

# Octal 3-State Bus Transceivers and D Flip-Flops

## High-Performance Silicon-Gate CMOS

The MC54/74HC646 is identical in pinout to the LS646. The device inputs are compatible with standard CMOS outputs; with pullup resistors, they are compatible with LSTTL outputs.

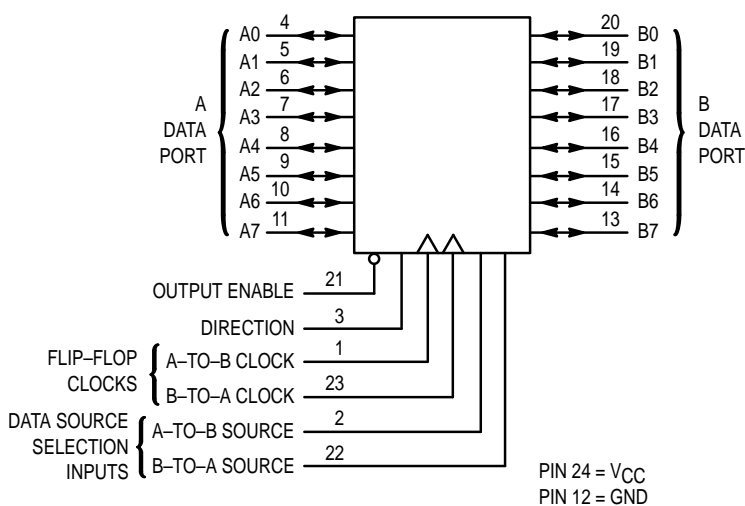
These devices are bus transceivers with D flip-flops. Depending on the status of the Data-Source Selection pins, data may be routed to the outputs either from the flip-flops or transmitted real-time from the inputs (see Function Table and Application Information).

The Output Enable and the Direction pins control the transceiver's function. Bus A and Bus B cannot be routed as outputs to each other simultaneously, but can be routed as inputs to the A and B flip-flops. Also, the A and B flip-flops can be routed as outputs to Bus A and Bus B. Additionally, when either or both of the ports are in the high-impedance state, these I/O pins may be used as inputs to the D flip-flops for data storage.

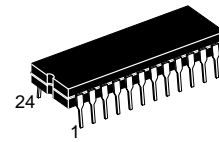
The user should note that because the clocks are not gated with the Direction and Output Enable pins, data at the A and B ports may be clocked into the storage flip-flops at any time.

- Output Drive Capability: 15 LSTTL Loads
- Outputs Directly Interface to CMOS, NMOS, and TTL
- Operating Voltage Range: 2 to 6 V
- Low Input Current: 1  $\mu$ A
- High Noise Immunity Characteristic of CMOS Devices
- In Compliance with the Requirements Defined by JEDEC Standard No. 7A
- Chip Complexity: 780 FETs or 195 Equivalent Gates

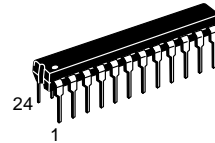
### LOGIC DIAGRAM



## MC54/74HC646



**J SUFFIX**  
CERAMIC PACKAGE  
CASE 758-02



**N SUFFIX**  
PLASTIC PACKAGE  
CASE 724-03



**DW SUFFIX**  
SOIC PACKAGE  
CASE 751E-04

### ORDERING INFORMATION

MC54HCXXXJ	Ceramic
MC74HCXXXN	Plastic
MC74HCXXXDW	SOIC

### PIN ASSIGNMENT

A-TO-B CLOCK	1	24	V <sub>CC</sub>
A-TO-B SOURCE	2	23	B-TO-A CLOCK
DIRECTION	3	22	B-TO-A SOURCE
A0	4	21	OUTPUT ENABLE
A1	5	20	B0
A2	6	19	B1
A3	7	18	B2
A4	8	17	B3
A5	9	16	B4
A6	10	15	B5
A7	11	14	B6
GND	12	13	B7



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## MAXIMUM RATINGS\*

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	DC Supply Voltage (Referenced to GND)	- 0.5 to + 7.0	V
V <sub>in</sub>	DC Input Voltage (Referenced to GND)	- 1.5 to V <sub>CC</sub> + 1.5	V
V <sub>I/O</sub>	DC I/O Voltage (Referenced to GND)	- 0.5 to V <sub>CC</sub> + 0.5	V
I <sub>in</sub>	DC Input Current, per Pin	± 20	mA
I <sub>I/O</sub>	DC I/O Current, per Pin	± 35	mA
I <sub>CC</sub>	DC Supply Current, V <sub>CC</sub> and GND Pins	± 75	mA
P <sub>D</sub>	Power Dissipation in Still Air, Plastic or Ceramic DIP† SOIC Package†	750 500	mW
T <sub>stg</sub>	Storage Temperature	- 65 to + 150	°C
T <sub>L</sub>	Lead Temperature, 1 mm from Case for 10 Seconds (Plastic DIP or SOIC Package) (Ceramic DIP)	260 300	°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range GND ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>CC</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either GND or V<sub>CC</sub>). Unused outputs must be left open. I/O pins must be connected to a properly terminated line or bus.

\* Maximum Ratings are those values beyond which damage to the device may occur. Functional operation should be restricted to the Recommended Operating Conditions.

† Derating — Plastic DIP: -10 mW/°C from 65° to 125°C  
Ceramic DIP: -10 mW/°C from 100° to 125°C  
SOIC Package: - 7 mW/°C from 65° to 125°C

For high frequency or heavy load considerations, see Chapter 2 of the Motorola High-Speed CMOS Data Book (DL129/D).

## RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Max	Unit
V <sub>CC</sub>	DC Supply Voltage (Referenced to GND)	2.0	6.0	V
V <sub>in</sub> , V <sub>out</sub>	DC Input Voltage, Output Voltage (Referenced to GND)	0	V <sub>CC</sub>	V
T <sub>A</sub>	Operating Temperature, All Package Types	- 55	+ 125	°C
t <sub>r</sub> , t <sub>f</sub>	Input Rise and Fall Time (Figure 1)	V <sub>CC</sub> = 2.0 V V <sub>CC</sub> = 4.5 V V <sub>CC</sub> = 6.0 V	0 1000 500 400	ns

## DC ELECTRICAL CHARACTERISTICS (Voltages Referenced to GND)

Symbol	Parameter	Test Conditions	V <sub>CC</sub> V	Guaranteed Limit			Unit
				- 55 to 25°C	≤ 85°C	≤ 125°C	
V <sub>IH</sub>	Minimum High-Level Input Voltage	V <sub>out</sub> = 0.1 V or V <sub>CC</sub> - 0.1 V  I <sub>out</sub>   ≤ 20 μA	2.0	1.5	1.5	1.5	V
			4.5	3.15	3.15	3.15	
			6.0	4.2	4.2	4.2	
V <sub>IL</sub>	Maximum Low-Level Input Voltage	V <sub>out</sub> = 0.1 V or V <sub>CC</sub> - 0.1 V  I <sub>out</sub>   ≤ 20 μA	2.0	0.3	0.3	0.3	V
			4.5	0.9	0.9	0.9	
			6.0	1.2	1.2	1.2	
V <sub>OH</sub>	Minimum High-Level Output Voltage	V <sub>in</sub> = V <sub>IH</sub> or V <sub>IL</sub>  I <sub>out</sub>   ≤ 20 μA	2.0	1.9	1.9	1.9	V
			4.5	4.4	4.4	4.4	
			6.0	5.9	5.9	5.9	
			V <sub>in</sub> = V <sub>IH</sub> or V <sub>IL</sub>  I <sub>out</sub>   ≤ 6.0 mA  I <sub>out</sub>   ≤ 7.8 mA	4.5	3.98	3.84	
V <sub>OL</sub>	Maximum Low-Level Output Voltage	V <sub>in</sub> = V <sub>IH</sub> or V <sub>IL</sub>  I <sub>out</sub>   ≤ 20 μA	2.0	0.1	0.1	0.1	V
			4.5	0.1	0.1	0.1	
			6.0	0.1	0.1	0.1	
			V <sub>in</sub> = V <sub>IH</sub> or V <sub>IL</sub>  I <sub>out</sub>   ≤ 6.0 mA  I <sub>out</sub>   ≤ 7.8 mA	4.5	0.26	0.33	
I <sub>in</sub>	Maximum Input Leakage Current	V <sub>in</sub> = V <sub>CC</sub> or GND (Pins 1, 2, 3, 21, 22, and 23)	6.0	± 0.1	± 1.0	± 1.0	μA

**DC ELECTRICAL CHARACTERISTICS** (Voltages Referenced to GND)

Symbol	Parameter	Test Conditions	V <sub>CC</sub> V				Unit
				- 55 to 25°C	≤ 85°C	≤ 125°C	
I <sub>OZ</sub>	Maximum Three-State Leakage Current	Output in High-Impedance State V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> V <sub>out</sub> = V <sub>CC</sub> or GND, I/O Pins	6.0	± 0.5	± 5.0	± 10	μA
I <sub>CC</sub>	Maximum Quiescent Supply Current (per Package)	V <sub>in</sub> = V <sub>CC</sub> or GND I <sub>out</sub> = 0 μA	6.0	8	80	160	μA

NOTE: Information on typical parametric values can be found in Chapter 2 of the Motorola High-Speed CMOS Data Book (DL129/D).

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## AC ELECTRICAL CHARACTERISTICS (C<sub>L</sub> = 50 pF, Input t<sub>r</sub> = t<sub>f</sub> = 6 ns)

Symbol	Parameter	V <sub>CC</sub> V	Guaranteed Limit			Unit
			- 55 to 25°C	≤ 85°C	≤ 125°C	
f <sub>max</sub>	Maximum Clock Frequency (50% Duty Cycle) (Figures 3, 4 and 9)	2.0	6.0	4.8	4.0	MHz
		4.5	30	24	20	
		6.0	35	28	24	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, Input A to Output B (or Input B to Output A) (Figures 1, 2 and 9)	2.0	170	215	255	ns
		4.5	34	43	51	
		6.0	29	37	43	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, A-to-B Clock to Output B (or B-to-A Clock to Output A) (Figures 3, 4 and 9)	2.0	220	275	330	ns
		4.5	44	55	66	
		6.0	37	47	56	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, A-to-B Source to Output B (or B-to-A Source to Output A) (Figures 5, 6 and 9)	2.0	170	215	255	ns
		4.5	34	43	51	
		6.0	29	37	43	
t <sub>PLZ</sub> , t <sub>PHZ</sub>	Maximum Propagation Delay, Output Enable to Output A or B (Figures 7, 8 and 10)	2.0	175	220	265	ns
		4.5	35	44	53	
		6.0	30	37	45	
t <sub>PZL</sub> , t <sub>PZH</sub>	Maximum Propagation Delay, Direction or Output Enable to Output A or B (Figures 7, 8 and 10)	2.0	175	220	265	ns
		4.5	35	44	53	
		6.0	30	37	45	
t <sub>TLH</sub> , t <sub>THL</sub>	Maximum Output Transition Time, Any Output (Figures 1 and 9)	2.0	60	75	90	ns
		4.5	12	15	18	
		6.0	10	13	15	
C <sub>in</sub>	Maximum Input Capacitance	—	10	10	10	pF
C <sub>out</sub>	Maximum Three-State Output Capacitance (Output in High-Impedance State)	—	15	15	15	pF

### NOTES:

- For propagation delays with loads other than 50 pF, see Chapter 2 of the Motorola High-Speed CMOS Data Book (DL129/D).
- Information on typical parametric values can be found in Chapter 2 of the Motorola High-Speed CMOS Data Book (DL129/D).

CPD	Power Dissipation Capacitance (Per Channel)*	Typical @ 25°C, V <sub>CC</sub> = 5.0 V		pF
		60		

\* Used to determine the no-load dynamic power consumption: P<sub>D</sub> = C<sub>PD</sub> V<sub>CC</sub><sup>2</sup>f + I<sub>CC</sub> V<sub>CC</sub>. For load considerations, see Chapter 2 of the Motorola High-Speed CMOS Data Book (DL129/D).

## TIMING REQUIREMENTS (Input t<sub>r</sub> = t<sub>f</sub> = 6 ns)

Symbol	Parameter	V <sub>CC</sub> V	Guaranteed Limit			Unit
			- 55 to 25°C	≤ 85°C	≤ 125°C	
t <sub>su</sub>	Minimum Setup Time, Input A to A-to-B Clock (or Input B to B-to-A Clock) (Figures 3 and 4)	2.0	100	125	150	ns
		4.5	20	25	30	
		6.0	17	21	26	
t <sub>h</sub>	Minimum Hold Time, A-to-B Clock to Input A (or B-to-A Clock to Input B) (Figures 3 and 4)	2.0	5	5	5	ns
		4.5	5	5	5	
		6.0	5	5	5	
t <sub>w</sub>	Minimum Pulse Width, A-to-B Clock (or B-to-A Clock) (Figures 3 and 4)	2.0	80	100	120	ns
		4.5	16	20	24	
		6.0	14	17	20	
t <sub>r</sub> , t <sub>f</sub>	Maximum Input Rise and Fall Times (Figure 1)	2.0	1000	1000	1000	ns
		4.5	500	500	500	
		6.0	400	400	400	

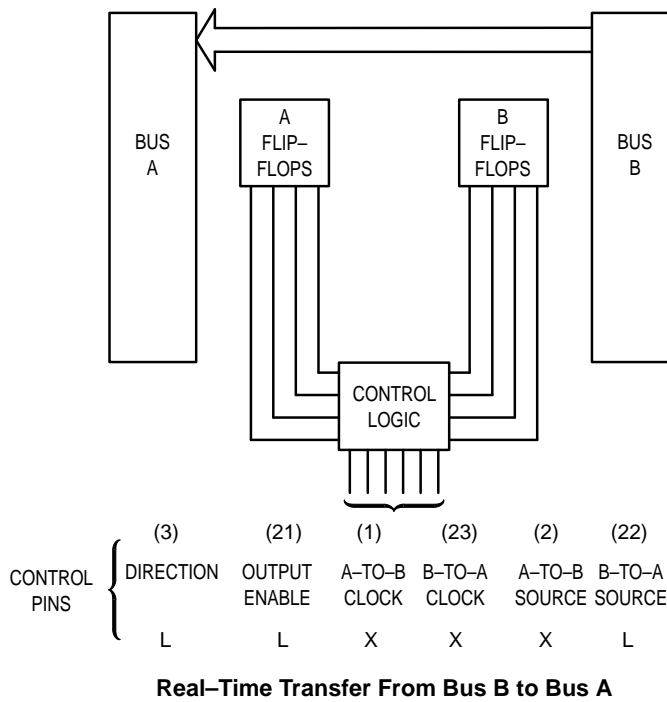
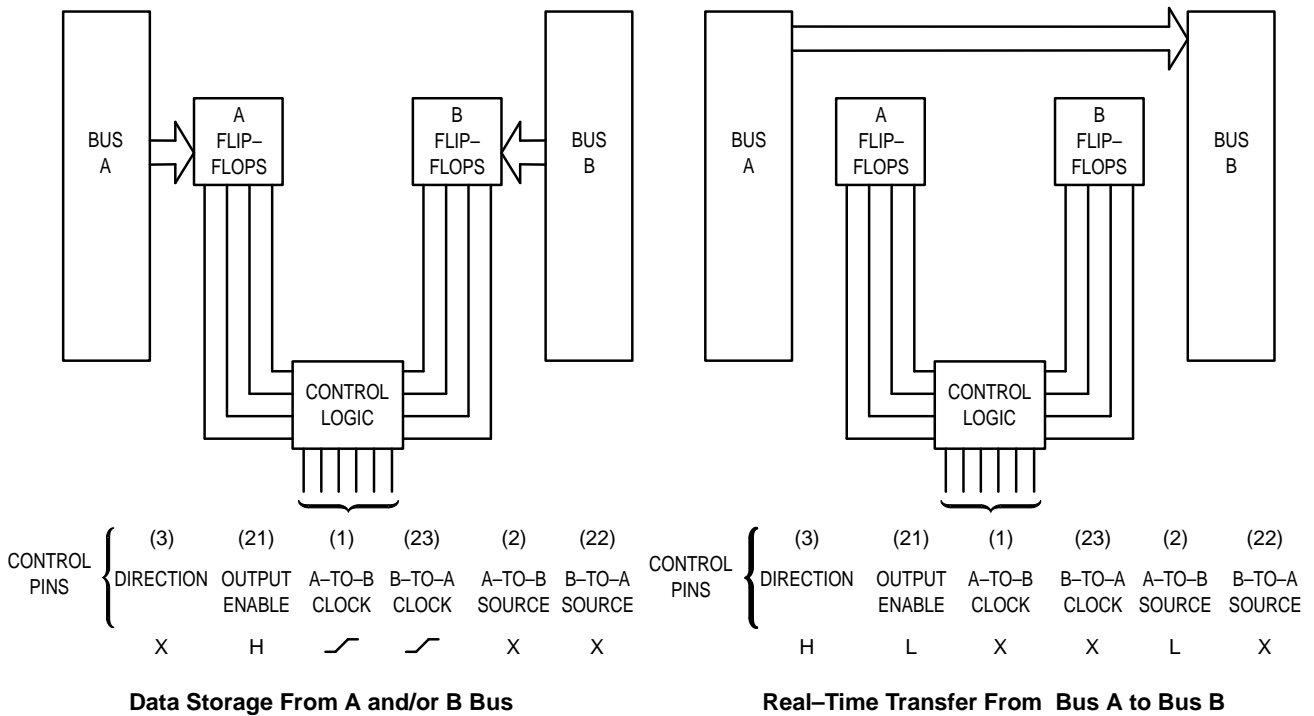
NOTE: Information on typical parametric values can be found in Chapter 2 of the Motorola High-Speed CMOS Data Book (DL129/D).

FUNCTION TABLE — HC646

Control Inputs						Data Port Status		Storage Flip-Flop States		Description of Operation	
Output Enable	Direction	A-to-B Clock	B-to-A Clock	A-to-B Source	B-to-A Source	A	B	Q <sub>A</sub>	Q <sub>B</sub>		
H	X	H, L, $\bar{\text{~}}$	H, L, $\bar{\text{~}}$	X	X	Input: X	Input: X	no change	no change	The output functions of the A and B ports are disabled	
		$\bar{\text{~}}$	$\bar{\text{~}}$	X	X	L H X X	X X L H	L H X X	X X L H	The ports may be used as inputs to the storage flip-flops. Data at the inputs are clocked into the flip-flops with the rising edge of the Clocks.	
L	H	H, L, $\bar{\text{~}}$	X*	L	X	L H	L H	no change no change	no change no change	The output mode of the B data port is enabled and behaves according to the following logic equation: $B = [A \cdot (\overline{A\text{-to-B Source}})] + [Q_A \cdot (A\text{-to-B Source})]$ 1.) When A-to-B Source is low, the data at the A data port are displayed at the B data port. The states of the storage flip-flops are not affected.	
				H	X	X	Q <sub>A</sub>	no change	no change	2.) When A-to-B Source is high, the states of the A storage flip-flops are displayed at the B data port.	
		$\bar{\text{~}}$	X*	L	X	L H	L H	L H	no change no change	no change no change	3.) When A-to-B Source is low, the data at the A data port are clocked into the A storage flip-flops by a rising-edge signal on the A-to-B Clock.
				H	X	L H	Q <sub>A</sub> Q <sub>A</sub>	L H	no change no change	no change no change	4.) When A-to-B Source is high, the data at the A data port are clocked into the A storage flip-flops by a rising-edge signal on the A-to-B Clock. The states, Q <sub>A</sub> , of the storage flip-flops propagate directly to the B data port.
L	L	X*	H, L, $\bar{\text{~}}$	X	L	L H	L H	no change no change	no change no change	The output mode of the A data port is enabled and behaves according to the following logic equation: $A = [B \cdot (\overline{B\text{-to-A Source}})] + [Q_B \cdot (B\text{-to-A Source})]$ 1.) When B-to-A Source is low, the data at the B data port are displayed at the A data port. The states of the storage flip-flops are not affected.	
				X	H	Q <sub>B</sub>	X	no change	no change	2.) When B-to-A Source is high, the states of the B storage flip-flops are displayed at the A data port.	
		X*	$\bar{\text{~}}$	X	L	L H	L H	no change no change	L H	no change no change	3.) When B-to-A Source is low, the data at the B data port are clocked into the B storage flip-flops by a rising-edge signal on the B-to-A Clock.
				X	H	Q <sub>B</sub> Q <sub>B</sub>	L H	no change no change	L H	no change no change	4.) When B-to-A Source is high, the data at the B data port are clocked into the B storage flip-flops by a rising-edge signal on the B-to-A Clock. The states, Q <sub>B</sub> , of the storage flip-flops propagate directly to the A data port.

\* The clocks are not internally gated with either the Output Enables or the Source inputs. Therefore, data at the A and B ports may be clocked into the storage flip-flops at any time.

**TYPICAL APPLICATIONS**



TIMING DIAGRAMS AND SWITCHING DIAGRAMS — HC646

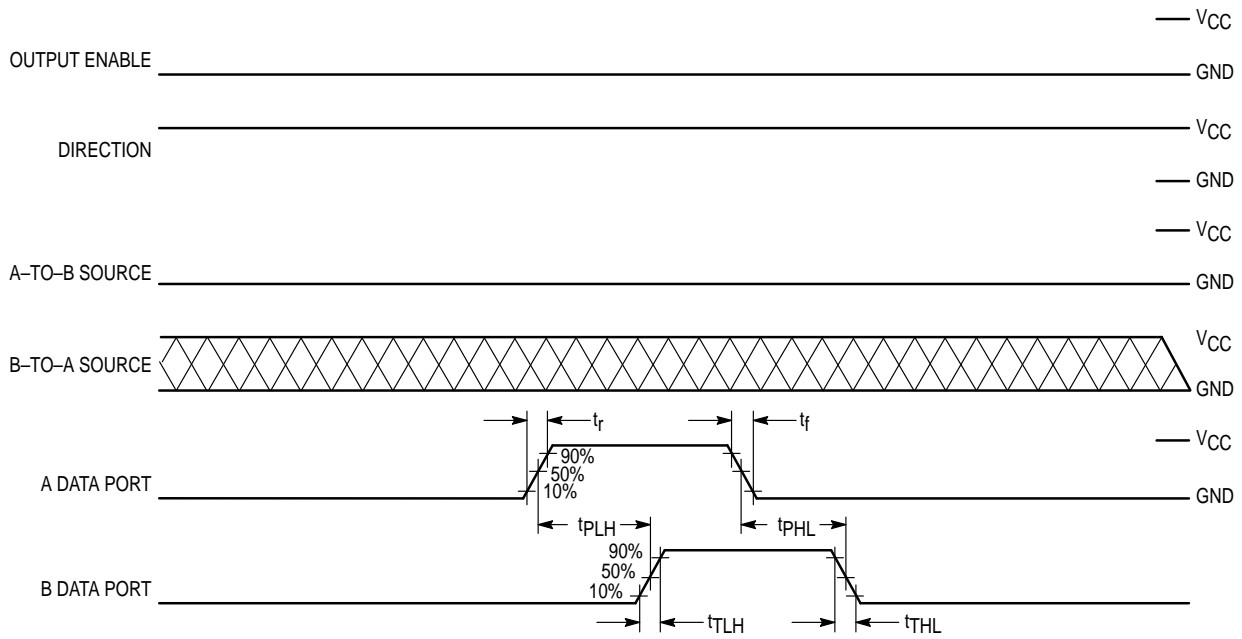


Figure 1. A Data Port = Input, B Data Port = Output

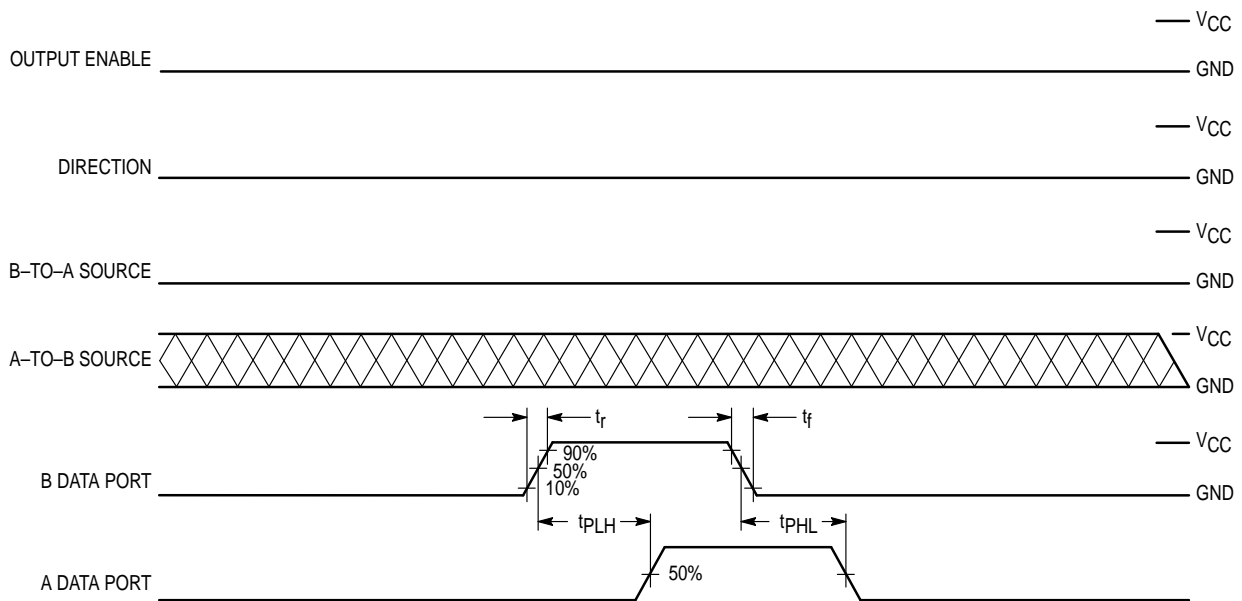
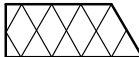
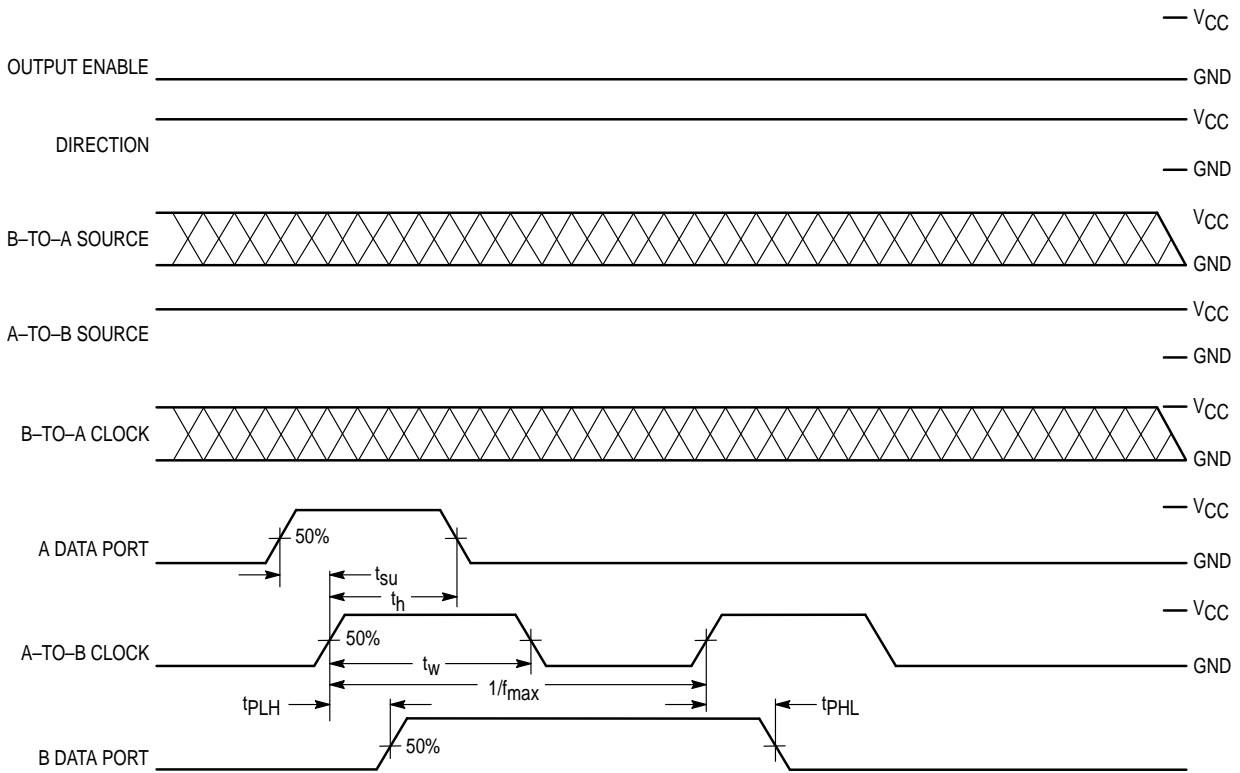


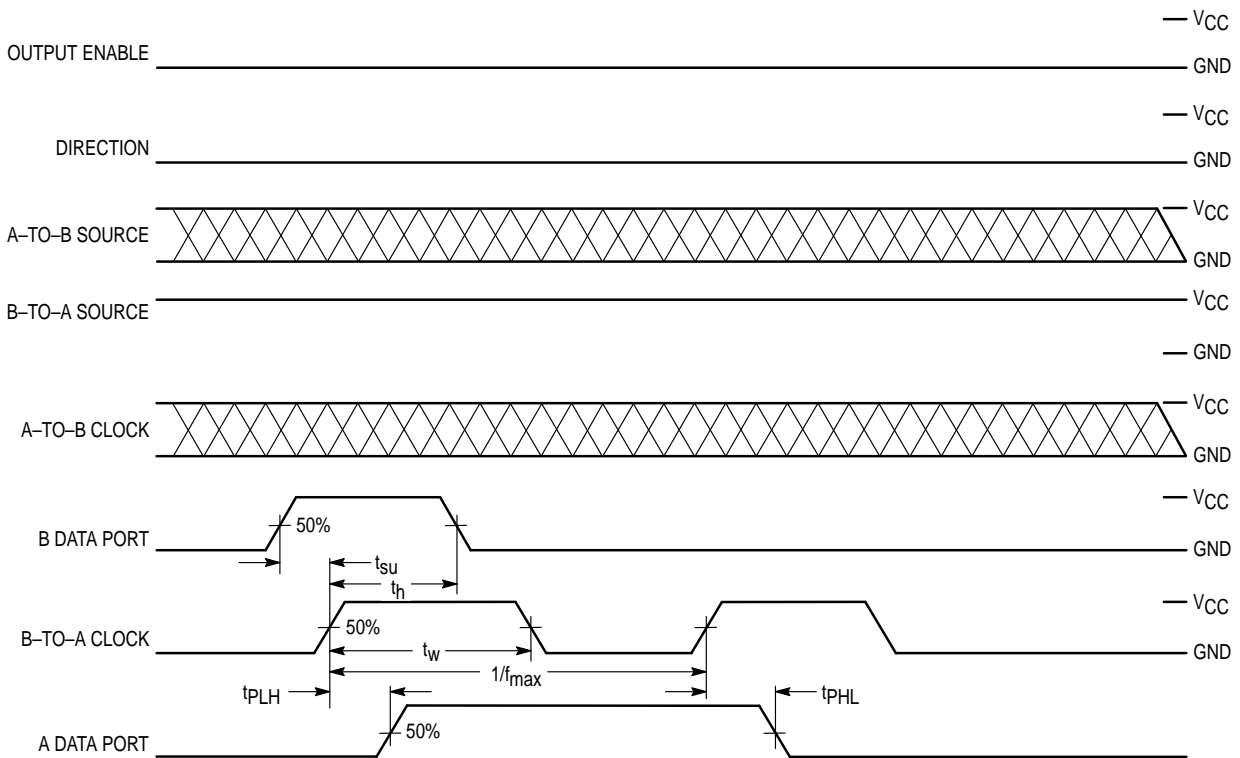
Figure 2. A Data Port = Output, B Data Port = Input

NOTE:  = Don't Care State

# MC54/74HC646

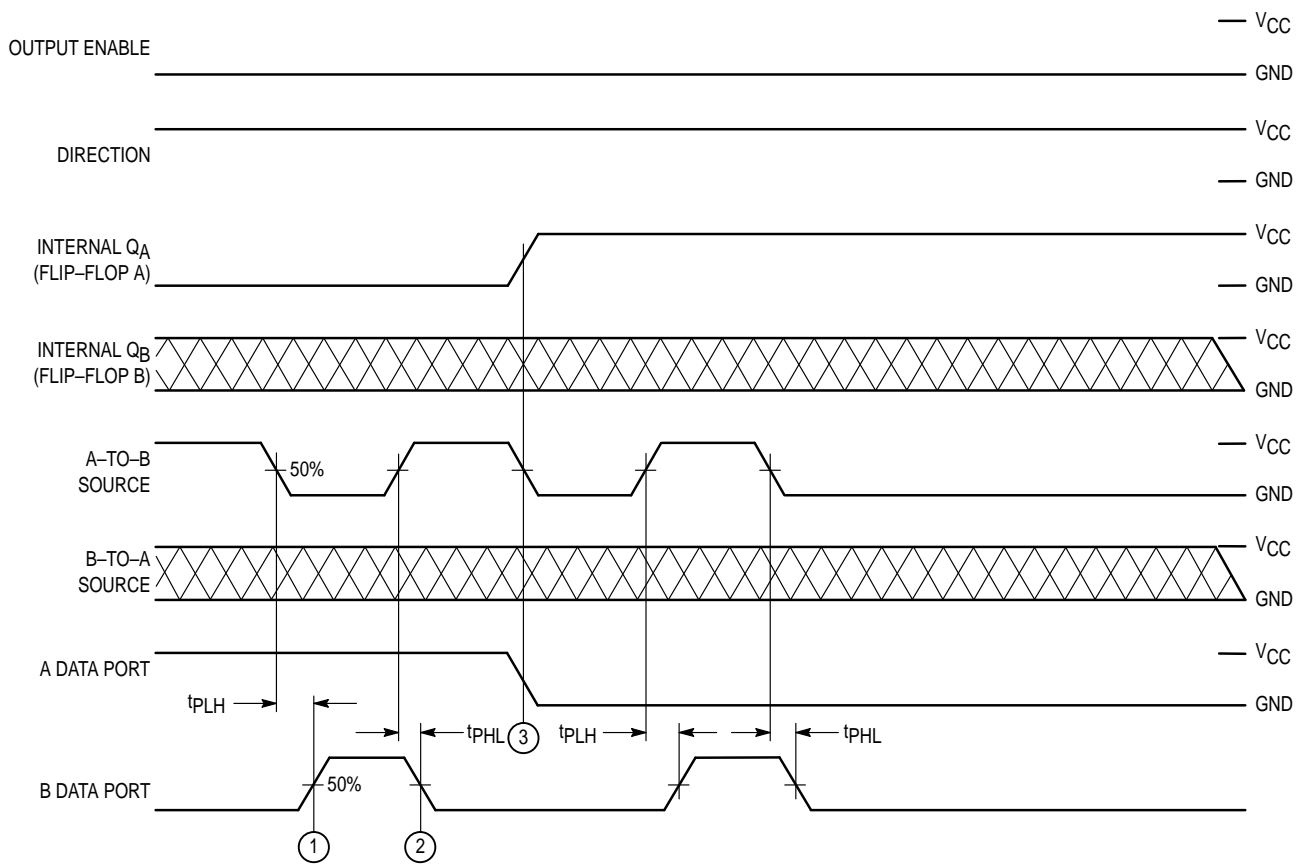


**Figure 3. A Data Port = Input, B Data Port = Output**



**Figure 4. B Data Port = Input, A Data Port = Output**



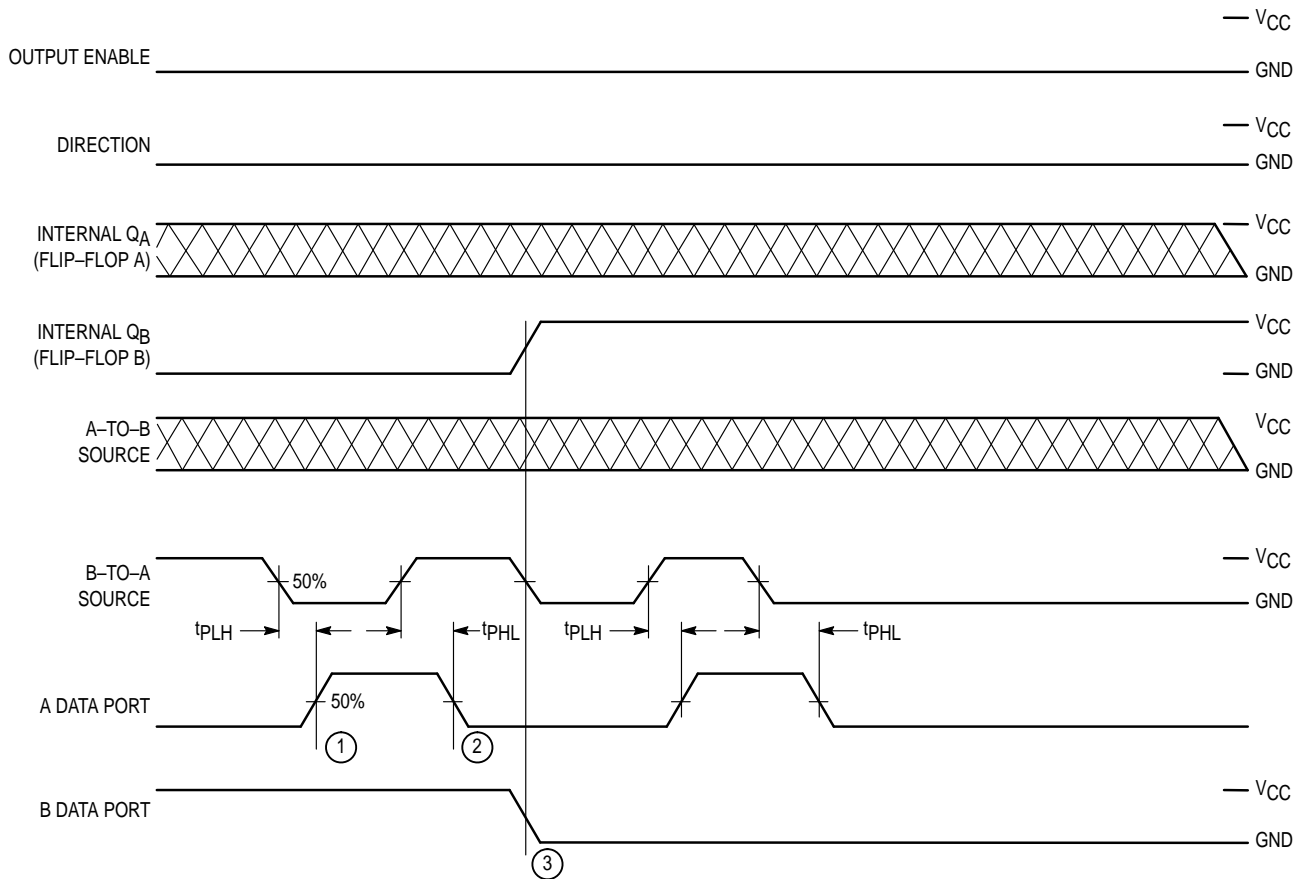


NOTES:

1. B Data Port (output) changes from the level of the storage flip-flop,  $Q_A$ , to the level of A Data Port (input).
2. B Data Port (output) changes from the level of the A Data Port (input) to the level of the storage flip-flop,  $Q_A$ .
3. The A storage flip-flop, A-to-B Source, and A Data Port (input) have simultaneously changed states.

Figure 5. A Data Port = Input, B Data Port = Output

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## NOTES:

1. A Data Port (output) changes from the level of the storage flip-flop, Q<sub>B</sub>, to the level of B Data Port (input).
2. A Data Port (output) changes from the level of the B Data Port (input) to the level of the storage flip-flop, Q<sub>B</sub>.
3. The B storage flip-flop, B-to-A Source, and B Data Port (input) have simultaneously changed states for the purpose of this example. A Data Port (output) is now displaying the voltage level of B Data Port (input).

Figure 6. A Data Port = Output, B Data Port = Input

## PIN DESCRIPTIONS

### INPUTS/OUTPUTS

#### A0–A7 (Pins 4–11) and B0–B7 (Pins 20–13)

A and B data ports. These pins may function either as inputs to or outputs from the transceivers.

### CONTROL INPUTS

#### Output Enable (Pin 21)

Active-low output enable. When this pin is low, the outputs are enabled and function normally. When this pin is high, the A and B data ports are in high-impedance states. See the Function Table.

#### Direction (Pin 3)

Data direction control. When the Output Enable pin is low, this control pin determines the direction of data flow. When

Direction is high, the A data ports are inputs and the B data ports are outputs. When Direction is low, the A data ports are outputs and the B data ports are inputs.

#### A-to-B Clock, B-to-A Clock (Pins 1, 23)

Clocks for the internal D flip-flops. With a low-to-high transition on the appropriate Clock pin, data on the A (or B) inputs are clocked into the internal A (or B) flip-flops. These clocks are not internally gated with the Output Enable or the Direction pins, therefore data at the A and B pins may be clocked into the storage flip-flops at any time.

#### A-to-B Source, B-to-A Source (Pins 2, 22)

Data-source selection pins. Depending upon the states of these pins (see the Function Table), data at the outputs may come either from the inputs or from the D flip-flops.

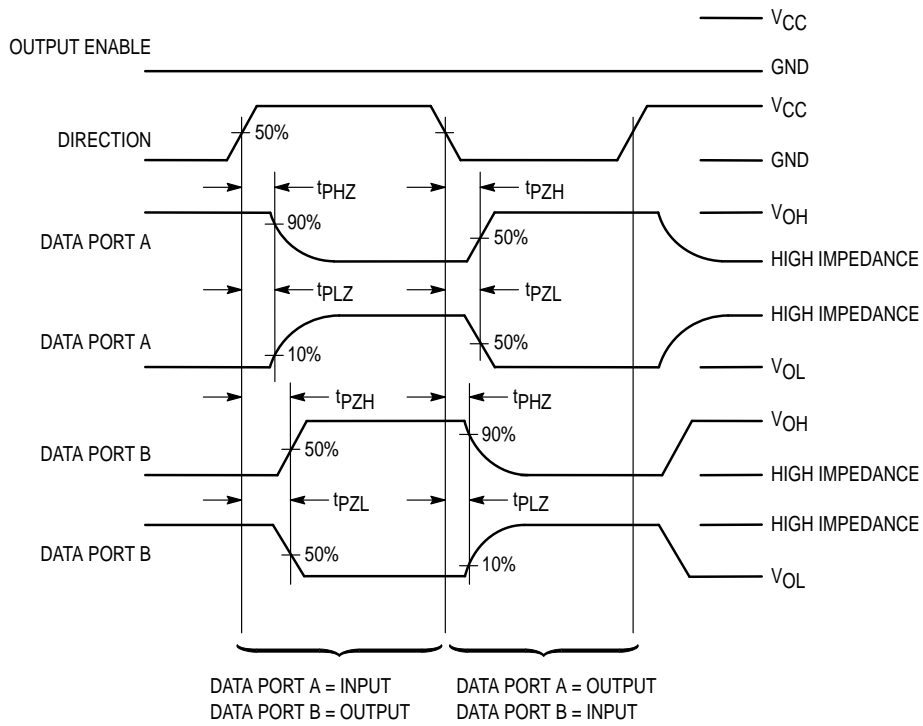


Figure 7.

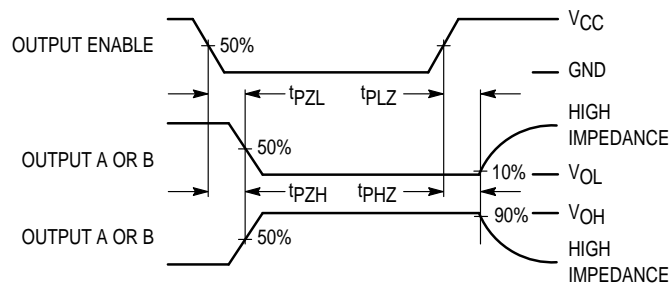
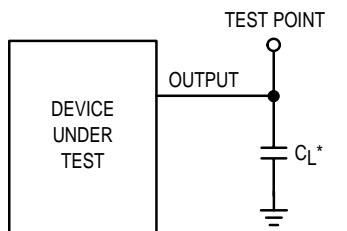
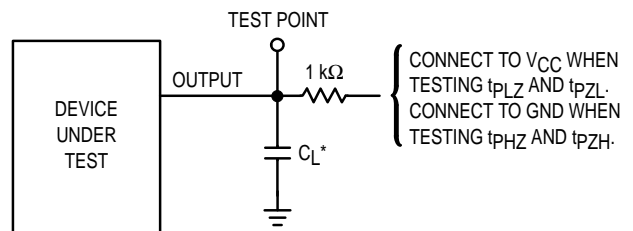


Figure 8.



\* Includes all probe and jig capacitance

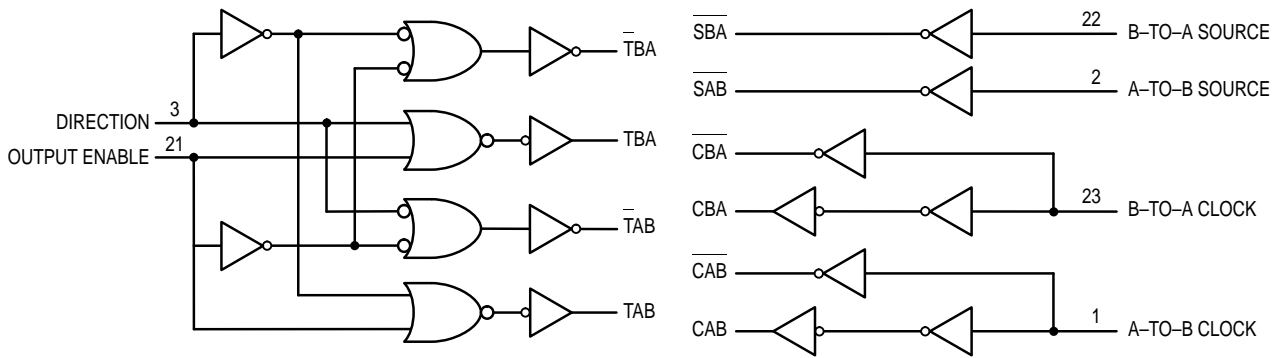
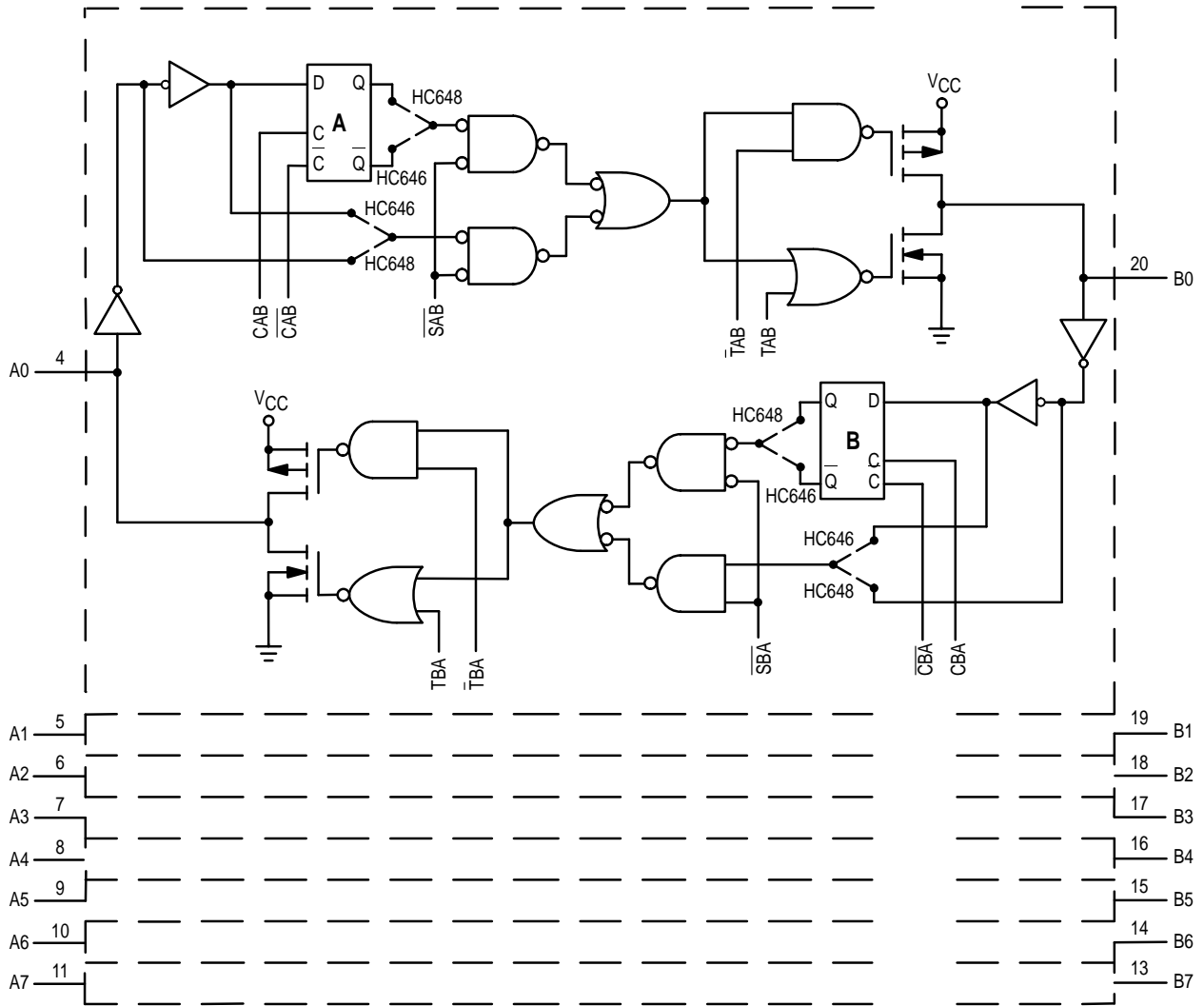
Figure 9. Test Circuit



\* Includes all probe and jig capacitance

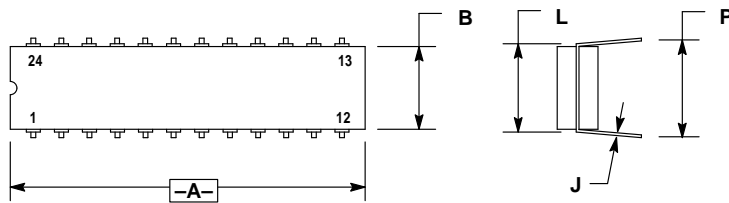
Figure 10. Test Circuit

LOGIC DETAIL



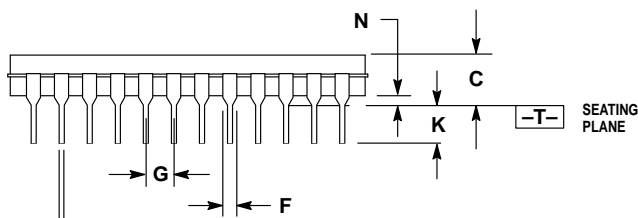
OUTLINE DIMENSIONS

**J SUFFIX**  
**CERAMIC PACKAGE**  
**CASE 758-02**  
**ISSUE A**



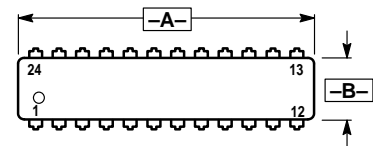
- NOTES:  
 3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
 4. CONTROLLING DIMENSION: INCH.  
 5. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.240	1.285	31.50	32.64
B	0.285	0.305	7.24	7.75
C	0.160	0.200	4.07	5.08
D	0.015	0.021	0.38	0.53
F	0.045	0.062	1.14	1.57
G	0.100 BSC		2.54 BSC	
J	0.008	0.013	0.20	0.33
K	0.100	0.165	2.54	4.19
L	0.300	0.310	7.62	7.87
N	0.020	0.050	0.51	1.27
P	0.360	0.400	9.14	10.16

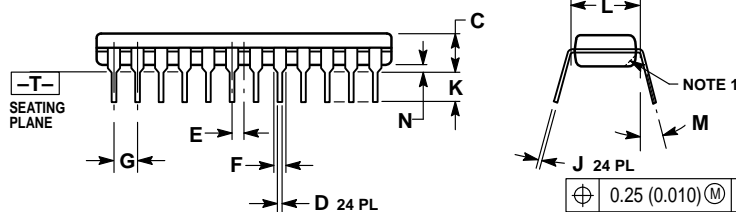


D 24 PL  
 ⊕ 0.25 (0.010) Ⓜ T A Ⓜ

**N SUFFIX**  
**PLASTIC PACKAGE**  
**CASE 724-03**  
**ISSUE D**



- NOTES:  
 1. CHAMFERED CONTOUR OPTIONAL.  
 2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.  
 3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
 4. CONTROLLING DIMENSION: INCH.

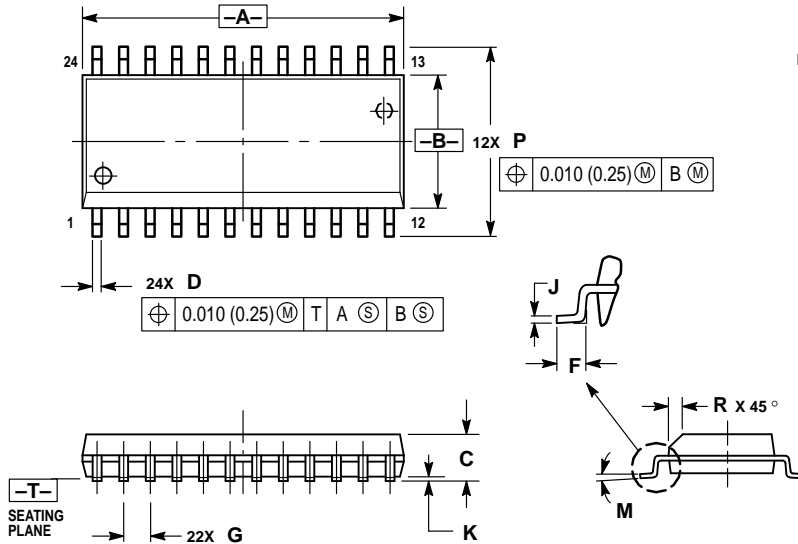


D 24 PL  
 ⊕ 0.25 (0.010) Ⓜ T A Ⓜ

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.230	1.265	31.25	32.13
B	0.250	0.270	6.35	6.85
C	0.145	0.175	3.69	4.44
D	0.015	0.020	0.38	0.51
E	0.050 BSC		1.27 BSC	
F	0.040	0.060	1.02	1.52
G	0.100 BSC		2.54 BSC	
J	0.007	0.012	0.18	0.30
K	0.110	0.140	2.80	3.55
L	0.300 BSC		7.62 BSC	
M	0°	15°	0°	15°
N	0.020	0.040	0.51	1.01

OUTLINE DIMENSIONS

DW SUFFIX  
PLASTIC SOIC PACKAGE  
CASE 751E-04  
ISSUE E



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
  4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
  5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.25	15.54	0.601	0.612
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.41	0.90	0.016	0.035
G	1.27 BSC		0.050 BSC	
J	0.23	0.32	0.009	0.013
K	0.13	0.29	0.005	0.011
M	0°	8°	0°	8°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029

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◇ CODELINE

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