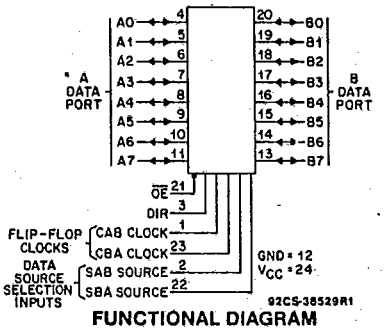
Technical Data

# CD54/74AC646, CD54/74AC648
# CD54/74ACT646, CD54/74ACT648

Advance Information

T-52-31




FUNCTIONAL DIAGRAM

## Octal-Bus Transceiver/Registers, 3-State

CD54/74AC/ACT646 - Non-Inverting
CD54/74AC/ACT648 - Inverting

**Type Features:**

- *Buffered inputs*
- *Typical propagation delay: 5.3 ns @ $V_{CC}$ = 5 V, $T_A$ = 25°C, $C_L$ = 50 pF*

The RCA CD54/74AC646 and CD54/74AC648 and the CD54/74ACT646 and CD54/74ACT648 3-state, octal-bus transceiver/registers use the RCA ADVANCED CMOS technology. The CD54/74AC648 and CD54/74ACT648 have inverting outputs. The CD54/74AC646 and CD54/74ACT646 have non-inverting outputs. These devices are bus transceivers with D-type flip-flops which act as internal storage registers on the LOW-to-HIGH transition of either CAB or CBA clock inputs. Output Enable ($\overline{OE}$) and Direction (DIR) inputs control the transceiver functions. Data present at the high-impedance output can be stored in either register or both but only one of the two buses can be enabled as outputs at any one time. The Select controls (SAB and SBA) can multiplex stored and transparent (real time) data. The Direction control determines which data bus will receive data when the Output Enable ($\overline{OE}$) is LOW. In the high-impedance mode (Output Enable HIGH), A data can be stored in one register and B data can be stored in the other register. The clocks are not gated with the Direction (DIR) and Output Enable ($\overline{OE}$) terminals; data at the A or B terminals can be clocked into the storage flip-flops at any time.

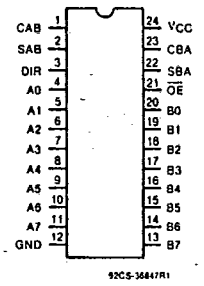
The CD74AC/ACT646 and CD74AC/ACT648 are supplied in 24-lead dual-in-line narrow-body plastic packages (EN suffix) and in 24-lead dual-in-line small-outline plastic packages (M suffix). Both package types are operable over the following temperature ranges: Commercial (0 to 70°C); Industrial (-40 to +85°C); and Extended Industrial/Military (-55 o +125°C).

The CD54AC/ACT646 and CD54AC/ACT648, available in chip form (H suffix), are operable over the -55 to +125°C temperature range.

**Family Features:**

- *Exceeds 2-kV 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 1.5-V to 5.5-V operation and balanced noise immunity at 30% of the supply*
- *± 24-mA output drive current*
  - *Fanout to 15 FAST* ICs*
  - *Drives 50-ohm transmission lines*

*FAST is a Registered Trademark of Fairchild Semiconductor Corp.




TERMINAL ASSIGNMENT

File Number 1970

Technical Data

# CD54/74AC646, CD54/74AC648
# CD54/74ACT646, CD54/74ACT648

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## FUNCTION TABLE

| INPUTS | | | | | | DATA I/O# | | OPERATION OR FUNCTION | |
|---|---|---|---|---|---|---|---|---|---|
| $\overline{OE}$ | DIR | CAB | CBA | SAB | SBA | A0 THRU A7 | B0 THRU B7 | 646 | 648 |
| X | X | ↓ | X | X | X | Input | Not specified | Store A, B unspecified | Store A, B unspecified |
| X | X | X | ↓ | X | X | Not specified | Input | Store B, A unspecified | Store B, A unspecified |
| H | X | ↓ | ↓ | X | X | Input | Input | Store A and B Data Isolation, hold storage | Store A and B Data Isolation, hold storage |
| H | X | H or L | H or L | X | X | | | | |
| L | L | X | X | X | L | Output | Input | Real-Time B Data to A Bus | Real-Time $\overline{B}$ Data to A Bus |
| L | L | X | H or L | X | H | | | Stored B Data to A Bus | Stored $\overline{B}$ Data to A Bus |
| L | H | X | X | L | X | Input | Output | Real-Time A Data to B Bus | Real-Time $\overline{A}$ Data to B Bus |
| L | H | H or L | X | H | X | | | Stored A Data to B Bus | Stored $\overline{A}$ Data to B Bus |

#The data output functions may be enabled or disabled by various signals at the $\overline{OE}$ and DIR inputs. Data input functions are always enabled, i.e., data at the bus pins will be stored on every low-to-high transition on the clock inputs.
To prevent excess currents in the High-Z modes, all I/O terminals should be terminated with 10 kΩ resistors.

**MAXIMUM RATINGS,** *Absolute-Maximum Values:*

DC SUPPLY-VOLTAGE ($V_{CC}$) ..... -0.5 to 6 V
DC INPUT DIODE CURRENT, $I_{IK}$ (for $V_I < -0.5$ V or $V_I > V_{CC} + 0.5$ V) ..... ±20 mA
DC OUTPUT DIODE CURRENT, $I_{OK}$ (for $V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V) ..... ±50 mA
DC OUTPUT SOURCE OR SINK CURRENT per Output Pin, $I_O$ (for $V_O > -0.5$ V or $V_O < V_{CC} + 0.5$ V) ..... ±50 mA
DC $V_{CC}$ or GROUND CURRENT ($I_{CC}$ or $I_{GND}$) ..... ±100 mA*
POWER DISSIPATION PER PACKAGE ($P_D$):
For $T_A$ = -55 to +100°C (PACKAGE TYPE E) ..... 500 mW
For $T_A$ = +100 to +125°C (PACKAGE TYPE E) ..... Derate Linearly at 8 mW/°C to 300 mW
For $T_A$ = -55 to +70°C (PACKAGE TYPE M) ..... 400 mW
For $T_A$ = +70 to +125°C (PACKAGE TYPE M) ..... Derate Linearly at 6 mW/°C to 70 mW
OPERATING-TEMPERATURE RANGE ($T_A$) ..... -55 to +125°C
STORAGE TEMPERATURE ($T_{stg}$) ..... -65 to +150°C
LEAD TEMPERATURE (DURING SOLDERING):
At distance 1/16 ± 1/32 in. (1.59 ± 0.79 mm) from case for 10 s maximum ..... +265°C
Unit inserted into PC board min. thickness 1/16 in. (1.59 mm) with solder contacting lead tips only ..... +300°C

*For up to 4 outputs per device; add ± 25 mA for each additional output.

**RECOMMENDED OPERATING CONDITIONS:**
**For maximum reliability, normal operating conditions should be selected so that operation is always within the following ranges:**

| CHARACTERISTICS | LIMITS | | UNITS |
|---|---|---|---|
| | MIN. | MAX. | |
| Supply-Voltage Range, $V_{CC}$*: (For $T_A$ = Full Package-Temperature Range) | | | |
| AC Types | 1.5 | 5.5 | V |
| ACT Types | 4.5 | 5.5 | V |
| DC Input or Output Voltage, $V_I$, $V_O$ | 0 | $V_{CC}$ | V |
| Operating Temperature, $T_A$ | -55 | +125 | °C |
| Input Rise and Fall Slew Rate, dt/dv | | | |
| at 1.5 V to 3 V (AC Types) | 0 | 50 | ns/V |
| at 3.6 V to 5.5 V (AC Types) | 0 | 20 | ns/V |
| at 4.5 V to 5.5 V (ACT Types) | 0 | 10 | ns/V |

*Unless otherwise specified, all voltages are referenced to ground.

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# CD54/74AC646, CD54/74AC648
# CD54/74ACT646, CD54/74ACT648

**STATIC ELECTRICAL CHARACTERISTICS: AC Series**

| CHARACTERISTICS | TEST CONDITIONS | | $V_{CC}$ (V) | AMBIENT TEMPERATURE ($T_A$) - °C | | | | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | +25 | | -40 to +85 | | -55 to +125 | | |
| | $V_I$ (V) | $I_O$ (mA) | | MIN. | MAX. | MIN. | MAX. | MIN. | MAX. | |
| High-Level Input Voltage $V_{IH}$ | | | 1.5 | 1.2 | — | 1.2 | — | 1.2 | — | V |
| | | | 3 | 2.1 | — | 2.1 | — | 2.1 | — | |
| | | | 5.5 | 3.85 | — | 3.85 | — | 3.85 | — | |
| Low-Level Input Voltage $V_{IL}$ | | | 1.5 | — | 0.3 | — | 0.3 | — | 0.3 | V |
| | | | 3 | — | 0.9 | — | 0.9 | — | 0.9 | |
| | | | 5.5 | — | 1.65 | — | 1.65 | — | 1.65 | |
| 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 | — | |
| | | -0.05 | 4.5 | 4.4 | — | 4.4 | — | 4.4 | — | |
| | | -4 | 3 | 2.58 | — | 2.48 | — | 2.4 | — | |
| | | -24 | 4.5 | 3.94 | — | 3.8 | — | 3.7 | — | |
| | #, * | -75 | 5.5 | — | — | 3.85 | — | — | — | |
| | | -50 | 5.5 | — | — | — | — | 3.85 | — | |
| 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 | |
| | | 0.05 | 4.5 | — | 0.1 | — | 0.1 | — | 0.1 | |
| | | 12 | 3 | — | 0.36 | — | 0.44 | — | 0.5 | |
| | | 24 | 4.5 | — | 0.36 | — | 0.44 | — | 0.5 | |
| | #, * | 75 | 5.5 | — | — | — | 1.65 | — | — | |
| | | 50 | 5.5 | — | — | — | — | — | 1.65 | |
| Input Leakage Current $I_I$ | $V_{CC}$ or GND | | 5.5 | — | ±0.1 | — | ±1 | — | ±1 | μA |
| 3-State Leakage Current $I_{OZ}$ | $V_{IH}$ or $V_{IL}$ $V_O$= $V_{CC}$ or GND | | 5.5 | — | ±0.5 | — | ±5 | — | ±10 | μA |
| Quiescent Supply Current, MSI $I_{CC}$ | $V_{CC}$ or GND | 0 | 5.5 | — | 8 | — | 80 | — | 160 | μA |

#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.
*Test verifies a minimum 50-ohm transmission-line-drive capability at +85°C, 75 ohms at +125°C.

# CD54/74AC646, CD54/74AC648
# CD54/74ACT646, CD54/74ACT648

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**STATIC ELECTRICAL CHARACTERISTICS: ACT Series**

| CHARACTERISTICS | TEST CONDITIONS | | $V_{CC}$ (V) | AMBIENT TEMPERATURE ($T_A$) - °C | | | | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | +25 | | -40 to +85 | | -55 to +125 | | |
| | $V_I$ (V) | $I_O$ (mA) | | MIN. | MAX. | MIN. | MAX. | MIN. | MAX. | |
| 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 | — | |
| | #, * | -75 | 5.5 | — | — | 3.85 | — | — | — | |
| | | -50 | 5.5 | — | — | — | — | 3.85 | — | |
| 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 | |
| | #, * | 75 | 5.5 | — | — | — | 1.65 | — | — | |
| | | 50 | 5.5 | — | — | — | — | — | 1.65 | |
| Input Leakage Current $I_I$ | $V_{CC}$ or GND | | 5.5 | — | ±0.1 | — | ±1 | — | ±1 | μA |
| 3-State Leakage Current $I_{OZ}$ | $V_{IH}$ or $V_{IL}$ $V_O$= $V_{CC}$ or GND | | 5.5 | — | ±0.5 | — | ±5 | — | ±10 | μA |
| Quiescent Supply Current, MSI $I_{CC}$ | $V_{CC}$ or GND | 0 | 5.5 | — | 8 | — | 80 | — | 160 | μA |
| Additional Quiescent Supply Current per Input Pin TTL Inputs High 1 Unit Load $\Delta I_{CC}$ | $V_{CC}$-2.1 | | 4.5 to 5.5 | — | 2.4 | — | 2.8 | — | 3 | mA |

#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.
*Test verifies a minimum 50-ohm transmission-line-drive capability at +85°C, 75 ohms at +125°C.

**ACT INPUT LOADING TABLE**

| INPUT | UNIT LOAD* |
|---|---|
| CAB, CBA | 1.25 |
| SAB, SBA | 1.2 |
| DIR | 0.67 |
| $\overline{OE}$ | 1.17 |
| An, Bn | 0.4 |

*Unit load is $\Delta I_{CC}$ limit specified in Static Characteristics Chart, e.g., 2.4 mA max. @ 25°C.

Technical Data

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# CD54/74AC646, CD54/74AC648
# CD54/74ACT646, CD54/74ACT648

**PREREQUISITE FOR SWITCHING: AC Series**

| CHARACTERISTICS | SYMBOL | $V_{CC}$ (V) | AMBIENT TEMPERATURE ($T_A$) - °C | | | | UNITS |
|---|---|---|---|---|---|---|---|
| | | | -40 to +85 | | -55 to +125 | | |
| | | | MIN. | MAX. | MIN. | MAX. | |
| Max. Frequency | $f_{max}$ | 1.5 | 11 | — | 10 | — | MHz |
| | | 3.3* | 101 | — | 89 | — | |
| | | 5† | 143 | — | 125 | — | |
| Setup Time Data to Clock | $t_{su}$ | 1.5 | 27 | — | 31 | — | ns |
| | | 3.3 | 3.1 | — | 3.5 | — | |
| | | 5 | 2.2 | — | 2.5 | — | |
| Hold Time Data to Clock | $t_H$ | 1.5 | 2 | — | 2 | — | ns |
| | | 3.3 | 2 | — | 2 | — | |
| | | 5 | 2 | — | 2 | — | |
| Clock Pulse Width | $t_w$ | 1.5 | 44 | — | 50 | — | ns |
| | | 3.3 | 4.9 | — | 5.6 | — | |
| | | 5 | 3.5 | — | 4 | — | |

*3.3 V: min. is @ 3 V
†5 V: min is @ 4.5 V

**SWITCHING CHARACTERISTICS: AC Series; $t_r$, $t_f$ = 3 ns, $C_L$ = 50 pF**

| CHARACTERISTICS | SYMBOL | $V_{CC}$ (V) | AMBIENT TEMPERATURE ($T_A$) - °C | | | | UNITS |
|---|---|---|---|---|---|---|---|
| | | | -40 to +85 | | -55 to +125 | | |
| | | | MIN. | MAX. | MIN. | MAX. | |
| Propagation Delays: | | | | | | | |
| Store A Data to B Bus | $t_{PLH}$ | 1.5 | — | 154 | — | 169 | ns |
| Store B Data to A Bus | | 3.3* | 4.8 | 17.1 | 4.7 | 18.9 | |
| 646 | $t_{PHL}$ | 5† | 3.5 | 12.3 | 3.4 | 13.5 | |
| Store $\overline{A}$ Data to B Bus | $t_{PLH}$ | 1.5 | — | 154 | — | 169 | ns |
| Store $\overline{B}$ Data to A Bus | | 3.3 | 4.8 | 17.1 | 4.7 | 18.9 | |
| 648 | $t_{PHL}$ | 5 | 3.5 | 12.3 | 3.4 | 13.5 | |
| $\overline{A}$ Data to B Bus | $t_{PLH}$ | 1.5 | — | 125 | — | 138 | ns |
| B Data to A Bus | | 3.3 | 4 | 14 | 3.9 | 15.4 | |
| 646 | $t_{PHL}$ | 5 | 2.8 | 10 | 2.8 | 11 | |
| $\overline{A}$ Data to B Bus | $t_{PLH}$ | 1.5 | — | 125 | — | 138 | ns |
| $\overline{B}$ Data to A Bus | | 3.3 | 4 | 14 | 3.9 | 15.4 | |
| 648 | $t_{PHL}$ | 5 | 2.8 | 10 | 2.8 | 11 | |
| Select to Data | $t_{PLH}$ | 1.5 | — | 136 | — | 150 | ns |
| 646 | | 3.3 | 4.3 | 15.3 | 4.2 | 16.8 | |
| | $t_{PHL}$ | 5 | 3.1 | 10.9 | 3 | 12 | |
| Select to Data | $t_{PLH}$ | 1.5 | — | 136 | — | 150 | ns |
| 648 | | 3.3 | 4.3 | 15.3 | 4.2 | 16.8 | |
| | $t_{PHL}$ | 5 | 3.1 | 10.9 | 3 | 12 | |
| 3-State Enabling/ Disabling Time Bus to Output or Register to Output | $t_{PZL}$ | 1.5 | — | 154 | — | 169 | ns |
| | $t_{PZH}$ | 3.3 | 5.2 | 18.4 | 5.1 | 20.2 | |
| | $t_{PLZ}$ | 5 | 3.5 | 12.3 | 3.4 | 13.5 | |
| | $t_{PHZ}$ | | | | | | |
| Power Dissipation Capacitance | $C_{PD}$§ | — | 150 Typ. | | 150 Typ. | | pF |
| Min. (Valley) $V_{OH}$ During Switching of Other Outputs (Output Under Test Not Switching) | $V_{OHV}$ See Fig. 1 | 5 | 4 Typ. @ 25°C | | | | V |
| Max. (Peak) $V_{OL}$ During Switching of Other Outputs (Output Under Test Not Switching) | $V_{OLP}$ See Fig. 1 | 5 | 1 Typ. @ 25°C | | | | V |
| Input Capacitance | $C_I$ | — | — | 10 | — | 10 | pF |
| 3-State Output Capacitance | $C_O$ | — | — | 15 | — | 15 | pF |

*3.3 V: min. is @ 3.6 V
max. is @ 3 V
†5 V: min. is @ 5.5 V
max. is @ 4.5 V

§$C_{PD}$ is used to determine the dynamic power consumption, per package.
$P_D = V_{CC}^2 C_{PD} f_i + \Sigma (V_{CC}^2 C_L f_o)$ where $f_i$ = input frequency
$f_o$ = output frequency
$C_L$ = output load capacitance
$V_{CC}$ = supply voltage.

# CD54/74AC646, CD54/74AC648
# CD54/74ACT646, CD54/74ACT648

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**PREREQUISITE FOR SWITCHING: ACT Series**

| CHARACTERISTICS | SYMBOL | $V_{CC}$ (V) | AMBIENT TEMPERATURE ($T_A$) - °C | | | | UNITS |
|---|---|---|---|---|---|---|---|
| | | | -40 to +85 | | -55 to +125 | | |
| | | | MIN. | MAX. | MIN. | MAX. | |
| Max. Frequency | $f_{max}$ | 5* | 125 | — | 110 | — | MHz |
| Setup Time Data to Clock | $t_{SU}$ | 5 | 2.2 | — | 2.5 | — | ns |
| Hold Time Data to Clock | $t_H$ | 5 | 2 | — | 2 | — | ns |
| Clock Pulse Width | $t_W$ | 5 | 3.9 | — | 4.5 | — | ns |

*5 V: min. is @ 4.5 V

**SWITCHING CHARACTERISTICS: ACT Series; $t_r$, $t_f$ = 3 ns, $C_L$ = 50 pF**

| CHARACTERISTICS | SYMBOL | $V_{CC}$ (V) | AMBIENT TEMPERATURE ($T_A$) - °C | | | | UNITS |
|---|---|---|---|---|---|---|---|
| | | | -40 to +85 | | -55 to +125 | | |
| | | | MIN. | MAX. | MIN. | MAX. | |
| Propagation Delays: Store A Data to B Bus, Store B Data to A Bus — 646 | $t_{PLH}$ $t_{PHL}$ | 5* | 4 | 14.1 | 3.9 | 15.5 | ns |
| Store $\overline{A}$ Data to B Bus, Store $\overline{B}$ Data to A Bus — 648 | $t_{PLH}$ $t_{PHL}$ | 5 | 4 | 14.1 | 3.9 | 15.5 | ns |
| A Data to B Bus, B Data to A Bus — 646 | $t_{PLH}$ $t_{PHL}$ | 5 | 3.2 | 11.4 | 3.1 | 12.5 | ns |
| $\overline{A}$ Data to B Bus, $\overline{B}$ Data to A Bus — 648 | $t_{PLH}$ $t_{PHL}$ | 5 | 3.2 | 11.4 | 3.1 | 12.5 | ns |
| Select to Data — 646 | $t_{PLH}$ $t_{PHL}$ | 5 | 3.7 | 13.2 | 3.6 | 14.5 | ns |
| Select to Data — 648 | $t_{PLH}$ $t_{PHL}$ | 5 | 4 | 14.1 | 3.9 | 15.5 | ns |
| 3-State Enabling/ Disabling Time Bus to Output or Register to Output | $t_{PZL}$ $t_{PZH}$ $t_{PLZ}$ $t_{PHZ}$ | 5 | 4 | 14.1 | 3.9 | 15.5 | ns |
| Power Dissipation Capacitance | $C_{PD}$§ | — | 150 Typ. | | 150 Typ. | | pF |
| Min. (Valley) $V_{OH}$ During Switching of Other Outputs (Output Under Test Not Switching) | $V_{OHV}$ See Fig. 1 | 5 | 4 Typ. @ 25°C | | | | V |
| Max. (Peak) $V_{OL}$ During Switching of Other Outputs (Output Under Test Not Switching) | $V_{OLP}$ See Fig. 1 | 5 | 1 Typ. @ 25°C | | | | V |
| Input Capacitance | $C_I$ | — | — | 10 | — | 10 | pF |
| 3-State Output Capacitance | $C_O$ | — | — | 15 | — | 15 | pF |

*5 V: min. is @ 5.5 V
max. is @ 4.5 V

§$C_{PD}$ is used to determine the dynamic power consumption, per package.
$P_D = C_{PD}V_{CC}^2 f_i + \Sigma (C_L V_{CC}^2 f_o) + V_{CC}\Delta I_{CC}$ where $f_i$ = input frequency
$f_o$ = output frequency
$C_L$ = output load capacitance
$V_{CC}$ = supply voltage.

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# CD54/74AC646, CD54/74AC648
# CD54/74ACT646, CD54/74ACT648

## PARAMETER MEASUREMENT INFORMATION

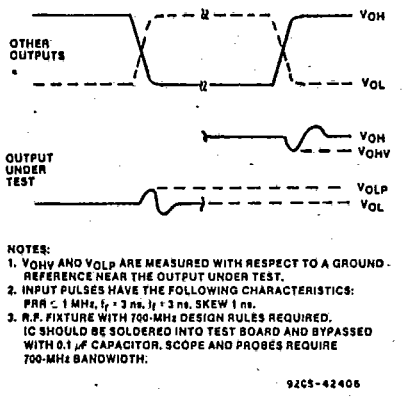



*Fig. 1 - Simultaneous switching transient waveforms.*

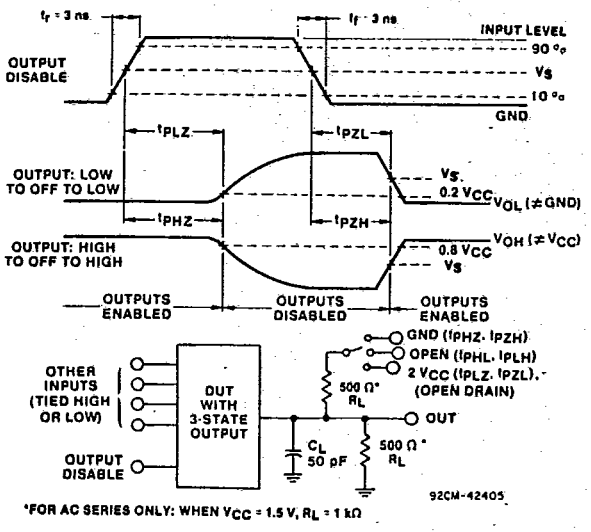



*Fig. 2 - Three-state propagation delay waveforms and test circuit.*

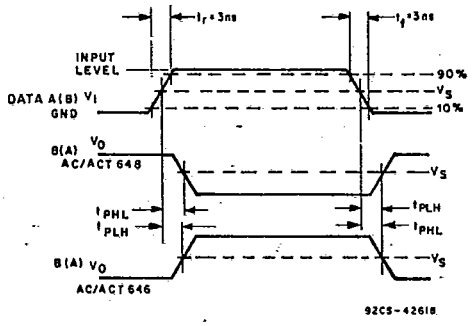



*Fig. 3 - Propagation delay times.*

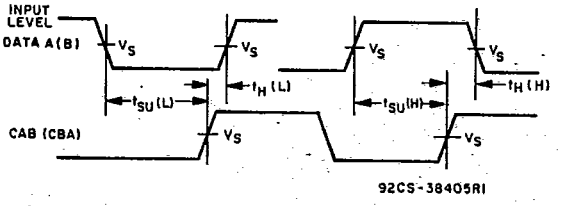



*Fig. 4 - Data setup and hold times.*

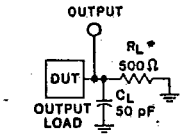
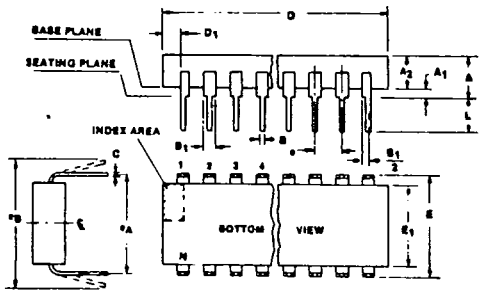



*Fig. 5 - Test circuit.*

| | CD54/74AC | CD54/74ACT |
|---|---|---|
| Input Level | $V_{CC}$ | 3 V |
| Input Switching Voltage, $V_S$ | 0.5 $V_{CC}$ | 1.5 V |
| Output Switching Voltage, $V_S$ | 0.5 $V_{CC}$ | 0.5 $V_{CC}$ |

# Dual-In-Line Plastic Packages

T-90-20




**(E) Suffix (JEDEC MS-001-AC)**
**14-Lead Dual-In-Line Plastic Package**

| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. | |
| A | — | 0.210 | — | 5.33 | 9 |
| $A_1$ | 0.015 | — | 0.39 | — | 9 |
| $A_2$ | 0.115 | 0.195 | 2.93 | 4.95 | |
| B | 0.014 | 0.022 | 0.356 | 0.558 | |
| $B_1$ | 0.045 | 0.070 | 1.15 | 1.77 | 3 |
| C | 0.008 | 0.015 | 0.204 | 0.381 | |
| D | 0.725 | 0.795 | 18.42 | 20.19 | 4 |
| $D_1$ | 0.005 | — | 0.13 | — | 12 |
| E | 0.300 | 0.325 | 7.62 | 8.25 | 5 |
| $E_1$ | 0.240 | 0.280 | 6.10 | 7.11 | 6, 7 |
| e | 0.100 BSC | | 2.54 BSC | | 8 |
| $e_A$ | 0.300 BSC | | 7.62 BSC | | 9 |
| $e_B$ | — | 0.430 | — | 10.92 | 10 |
| L | 0.115 | 0.160 | 2.93 | 4.06 | 9 |
| N | 14 | | 14 | | 11 |

92CS-39901

**(E) Suffix (JEDEC MS-001-AA)**
**16-Lead Dual-In-Line Plastic Package**

| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. | |
| A | — | 0.210 | — | 5.33 | 9 |
| $A_1$ | 0.015 | — | 0.39 | — | 9 |
| $A_2$ | 0.115 | 0.195 | 2.93 | 4.95 | |
| B | 0.014 | 0.022 | 0.356 | 0.558 | |
| $B_1$ | 0.045 | 0.070 | 1.15 | 1.77 | 3 |
| C | 0.008 | 0.015 | 0.204 | 0.381 | |
| D | 0.745 | 0.840 | 18.93 | 21.33 | 4 |
| $D_1$ | 0.005 | — | 0.13 | — | 12 |
| E | 0.300 | 0.325 | 7.62 | 8.25 | 5 |
| $E_1$ | 0.240 | 0.280 | 6.10 | 7.11 | 6, 7 |
| e | 0.100 BSC | | 2.54 BSC | | 8 |
| $e_A$ | 0.300 BSC | | 7.62 BSC | | 9 |
| $e_B$ | — | 0.430 | — | 10.92 | 10 |
| L | 0.115 | 0.160 | 2.93 | 4.06 | 9 |
| N | 16 | | 16 | | 11 |

92CS-39900

**Notes:**

1. Refer to JEDEC Publication No. 95 JEDEC Registered and Standard Outlines for Solid State Products, for rules and general information concerning registered and standard outlines, in Section 2.2.
2. Protrusions (flash) on the base plane surface shall not exceed 0.010 in. (0.25 mm).
3. The dimension shown is for full leads. "Half" leads are optional at lead positions
   $1, N, \frac{N}{2}, \frac{N}{2}+1.$
4. Dimension D does not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 in. (0.25 mm).
5. E is the dimension to the outside of the leads and is measured with the leads perpendicular to the base plane (zero lead spread).
6. Dimension $E_1$ does not include mold flash or protrusions.
7. Package body and leads shall be symmetrical around center line shown in end view.
8. Lead spacing e shall be non-cumulative and shall be measured at the lead tip. This measurement shall be made before insertion into gauges, boards or sockets.
9. This is a basic installed dimension. Measurement shall be made with the device installed in the seating plane gauge (JEDEC Outline No. GS-3, seating plane gauge). Leads shall be in true position within 0.010 in. (0.25 mm) diameter for dimension $e_A$.
10. $e_B$ is the dimension to the outside of the leads and is measured at the lead tips before the device is installed. Negative lead spread is not permitted.
11. N is the maximum number of lead positions.
12. Dimension $D_1$ at the left end of the package must equal dimension $D_1$ at the right end of the package within 0.030 in. (0.76 mm).
13. For automatic insertion, any raised irregularity on the top surface (step, mesa, etc.) shall be symmetrical about the lateral and longitudinal package centerlines.

**(E) Suffix (JEDEC MS-001-AE)**
**20-Lead Dual-In-Line Plastic Package**

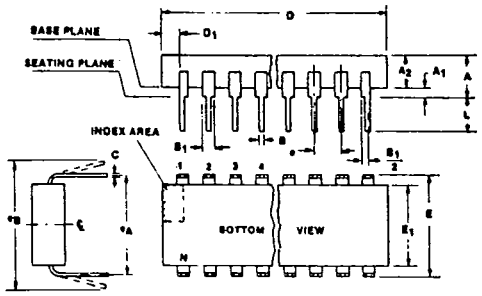
| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. | |
| A | — | 0.210 | — | 5.33 | 9 |
| $A_1$ | 0.015 | — | 0.39 | — | 9 |
| $A_2$ | 0.115 | 0.195 | 2.93 | 4.95 | |
| B | 0.014 | 0.022 | 0.356 | 0.558 | |
| $B_1$ | 0.045 | 0.070 | 1.15 | 1.77 | 3 |
| C | 0.008 | 0.015 | 0.204 | 0.381 | |
| D | 0.925 | 1.060 | 23.5 | 26.9 | 4 |
| $D_1$ | 0.005 | — | 0.13 | — | 12 |
| E | 0.300 | 0.325 | 7.62 | 8.25 | 5 |
| $E_1$ | 0.240 | 0.280 | 6.10 | 7.11 | 6, 7 |
| e | 0.100 BSC | | 2.54 BSC | | 8 |
| $e_A$ | 0.300 BSC | | 7.62 BSC | | 9 |
| $e_B$ | — | 0.430 | — | 10.92 | 10 |
| L | 0.115 | 0.160 | 2.93 | 4.06 | 9 |
| N | 20 | | 20 | | 11 |

92CS-39997

# Dual-In-Line Plastic Packages

T-90-20

(E) Suffix (JEDEC MS-001-AF)
24-Lead Dual-In-Line Plastic Package




| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. | |
| A | — | 0.210 | — | 5.33 | 9 |
| $A_1$ | 0.015 | — | 0.39 | — | 9 |
| $A_2$ | 0.115 | 0.195 | 2.93 | 4.95 | |
| B | 0.014 | 0.022 | 0.356 | 0.558 | |
| $B_1$ | 0.045 | 0.070 | 1.15 | 1.77 | 3 |
| C | 0.008 | 0.015 | 0.204 | 0.381 | |
| D | 1.125 | 1.275 | 28.6 | 32.3 | 4 |
| $D_1$ | 0.005 | — | 0.13 | — | 12 |
| E | 0.300 | 0.325 | 7.62 | 8.25 | 5 |
| $E_1$ | 0.240 | 0.280 | 6.10 | 7.11 | 6, 7 |
| e | 0.100 BSC | | 2.54 BSC | | 8 |
| $e_A$ | 0.300 BSC | | 7.62 BSC | | 9 |
| $e_B$ | — | 0.430 | — | 10.92 | 10 |
| L | 0.115 | 0.160 | 2.93 | 4.06 | 9 |
| N | 24 | | 24 | | 11 |

92CS-39943

Notes:

1. Refer to JEDEC Publication No. 95 JEDEC Registered and Standard Outlines for Solid State Products, for rules and general information concerning registered and standard outlines, in Section 2.2.
2. Protrusions (flash) on the base plane surface shall not exceed 0.010 in. (0.25 mm).
3. The dimension shown is for full leads. "Half" leads are optional at lead positions

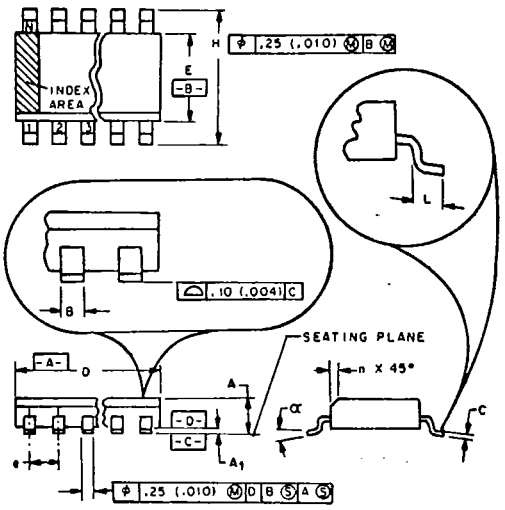
   $1, N, \frac{N}{2}, \frac{N}{2}+1.$

4. Dimension D does not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 in. (0.25 mm).
5. E is the dimension to the outside of the leads and is measured with the leads perpendicular to the base plane (zero lead spread).
6. Dimension $E_1$ does not include mold flash or protrusions.
7. Package body and leads shall be symmetrical around center line shown in end view.
8. Lead spacing e shall be non-cumulative and shall be measured at the lead tip. This measurement shall be made before insertion into gauges, boards or sockets.
9. This is a basic installed dimension. Measurement shall be made with the device installed in the seating plane gauge (JEDEC Outline No. GS-3, seating plane gauge). Leads shall be in true position within 0.010 in. (0.25 mm) diameter for dimension $e_A$.
10. $e_B$ is the dimension to the outside of the leads and is measured at the lead tips before the device is installed. Negative lead spread is not permitted.
11. N is the maximum number of lead positions.
12. Dimension $D_1$ at the left end of the package must equal dimension $D_1$ at the right end of the package within 0.030 in. (0.76 mm).
13. For automatic insertion, any raised irregularity on the top surface (step, mesa, etc.) shall be symmetrical about the lateral and longitudinal package centerlines.

13

# Dual-In-Line Small-Outline Plastic Packages

T-90-20




**NOTES:**

1. Refer to applicable symbol list.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. "D" is a reference datum.
4. "A" and "B" are reference datums and do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15 mm (0.006 in.).
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the cross-hatched area.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. Controlling dimensions: MILLIMETERS.

**M Suffix (JEDEC MS-012AB)**
**14-Lead Dual-In-Line Small-Outline (SO) Package**

| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. | |
| A | 0.0532 | 0.0688 | 1.35 | 1.75 | |
| $A_1$ | 0.0040 | 0.0098 | 0.10 | 0.25 | |
| B | 0.0138 | 0.020 | 0.35 | 0.508 | |
| C | 0.0075 | 0.0098 | 0.19 | 0.25 | |
| D | 0.3367 | 0.3444 | 8.55 | 8.75 | 4 |
| E | 0.1497 | 0.1574 | 3.80 | 4.00 | 4 |
| e | 0.050 BSC | | 1.27 BSC | | |
| H | 0.2284 | 0.2440 | 5.80 | 6.20 | |
| h | 0.0099 | 0.0196 | 0.25 | 0.50 | 5 |
| L | 0.016 | 0.050 | 0.40 | 1.27 | 6 |
| N | 14 | | 14 | | 7 |
| α | 0° | 8° | 0° | 8° | |

Notes: 1, 2, 3, 8, 9

92CS-38924R2

**M Suffix (JEDEC MS-012AC)**
**16-Lead Dual-In-Line Small-Outline (SO) Package**

| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. | |
| A | 0.0532 | 0.0688 | 1.35 | 1.75 | |
| $A_1$ | 0.0040 | 0.0098 | 0.10 | 0.25 | |
| B | 0.0138 | 0.020 | 0.35 | 0.508 | |
| C | 0.0075 | 0.0098 | 0.19 | 0.25 | |
| D | 0.3859 | 0.3937 | 9.80 | 10.00 | 4 |
| E | 0.1497 | 0.1574 | 3.80 | 4.00 | 4 |
| e | 0.050 BSC | | 1.27 BSC | | |
| H | 0.2284 | 0.2440 | 5.80 | 6.20 | |
| h | 0.0099 | 0.0196 | 0.25 | 0.50 | 5 |
| L | 0.016 | 0.050 | 0.40 | 1.27 | 6 |
| N | 16 | | 16 | | 7 |
| α | 0° | 8° | 0° | 8° | |

Notes: 1, 2, 3, 8, 9

92CS-38925R2

**M Suffix (JEDEC MS-013AC)**
**20-Lead Dual-In-Line Small-Outline (SO) Package**

| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. | |
| A | 0.0926 | 0.1043 | 2.35 | 2.65 | |
| $A_1$ | 0.0040 | 0.0118 | 0.10 | 0.30 | |
| B | 0.0138 | 0.020 | 0.35 | 0.508 | |
| C | 0.0091 | 0.0125 | 0.23 | 0.32 | |
| D | 0.4961 | 0.5118 | 12.60 | 13.00 | 4 |
| E | 0.2914 | 0.2992 | 7.40 | 7.60 | 4 |
| e | 0.050 BSC | | 1.27 BSC | | |
| H | 0.394 | 0.419 | 10.00 | 10.65 | |
| h | 0.010 | 0.029 | 0.25 | 0.75 | 5 |
| L | 0.016 | 0.050 | 0.40 | 1.27 | 6 |
| N | 20 | | 20 | | 7 |
| α | 0° | 8° | 0° | 8° | |

Notes: 1, 2, 3, 8, 9

92CS-38926R2

**M Suffix (JEDEC MS-013AD)**
**24-Lead Dual-In-Line Small-Outline (SO) Package**

| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN. | MAX. | MIN. | MAX. | |
| A | 0.0926 | 0.1043 | 2.35 | 2.65 | |
| $A_1$ | 0.0040 | 0.0118 | 0.10 | 0.30 | |
| B | 0.0138 | 0.020 | 0.35 | 0.508 | |
| C | 0.0091 | 0.0125 | 0.23 | 0.32 | |
| D | 0.5985 | 0.6141 | 15.20 | 15.60 | 4 |
| E | 0.2914 | 0.2992 | 7.40 | 7.60 | 4 |
| e | 0.050 BSC | | 1.27 BSC | | |
| H | 0.394 | 0.419 | 10.00 | 10.65 | |
| h | 0.010 | 0.029 | 0.25 | 0.75 | 5 |
| L | 0.016 | 0.050 | 0.40 | 1.27 | 6 |
| N | 24 | | 24 | | 7 |
| α | 0° | 8° | 0° | 8° | |

Notes: 1, 2, 3, 8, 9

92CS-39037R2