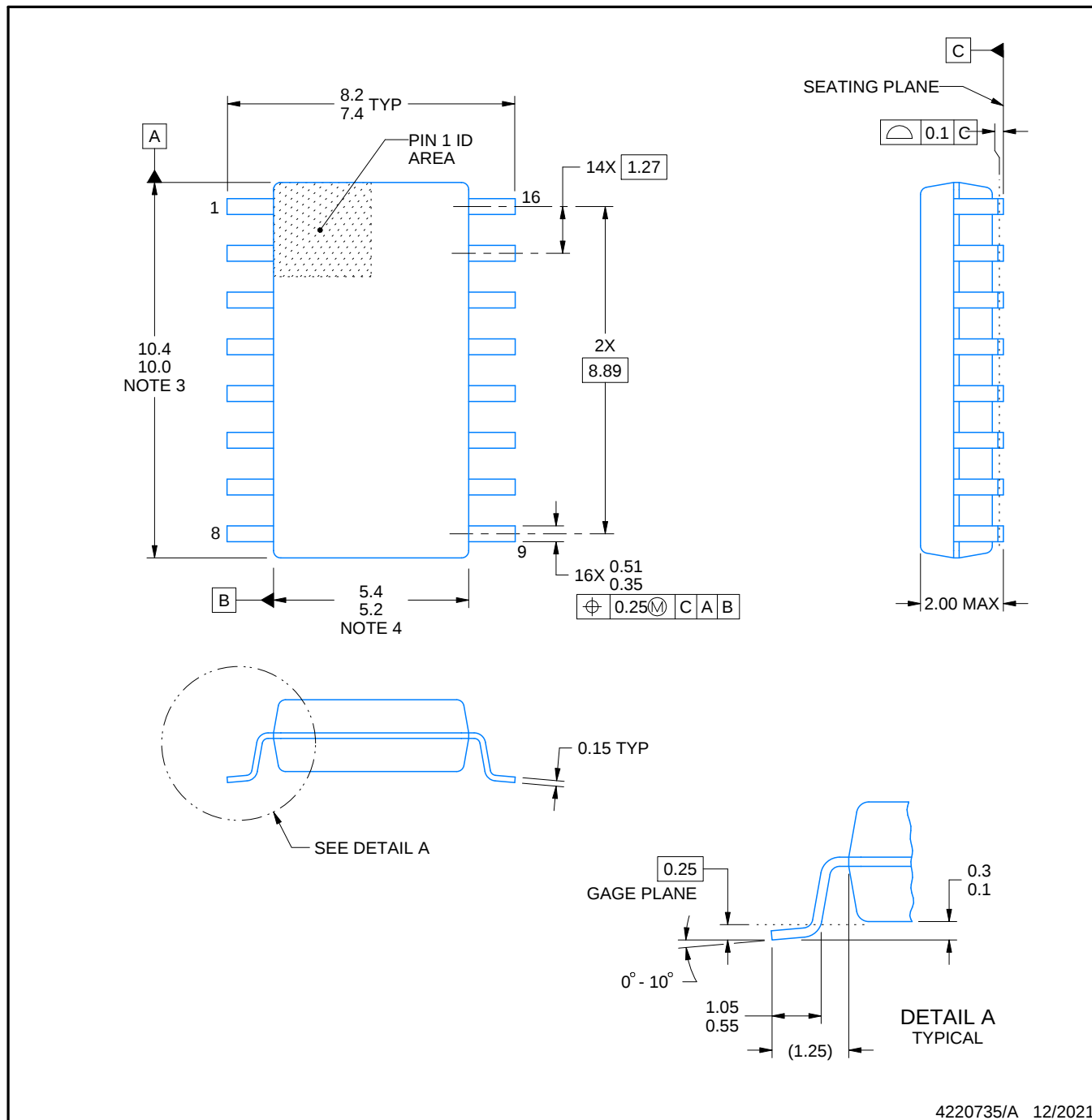


PACKAGE OUTLINE

NS0016A

SOP - 2.00 mm max height

SOP



4220735/A 12/2021

NOTES:

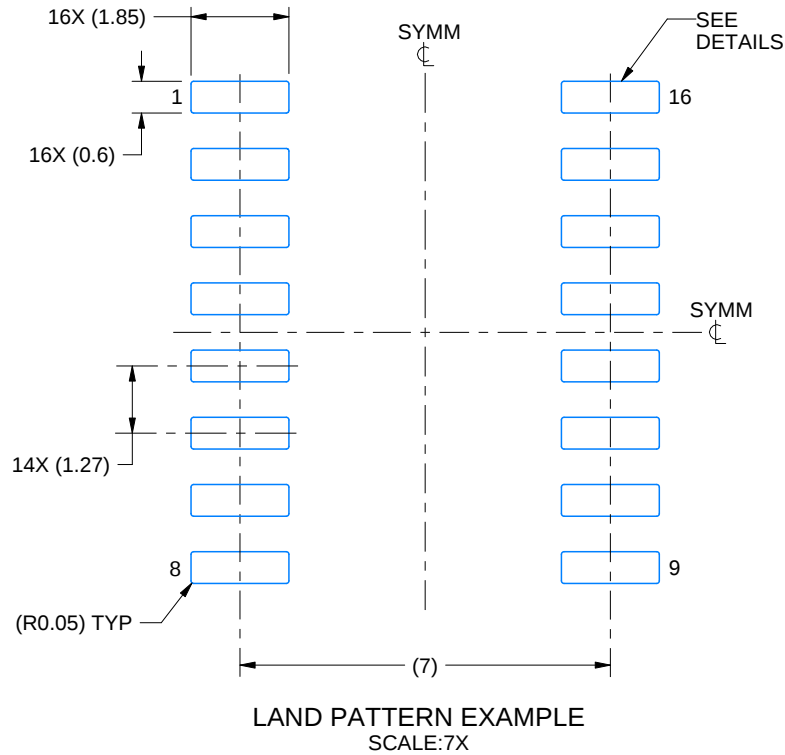
1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm, per side.

EXAMPLE BOARD LAYOUT

NS0016A

SOP - 2.00 mm max height

SOP

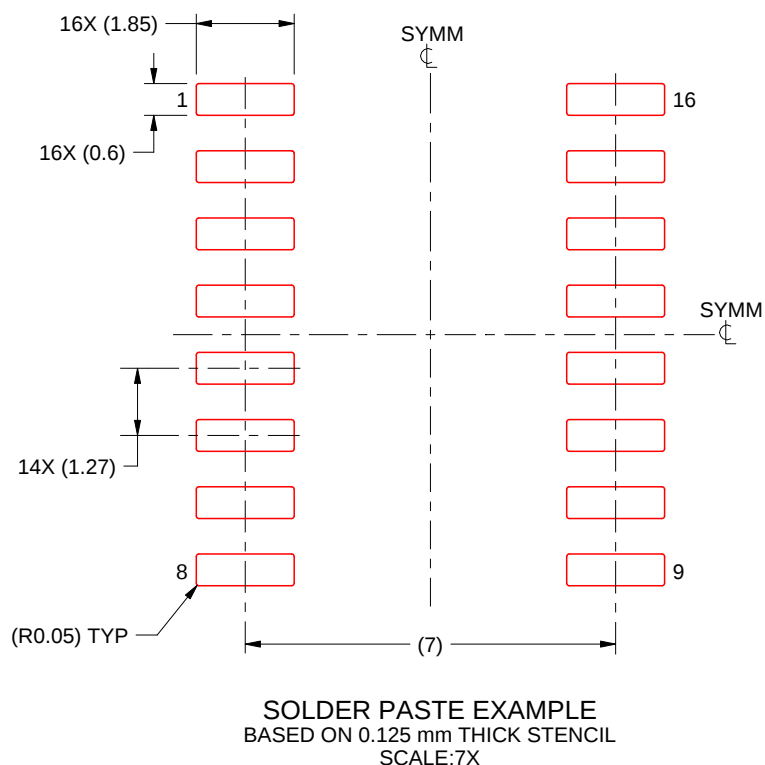


4220735/A 12/2021

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.

6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



4220735/A 12/2021

NOTES: (continued)

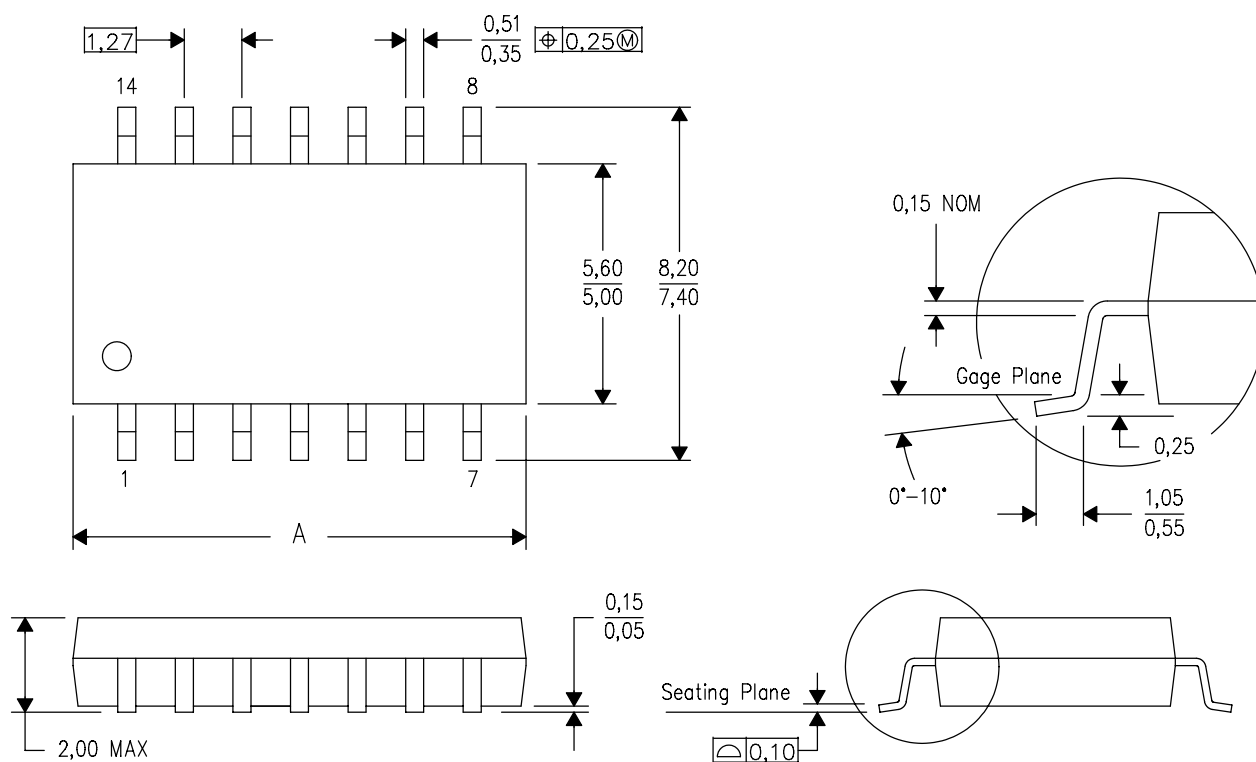
7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

MECHANICAL DATA

NS (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

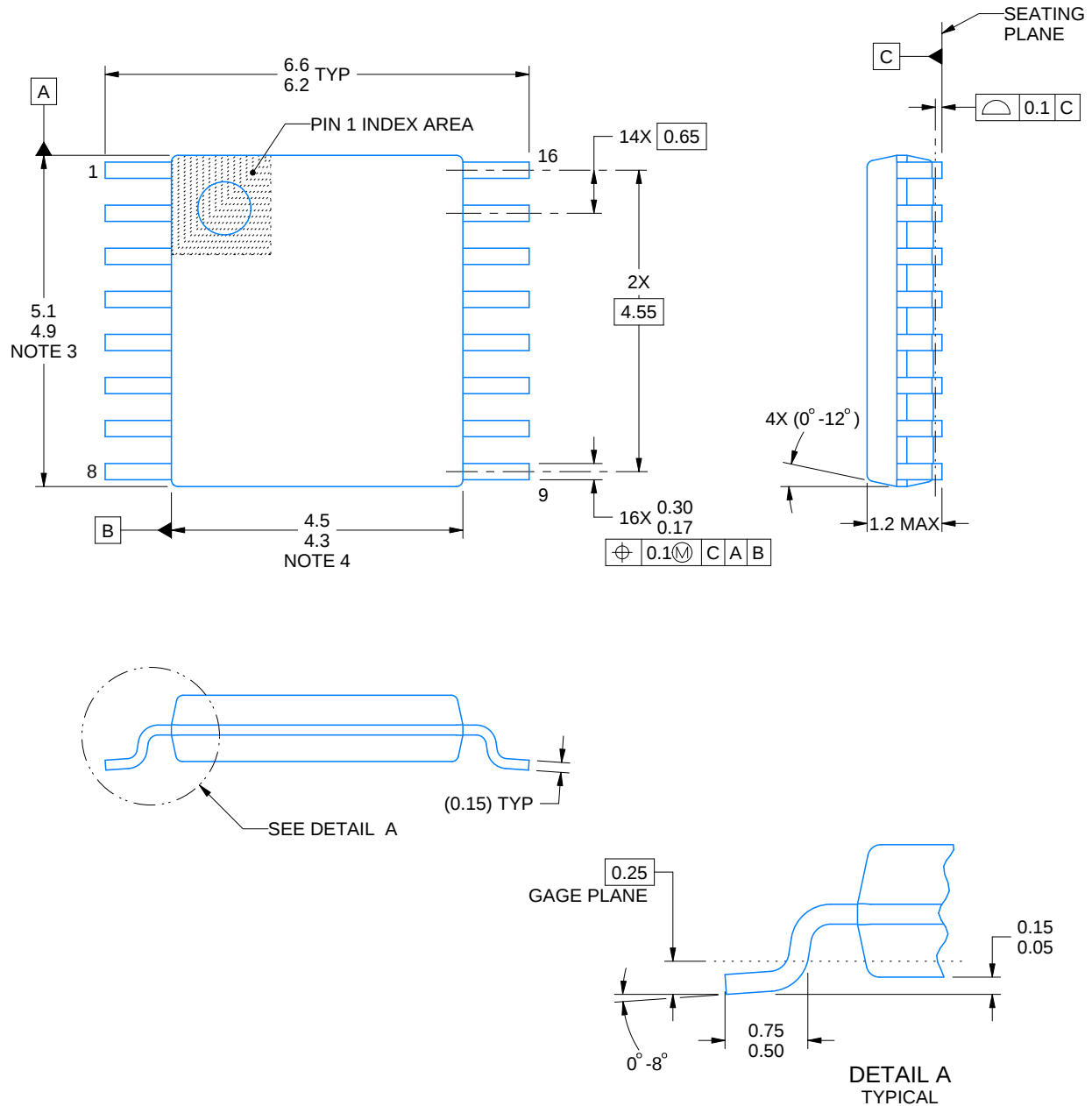
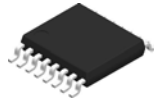
14-PINS SHOWN



DIM \ PINS **	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

4040062/C 03/03

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



4220204/B 12/2023

NOTES:

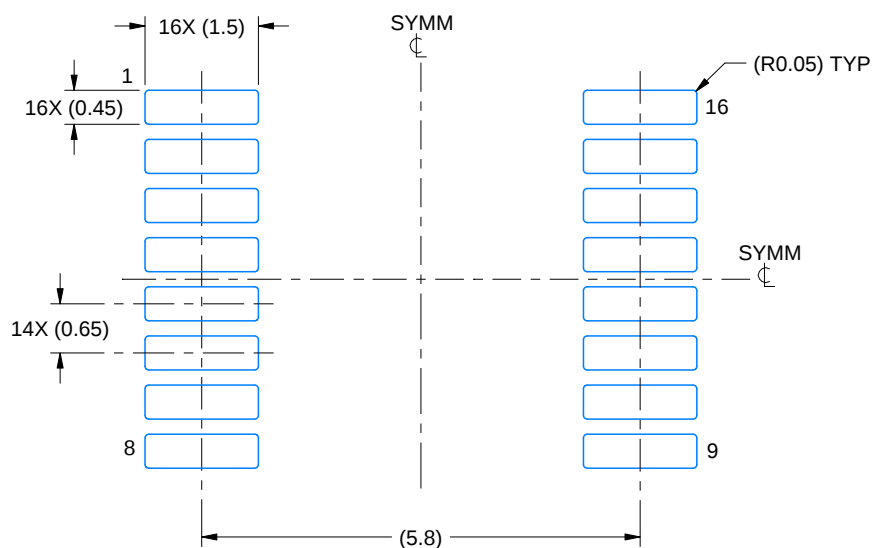
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

EXAMPLE BOARD LAYOUT

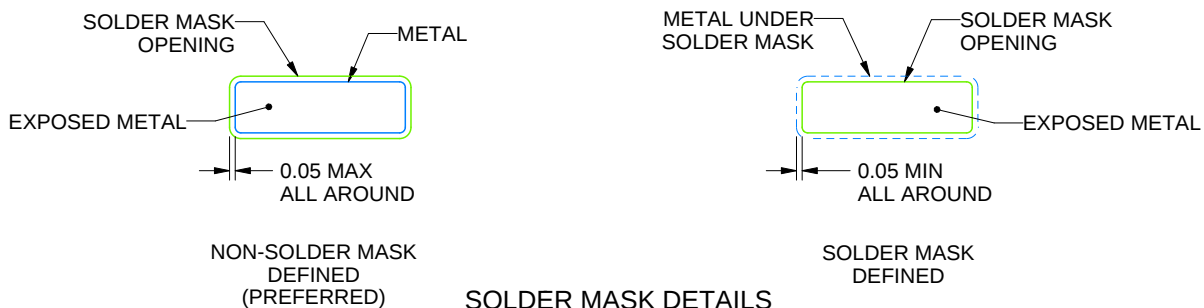
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4220204/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

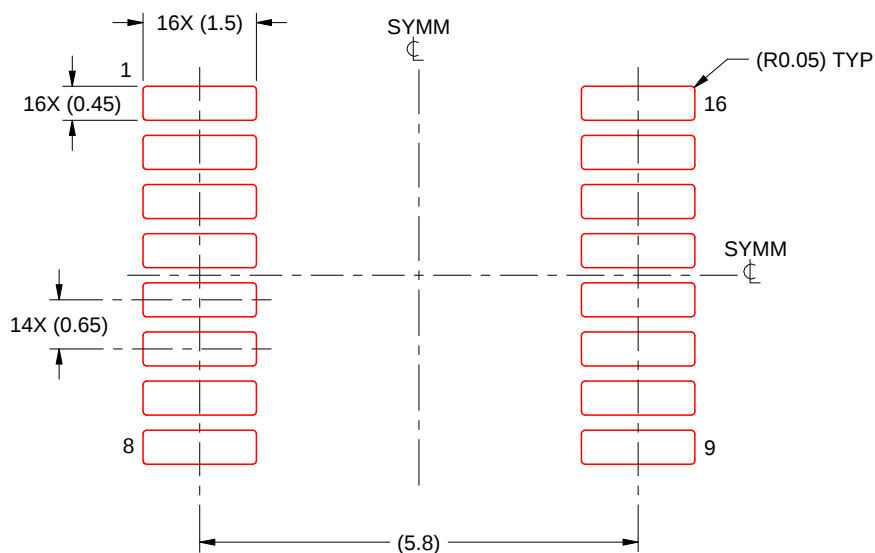
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220204/B 12/2023

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2025, Texas Instruments Incorporated