

CD4555B, CD4556B Types

CMOS Dual Binary to 1 of 4 Decoder/Demultiplexers

High-Voltage Types (20-Volt Rating)

CD4555B: Outputs High on Select

CD4556B: Outputs Low on Select

■ CD4555B and CD4556B are dual one-of-four decoders/demultiplexers. Each decoder has two select inputs (A and B), an Enable input (\bar{E}), and four mutually exclusive outputs. On the CD4555B the outputs are high on select; on the CD4556B the outputs are low on select.

When the Enable input is high, the outputs of the CD4555B remain low and the outputs of the CD4556B remain high regardless of the state of the select inputs A and B. The CD4555B and CD4556B are similar to types MC14555 and MC14556, respectively.

The CD4555B and CD4556B types are supplied in 16-lead hermetic dual-in-line ceramic packages (F3A suffix), 16-lead dual-in-line plastics packages (E suffix), and 16-lead small-outline packages (M, M96, and MT suffixes). The CD4555B is also supplied in 16-lead small-outline packages (NSR suffix) and 16-lead thin shrink small-outline packages (PW and PWR suffixes.)

RECOMMENDED OPERATING CONDITIONS

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

CHARACTERISTIC	V _{DD}	MIN.	MAX.	UNITS
Supply Voltage Range (For T _A = Full Package Temp. Range)	—	3	18	V

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} +0.5V

DC INPUT CURRENT, ANY ONE INPUT ±10mA

POWER DISSIPATION PER PACKAGE (P_D):

For T_A = -55°C to +100°C 500mW

For T_A = +100°C to +125°C Derate Linearly at 12mW/°C to 200mW

DEVICE DISSIPATION PER OUTPUT TRANSISTOR

FOR T_A = FULL PACKAGE-TEMPERATURE RANGE (All Package Types)..... 100mW

OPERATING-TEMPERATURE RANGE (T_A) -55°C to +125°C

STORAGE TEMPERATURE RANGE (T_{stg}) -65°C to +150°C

LEAD TEMPERATURE (DURING SOLDERING):

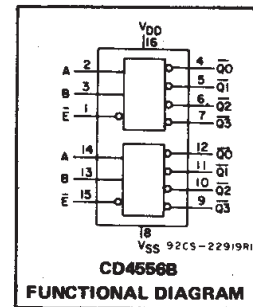
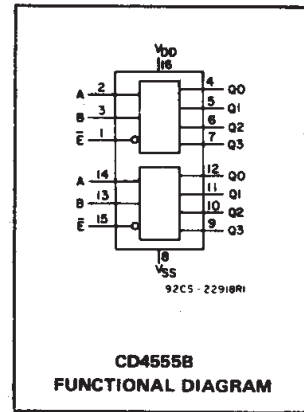
At distance 1/16 ± 1/32 inch (1.59 ± 0.79mm) from case for 10s max +265°C

Features:

- Expandable with multiple packages
- Standard, symmetrical output characteristics
- 100% tested for quiescent current at 20 V
- Maximum input current of 1 μA at 18 V over full package temperature range; 100 nA at 18 V and 25°C
- Noise margin (full package-temperature range): 1 V at V_{DD} = 5 V
2 V at V_{DD} = 10 V
2.5 V at V_{DD} = 15 V
- 5-V, 10-V, and 15-V parametric ratings
- Meets all requirements of JEDEC Tentative Standard No. 13B, "Standard Specifications for Description of 'B' Series CMOS Devices"

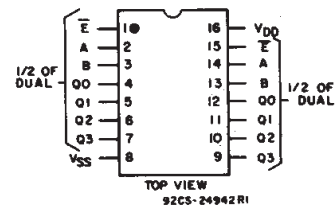
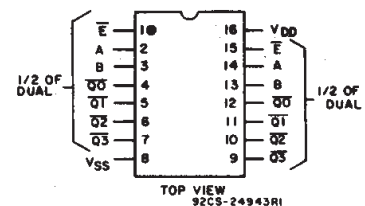
Applications:

- Decoding ■ Code conversion
- Demultiplexing (using Enable input as a data input)
- Memory chip-enable selection
- Function selection



**3
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TERMINAL ASSIGNMENTS



CD4555B, CD4556B Types

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS			LIMITS AT INDICATED TEMPERATURES (°C)							UNITS
	V _O (V)	V _{IN} (V)	V _{DD} (V)	-55	-40	+85	+125	+25			
								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	—	
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

DYNAMIC ELECTRICAL CHARACTERISTICS at T_A = 25°C; Input t_p, t_f = 20 ns, C_L = 50 pF, R_L = 200 KΩ

CHARACTERISTIC	TEST CONDITIONS	LIMITS		UNITS	
		V _{DD} Volts	TYP.		MAX.
Propagation Delay Time, t _{PHL} , A or B Input to Any Output	t _{PLH}	5	220	440	ns
		10	95	190	
		15	70	140	
E̅ Input to Any Output		5	200	400	ns
		10	85	170	
		15	65	130	
Transition Time t _{THL} , t _{TLH}		5	100	200	ns
		10	50	100	
		15	40	80	
Input Capacitance C _{IN}	Any Input		5	7,5	pF

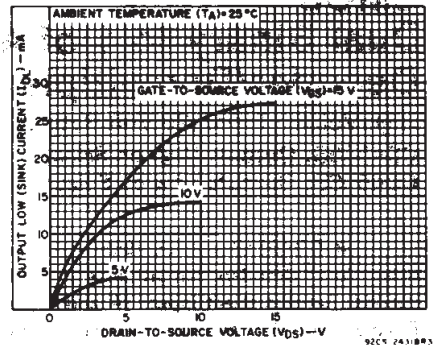


Fig. 1 — Typical output low (sink) current characteristics.

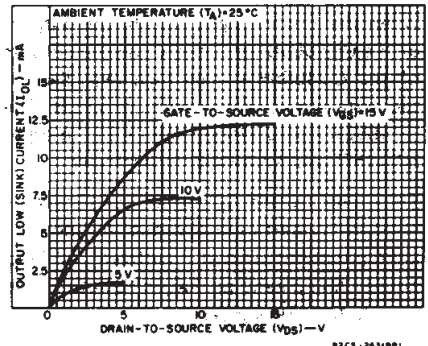


Fig. 2 — Minimum output low (sink) current characteristics.

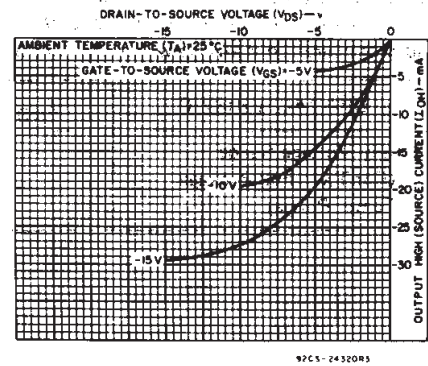


Fig. 3 — Typical output high (source) current characteristics.

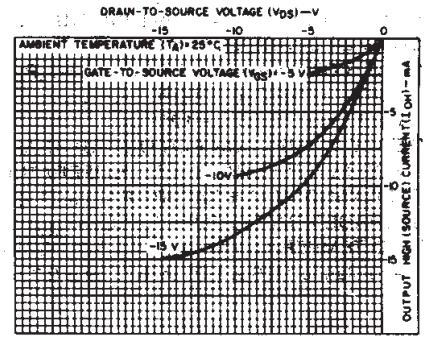
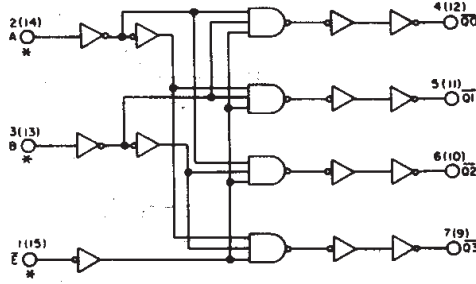
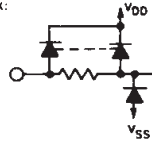


Fig. 4 — Minimum output high (source) current characteristics.

CD4555B, CD4556B Types

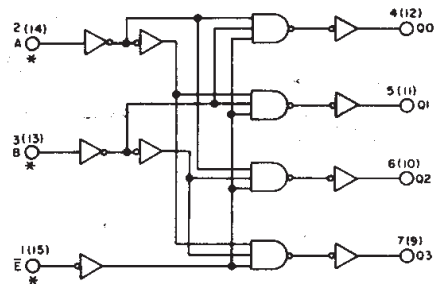


* ALL INPUTS PROTECTED BY CMOS PROTECTION NETWORK:

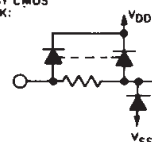


92CS-24222R1

Fig. 5 - CD4556B logic diagram (1 of 2 identical circuits).



* ALL INPUTS PROTECTED BY CMOS PROTECTION NETWORK:



92CS-24221R1

Fig. 6 - CD4555B logic diagram (1 of 2 identical circuits).

TRUTH TABLE

INPUTS			OUTPUTS CD4555B				OUTPUTS CD4556B			
\bar{E}	B	A	Q3	Q2	Q1	Q0	$\bar{Q}3$	$\bar{Q}2$	$\bar{Q}1$	$\bar{Q}0$
0	0	0	0	0	0	1	1	1	1	0
0	0	1	0	0	1	0	1	1	0	1
0	1	0	0	1	0	0	1	0	1	1
0	1	1	1	0	0	0	0	1	1	1
1	X	X	0	0	0	0	1	1	1	1

X = DON'T CARE

LOGIC 1 \equiv HIGH
LOGIC 0 \equiv LOW

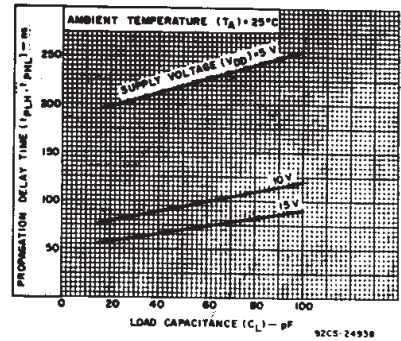


Fig. 7 - Typical propagation delay time vs. load capacitance (A or B input to any output).

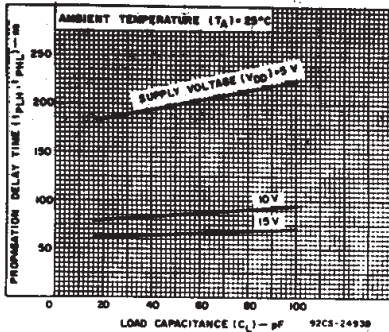


Fig. 8 - Typical propagation delay time vs. load capacitance (E input to any output).

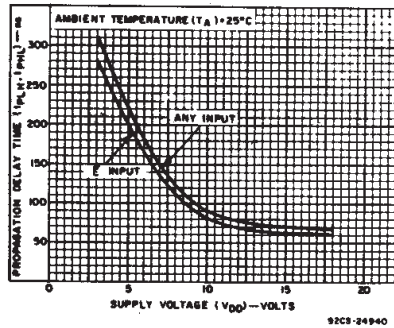


Fig. 9 - Typical propagation delay time vs. supply voltage.

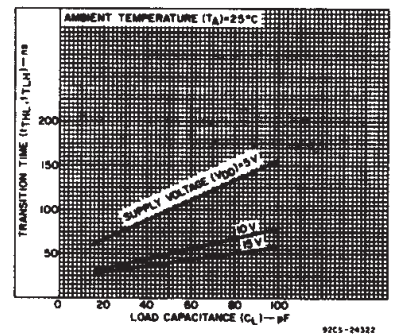


Fig. 10 - Typical transition time vs. load capacitance.

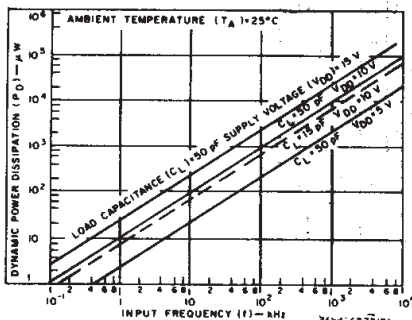


Fig. 11 - Typical dynamic power dissipation vs. frequency.

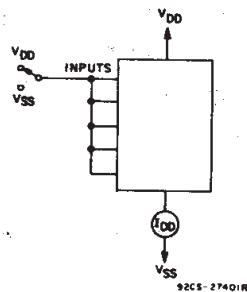


Fig. 12 - Quiescent device current test circuit.

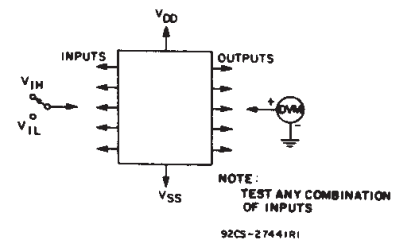


Fig. 13 - Input voltage test circuit.

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CD4555B, CD4556B Types

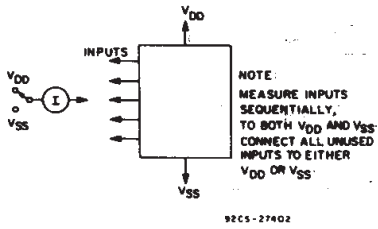


Fig. 14 - Input current test circuit.

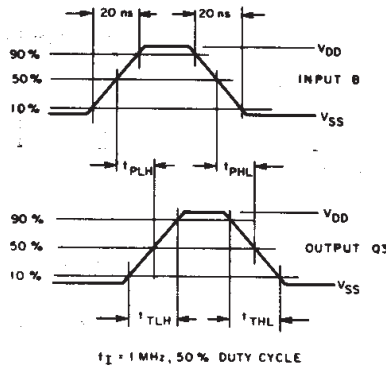


Fig. 15 - CD4555B B input to Q3 output dynamic signal waveforms.

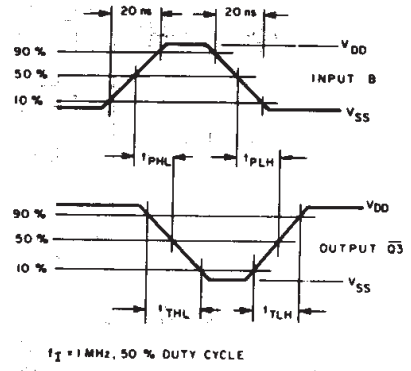


Fig. 16 - CD4556B B input to Q3 output dynamic signal waveforms.

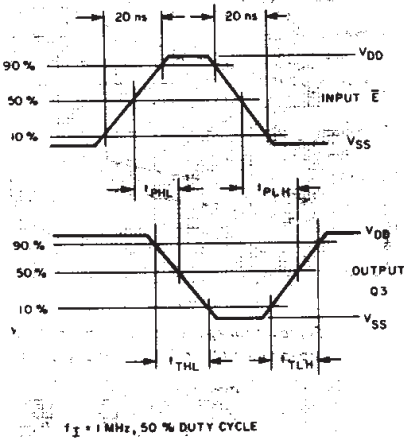


Fig. 17 - CD4555B E input to Q3 output dynamic signal waveforms.

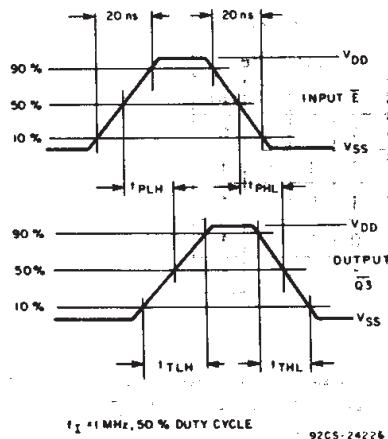
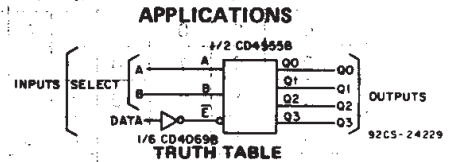


Fig. 18 - CD4556B E input to Q3 output dynamic signal waveforms.



TRUTH TABLE

SELECT INPUTS		OUTPUTS			
B	A	Q0	Q1	Q2	Q3
0	0	DATA	0	0	0
0	1	0	DATA	0	0
1	0	0	0	DATA	0
1	1	0	0	0	DATA

Fig. 19 - 1-of-4 line data demultiplexer using CD4555B.

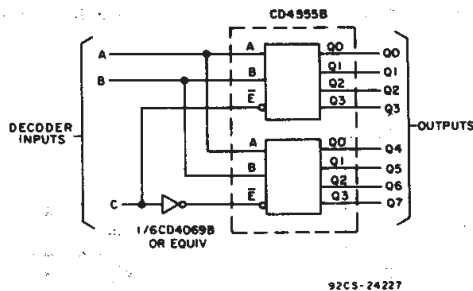


Fig. 20 - 1-of-8 decoder using CD4555B.

TRUTH TABLE

INPUTS			Q OUTPUTS							
C	B	A	0	1	2	3	4	5	6	7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1

CD4555B, CD4556B Types

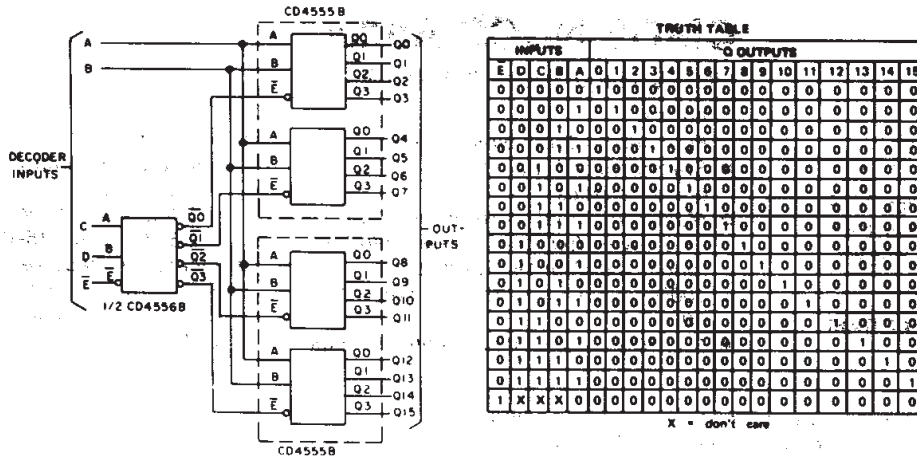
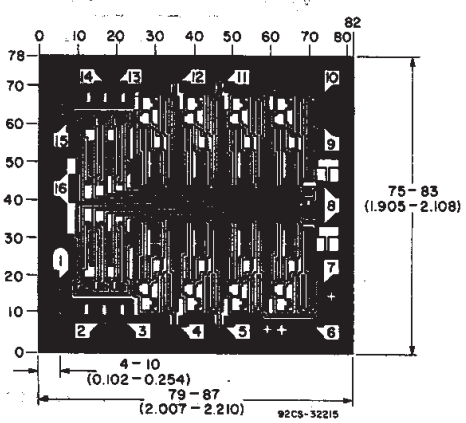
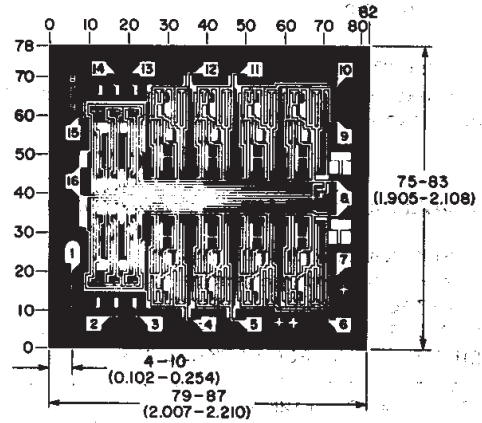


Fig. 21 - 1-of-16 decoder using CD4555B and CD4556B.



DIMENSIONS AND PAD LAYOUT FOR CD4555BH.



DIMENSIONS AND PAD LAYOUT FOR CD4556BH.

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

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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)
7704701EA	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	7704701EA CD4555BF3A
7704801EA	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	7704801EA CD4556BF3A
CD4555BE	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4555BE
CD4555BE.A	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4555BE
CD4555BEE4	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4555BE
CD4555BF3A	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	7704701EA CD4555BF3A
CD4555BF3A.A	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	7704701EA CD4555BF3A
CD4555BM	Obsolete	Production	SOIC (D) 16	-	-	Call TI	Call TI	-55 to 125	CD4555BM
CD4555BM96	Active	Production	SOIC (D) 16	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4555BM
CD4555BM96.A	Active	Production	SOIC (D) 16	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4555BM
CD4555BMT	Obsolete	Production	SOIC (D) 16	-	-	Call TI	Call TI	-55 to 125	CD4555BM
CD4555BNSR	Active	Production	SOP (NS) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4555B
CD4555BNSR.A	Active	Production	SOP (NS) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4555B
CD4555BPW	Obsolete	Production	TSSOP (PW) 16	-	-	Call TI	Call TI	-55 to 125	CM555B
CD4555BPWR	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM555B
CD4555BPWR.A	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM555B
CD4555BPWRG4	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CM555B
CD4556BE	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4556BE
CD4556BE.A	Active	Production	PDIP (N) 16	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-55 to 125	CD4556BE
CD4556BF	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	CD4556BF
CD4556BF.A	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	CD4556BF
CD4556BF3A	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	7704801EA CD4556BF3A
CD4556BF3A.A	Active	Production	CDIP (J) 16	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	7704801EA CD4556BF3A
CD4556BM	Obsolete	Production	SOIC (D) 16	-	-	Call TI	Call TI	-55 to 125	CD4556BM
CD4556BM96	Active	Production	SOIC (D) 16	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4556BM

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)
CD4556BM96.A	Active	Production	SOIC (D) 16	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 125	CD4556BM
CD4556BMT	Obsolete	Production	SOIC (D) 16	-	-	Call TI	Call TI	-55 to 125	CD4556BM

⁽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.

OTHER QUALIFIED VERSIONS OF CD4555B, CD4555B-MIL, CD4556B, CD4556B-MIL :

- Catalog : [CD4555B](#), [CD4556B](#)

- Military : [CD4555B-MIL](#), [CD4556B-MIL](#)

NOTE: Qualified Version Definitions:

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

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*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
CD4555BM96	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
CD4555BNSR	SOP	NS	16	2000	330.0	16.4	8.1	10.4	2.5	12.0	16.0	Q1
CD4555BPWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
CD4556BM96	SOIC	D	16	2500	330.0	16.4	6.5	10.3	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)
CD4555BM96	SOIC	D	16	2500	340.5	336.1	32.0
CD4555BNSR	SOP	NS	16	2000	353.0	353.0	32.0
CD4555BPWR	TSSOP	PW	16	2000	353.0	353.0	32.0
CD4556BM96	SOIC	D	16	2500	340.5	336.1	32.0

TUBE


*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
CD4555BE	N	PDIP	16	25	506	13.97	11230	4.32
CD4555BE	N	PDIP	16	25	506	13.97	11230	4.32
CD4555BE.A	N	PDIP	16	25	506	13.97	11230	4.32
CD4555BE.A	N	PDIP	16	25	506	13.97	11230	4.32
CD4555BEE4	N	PDIP	16	25	506	13.97	11230	4.32
CD4555BEE4	N	PDIP	16	25	506	13.97	11230	4.32
CD4556BE	N	PDIP	16	25	506	13.97	11230	4.32
CD4556BE	N	PDIP	16	25	506	13.97	11230	4.32
CD4556BE.A	N	PDIP	16	25	506	13.97	11230	4.32
CD4556BE.A	N	PDIP	16	25	506	13.97	11230	4.32

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- 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 AC.

J (R-GDIP-T**)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE

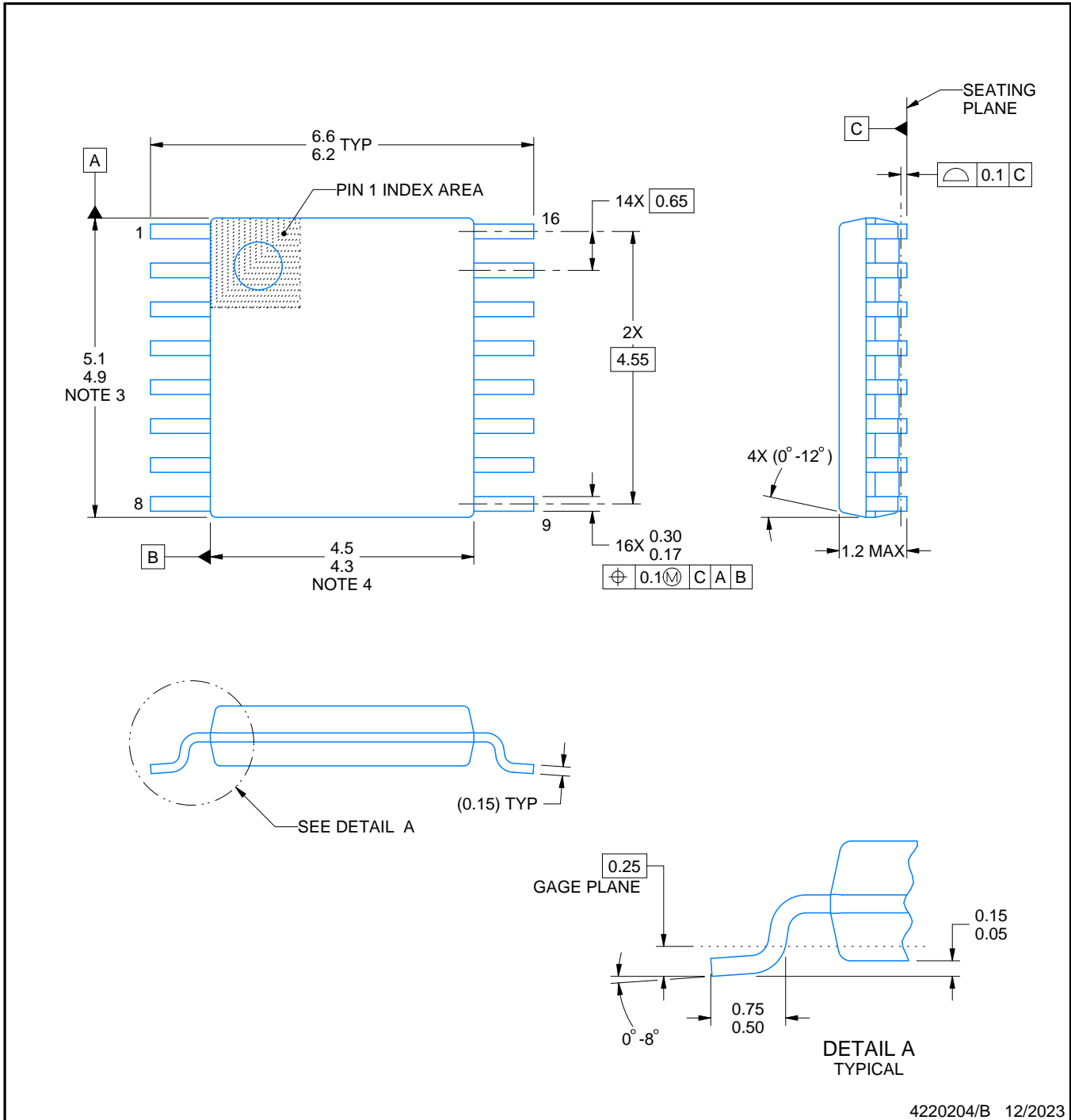


DIM \ PINS **	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



4040083/F 03/03

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



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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



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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

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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**)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN





PACKAGE OUTLINE

NS0016A

SOP - 2.00 mm max height

SOP



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NOTES:

- All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- 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.
- 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



SOLDER MASK DETAILS

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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.

EXAMPLE STENCIL DESIGN

NS0016A

SOP - 2.00 mm max height

SOP



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:7X

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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.

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