

# DATA SHEET

## **74LVC374A**

Octal D-type flip-flop with 5 V  
tolerant inputs/outputs; positive  
edge-trigger; 3-state

Product specification  
Supersedes data of 1998 July 29

2003 May 14

# Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger; 3-state

## 74LVC374A

### FEATURES

- 5 V tolerant inputs/outputs; for interfacing with 5 V logic
- Wide supply voltage range from 1.2 to 3.6 V
- Inputs accept voltages up to 5.5 V
- CMOS low power consumption
- Direct interface with TTL levels
- High-impedance when  $V_{CC} = 0$  V
- 8-bit positive edge-triggered register
- Independent register and 3-state buffer operation
- Complies with JEDEC standard no. 8-1A
- ESD protection:  
HBM EIA/JESD22-A114-A exceeds 2000 V  
MM EIA/JESD22-A115-A exceeds 200 V.
- Specified from  $-40$  to  $+85$  °C and  $-40$  to  $+125$  °C.

### DESCRIPTION

The 74LVC374A is a high-performance, low-power, low-voltage, Si-gate CMOS device, superior to most advanced CMOS compatible TTL families.

Inputs can be driven from either 3.3 or 5 V devices. In 3-state operation, outputs can handle 5 V. This feature allows the use of these devices as translators in a mixed 3.3 and 5 V environment.

The 74LVC374A is an octal D-type flip-flop featuring separate D-type inputs for each flip-flop and 3-state outputs for bus-oriented applications. A clock input (CP) and an outputs enable input ( $\overline{OE}$ ) are common to all flip-flops.

The eight flip-flops will store the state of their individual D-inputs that meet the set-up and hold times requirements on the LOW-to-HIGH CP transition.

When pin  $\overline{OE}$  is LOW, the contents of the eight flip-flops is available at the outputs. When pin  $\overline{OE}$  is HIGH, the outputs go to the high-impedance OFF-state. Operation of the  $\overline{OE}$  input does not affect the state of the flip-flops.

The 74LVC374A is functionally identical to the 74LVC574A, but the 74LVC574A has a different pin arrangement.

### QUICK REFERENCE DATA

GND = 0 V;  $T_{amb} = 25$  °C;  $t_r = t_f \leq 2.5$  ns.

| SYMBOL            | PARAMETER                              | CONDITIONS                      | TYPICAL | UNIT |
|-------------------|----------------------------------------|---------------------------------|---------|------|
| $t_{PHL}/t_{PLH}$ | propagation delay CP to Qn             | $C_L = 50$ pF; $V_{CC} = 3.3$ V | 2.7     | ns   |
| $f_{max}$         | maximum clock frequency                |                                 | 100     | MHz  |
| $C_I$             | input capacitance                      |                                 | 4.0     | pF   |
| $C_{PD}$          | power dissipation capacitance per gate | $V_{CC} = 3.3$ V; notes 1 and 2 | 15      | pF   |

### Notes

1.  $C_{PD}$  is used to determine the dynamic power dissipation ( $P_D$  in  $\mu$ W).

$$P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o) \text{ where:}$$

$f_i$  = input frequency in MHz;

$f_o$  = output frequency in MHz;

$C_L$  = output load capacitance in pF;

$V_{CC}$  = supply voltage in Volts;

$N$  = total load switching outputs;

$\Sigma(C_L \times V_{CC}^2 \times f_o)$  = sum of the outputs.

2. The condition is  $V_I = \text{GND to } V_{CC}$ .

# Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger; 3-state

74LVC374A

## FUNCTION TABLE

See note 1.

| OPERATING MODE                    | INPUT                  |    |    | INTERNAL FLIP-FLOP | OUTPUT<br>Qn |
|-----------------------------------|------------------------|----|----|--------------------|--------------|
|                                   | $\overline{\text{OE}}$ | CP | Dn |                    |              |
| Load and read register            | L                      | ↑  | l  | L                  | L            |
|                                   | L                      | ↑  | h  | H                  | H            |
| Load register and disable outputs | H                      | ↑  | l  | L                  | Z            |
|                                   | H                      | ↑  | h  | H                  | Z            |

## Note

- H = HIGH voltage level;  
h = HIGH voltage level one set-up time prior to the LOW-to-HIGH CP transition;  
L = LOW voltage level;  
l = LOW voltage level one set-up time prior to the LOW-to-HIGH CP transition;  
Z = high-impedance OFF-state;  
↑ = LOW-to-HIGH clock transition.

## ORDERING INFORMATION

| TYPE NUMBER | PACKAGE           |      |          |          |          |
|-------------|-------------------|------|----------|----------|----------|
|             | TEMPERATURE RANGE | PINS | PACKAGE  | MATERIAL | CODE     |
| 74LVC374AD  | −40 to +125 °C    | 20   | SO20     | plastic  | SOT163-1 |
| 74LVC374ADB | −40 to +125 °C    | 20   | SSOP20   | plastic  | SOT339-1 |
| 74LVC374APW | −40 to +125 °C    | 20   | TSSOP20  | plastic  | SOT360-1 |
| 74LVC374ABQ | −40 to +125 °C    | 20   | DHVQFN20 | plastic  | SOT764-1 |

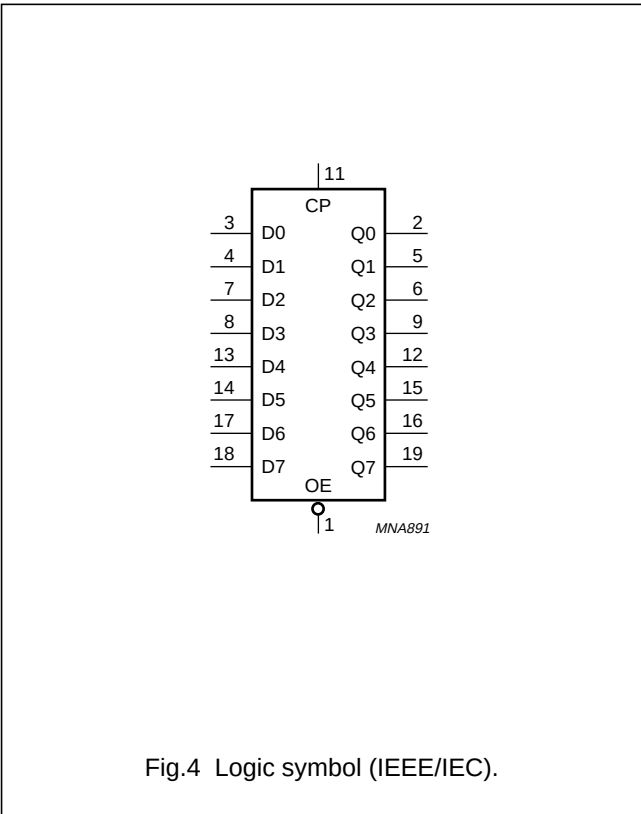
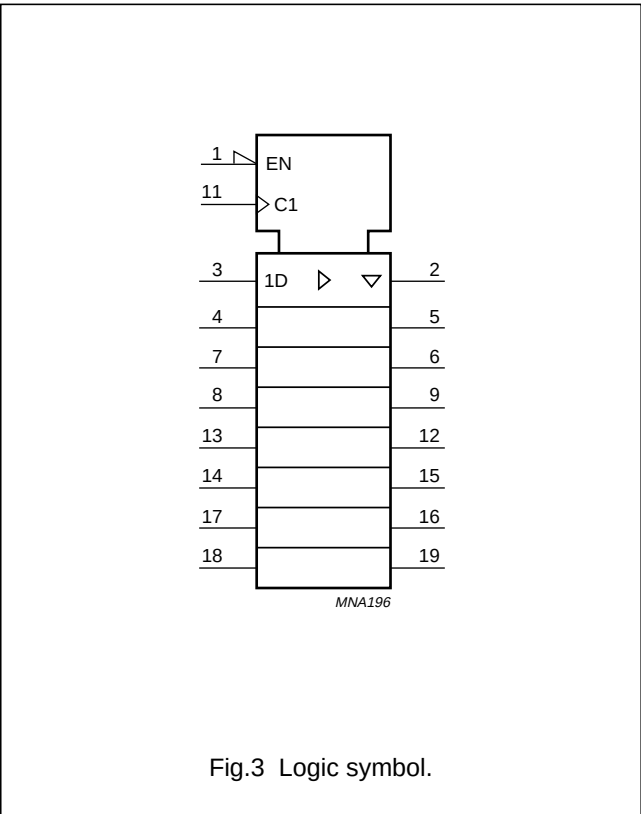
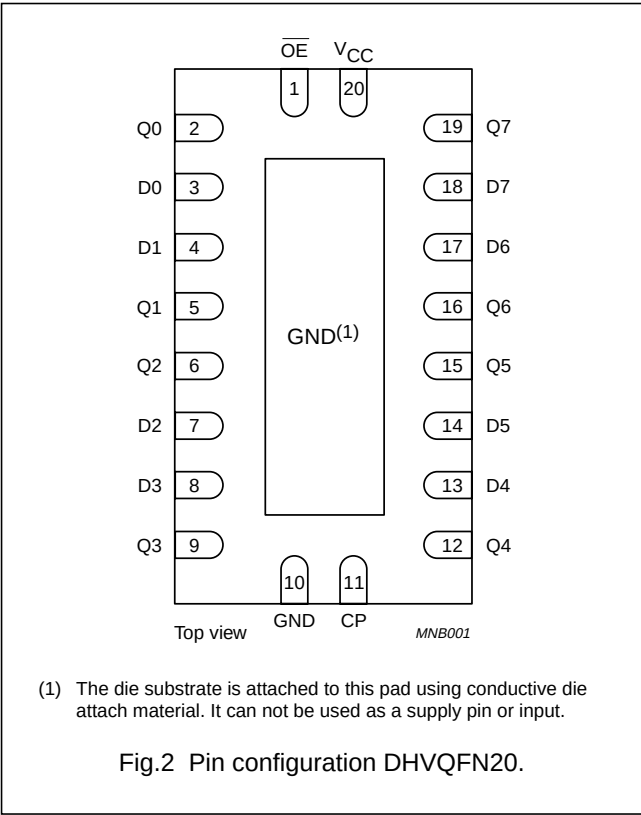
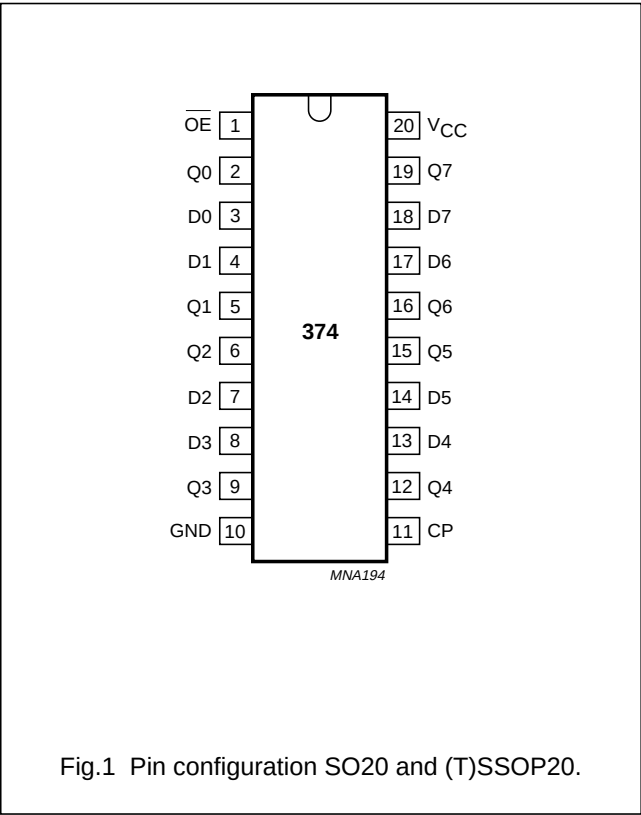
## PINNING

| PIN | SYMBOL                 | DESCRIPTION                      |
|-----|------------------------|----------------------------------|
| 1   | $\overline{\text{OE}}$ | output enable input (active LOW) |
| 2   | Q0                     | 3-state flip-flop output         |
| 3   | D0                     | data input                       |
| 4   | D1                     | data input                       |
| 5   | Q1                     | 3-state flip-flop output         |
| 6   | Q2                     | 3-state flip-flop output         |
| 7   | D2                     | data input                       |
| 8   | D3                     | data input                       |
| 9   | Q3                     | 3-state flip-flop output         |
| 10  | GND                    | ground (0 V)                     |

| PIN | SYMBOL          | DESCRIPTION                               |
|-----|-----------------|-------------------------------------------|
| 11  | CP              | clock input (LOW-to-HIGH, edge-triggered) |
| 12  | Q4              | 3-state flip-flop output                  |
| 13  | D4              | data input                                |
| 14  | D5              | data input                                |
| 15  | Q5              | 3-state flip-flop output                  |
| 16  | Q6              | 3-state flip-flop output                  |
| 17  | D6              | data input                                |
| 18  | D7              | data input                                |
| 19  | Q7              | 3-state flip-flop output                  |
| 20  | V <sub>CC</sub> | supply voltage                            |

Octal D-type flip-flop with 5 V tolerant inputs/outputs;  
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74LVC374A



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74LVC374A

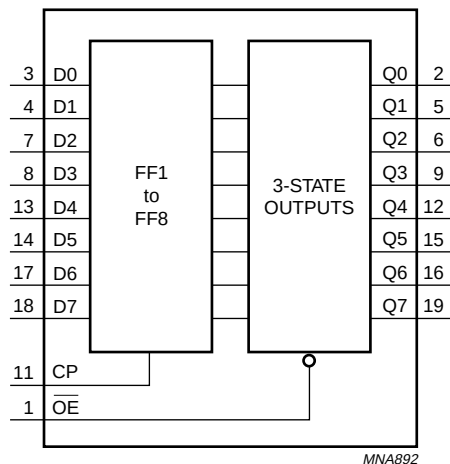


Fig.5 Functional diagram.

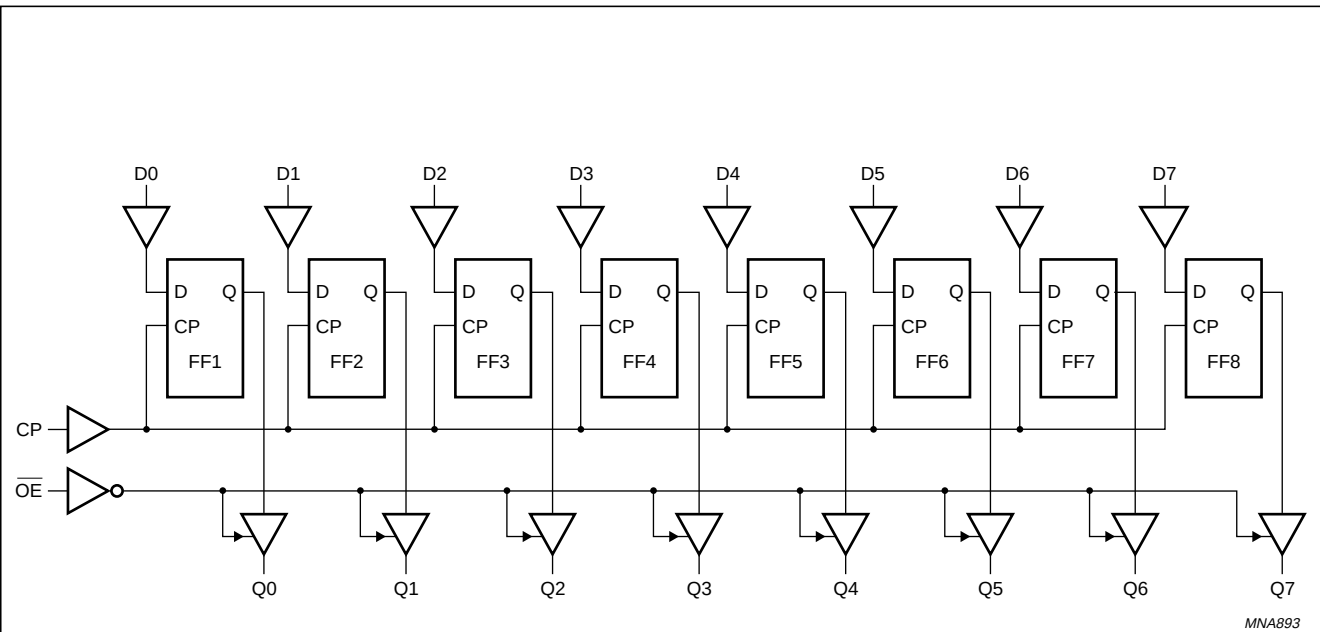


Fig.6 Logic diagram.

# Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger; 3-state

74LVC374A

## RECOMMENDED OPERATING CONDITIONS

| SYMBOL                          | PARAMETER                     | CONDITIONS                     | MIN. | MAX.            | UNIT |
|---------------------------------|-------------------------------|--------------------------------|------|-----------------|------|
| V <sub>CC</sub>                 | supply voltage                | for maximum speed performance  | 2.7  | 3.6             | V    |
|                                 |                               | for low-voltage applications   | 1.2  | 3.6             | V    |
| V <sub>I</sub>                  | input voltage                 |                                | 0    | 5.5             | V    |
| V <sub>O</sub>                  | output voltage                | output HIGH or LOW state       | 0    | V <sub>CC</sub> | V    |
|                                 |                               | output 3-state                 | 0    | 5.5             | V    |
| T <sub>amb</sub>                | operating ambient temperature | in free air                    | −40  | +125            | °C   |
| t <sub>r</sub> , t <sub>f</sub> | input rise and fall times     | V <sub>CC</sub> = 1.2 to 2.7 V | 0    | 20              | ns/V |
|                                 |                               | V <sub>CC</sub> = 2.7 to 3.6 V | 0    | 10              | ns/V |

## LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134); voltages are referenced to GND (ground = 0 V).

| SYMBOL                             | PARAMETER                      | CONDITIONS                                             | MIN. | MAX.                  | UNIT |
|------------------------------------|--------------------------------|--------------------------------------------------------|------|-----------------------|------|
| V <sub>CC</sub>                    | supply voltage                 |                                                        | −0.5 | +6.5                  | V    |
| I <sub>IK</sub>                    | input diode current            | V <sub>I</sub> < 0                                     | −    | −50                   | mA   |
| V <sub>I</sub>                     | input voltage                  | note 1                                                 | −0.5 | +6.5                  | V    |
| I <sub>OK</sub>                    | output diode current           | V <sub>O</sub> > V <sub>CC</sub> or V <sub>O</sub> < 0 | −    | ±50                   | mA   |
| V <sub>O</sub>                     | output voltage                 | output HIGH or LOW state; note 1                       | −0.5 | V <sub>CC</sub> + 0.5 | V    |
|                                    |                                | output 3-state; note 1                                 | −0.5 | +6.5                  | V    |
| I <sub>O</sub>                     | output source or sink current  | V <sub>O</sub> = 0 to V <sub>CC</sub>                  | −    | ±50                   | mA   |
| I <sub>CC</sub> , I <sub>GND</sub> | V <sub>CC</sub> or GND current |                                                        | −    | ±100                  | mA   |
| T <sub>stg</sub>                   | storage temperature            |                                                        | −65  | +150                  | °C   |
| P <sub>tot</sub>                   | power dissipation              | T <sub>amb</sub> = −40 to +125 °C; note 2              | −    | 500                   | mW   |

## Notes

- The input and output voltage ratings may be exceeded if the input and output current ratings are observed.
- For SO20 packages: above 70 °C derate linearly with 8 mW/K.  
For SSOP20 and TSSOP20 packages: above 60 °C derate linearly with 5.5 mW/K.  
For DHVQFN20 packages: above 60 °C derate linearly with 4.5 mW/K.

# Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger; 3-state

74LVC374A

## DC CHARACTERISTICS

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

| SYMBOL                                   | PARAMETER                                         | TEST CONDITIONS                                                                                                                                                  |                     | MIN.                  | TYP. | MAX. | UNIT |
|------------------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------|------|------|------|
|                                          |                                                   | OTHER                                                                                                                                                            | V <sub>CC</sub> (V) |                       |      |      |      |
| T <sub>amb</sub> = −40 to +85 °C; note 1 |                                                   |                                                                                                                                                                  |                     |                       |      |      |      |
| V <sub>IH</sub>                          | HIGH-level input voltage                          |                                                                                                                                                                  | 1.2                 | V <sub>CC</sub>       | −    | −    | V    |
|                                          |                                                   |                                                                                                                                                                  | 2.7 to 3.6          | 2.0                   | −    | −    | V    |
| V <sub>IL</sub>                          | LOW-level input voltage                           |                                                                                                                                                                  | 1.2                 | −                     | −    | GND  | V    |
|                                          |                                                   |                                                                                                                                                                  | 2.7 to 3.6          | −                     | −    | 0.8  | V    |
| V <sub>OH</sub>                          | HIGH-level output voltage                         | V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>I <sub>O</sub> = −100 μA<br>I <sub>O</sub> = −12 mA<br>I <sub>O</sub> = −18 mA<br>I <sub>O</sub> = −24 mA | 2.7 to 3.6          | V <sub>CC</sub> − 0.2 | −    | −    | V    |
|                                          |                                                   |                                                                                                                                                                  | 2.7                 | V <sub>CC</sub> − 0.5 | −    | −    | V    |
|                                          |                                                   |                                                                                                                                                                  | 3.0                 | V <sub>CC</sub> − 0.6 | −    | −    | V    |
|                                          |                                                   |                                                                                                                                                                  | 3.0                 | V <sub>CC</sub> − 0.8 | −    | −    | V    |
| V <sub>OL</sub>                          | LOW-level output voltage                          | V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>I <sub>O</sub> = 100 μA<br>I <sub>O</sub> = 12 mA<br>I <sub>O</sub> = 24 mA                               | 2.7 to 3.6          | −                     | −    | 0.20 | V    |
|                                          |                                                   |                                                                                                                                                                  | 2.7                 | −                     | −    | 0.40 | V    |
|                                          |                                                   |                                                                                                                                                                  | 3.0                 | −                     | −    | 0.55 | V    |
| I <sub>LI</sub>                          | input leakage current                             | V <sub>I</sub> = 5.5 V or GND                                                                                                                                    | 3.6                 | −                     | ±0.1 | ±5   | μA   |
| I <sub>OZ</sub>                          | 3-state output OFF-state current                  | V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> ;<br>V <sub>O</sub> = 5.5 V or GND                                                                           | 3.6                 | −                     | ±0.1 | ±5   | μA   |
| I <sub>off</sub>                         | power-off leakage supply                          | V <sub>I</sub> or V <sub>O</sub> = 5.5 V                                                                                                                         | 0.0                 | −                     | ±0.1 | ±10  | μA   |
| I <sub>CC</sub>                          | quiescent supply current                          | V <sub>I</sub> = V <sub>CC</sub> or GND;<br>I <sub>O</sub> = 0                                                                                                   | 3.6                 | −                     | 0.1  | 10   | μA   |
| ΔI <sub>CC</sub>                         | additional quiescent supply current per input pin | V <sub>I</sub> = V <sub>CC</sub> − 0.6 V;<br>I <sub>O</sub> = 0                                                                                                  | 2.7 to 3.6          | −                     | 5    | 500  | μA   |

# Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger; 3-state

74LVC374A

| SYMBOL                            | PARAMETER                                         | TEST CONDITIONS                                                                                                                                                  |                     | MIN.                   | TYP. | MAX. | UNIT |
|-----------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------|------|------|------|
|                                   |                                                   | OTHER                                                                                                                                                            | V <sub>CC</sub> (V) |                        |      |      |      |
| T <sub>amb</sub> = −40 to +125 °C |                                                   |                                                                                                                                                                  |                     |                        |      |      |      |
| V <sub>IH</sub>                   | HIGH-level input voltage                          |                                                                                                                                                                  | 1.2                 | V <sub>CC</sub>        | −    | −    | V    |
|                                   |                                                   |                                                                                                                                                                  | 2.7 to 3.6          | 2.0                    | −    | −    | V    |
| V <sub>IL</sub>                   | LOW-level input voltage                           |                                                                                                                                                                  | 1.2                 | −                      | −    | GND  | V    |
|                                   |                                                   |                                                                                                                                                                  | 2.7 to 3.6          | −                      | −    | 0.8  | V    |
| V <sub>OH</sub>                   | HIGH-level output voltage                         | V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>I <sub>O</sub> = −100 μA<br>I <sub>O</sub> = −12 mA<br>I <sub>O</sub> = −18 mA<br>I <sub>O</sub> = −24 mA | 2.7 to 3.6          | V <sub>CC</sub> − 0.3  | −    | −    | V    |
|                                   |                                                   |                                                                                                                                                                  | 2.7                 | V <sub>CC</sub> − 0.65 | −    | −    | V    |
|                                   |                                                   |                                                                                                                                                                  | 3.0                 | V <sub>CC</sub> − 0.75 | −    | −    | V    |
|                                   |                                                   |                                                                                                                                                                  | 3.0                 | V <sub>CC</sub> − 1    | −    | −    | V    |
| V <sub>OL</sub>                   | LOW-level output voltage                          | V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>I <sub>O</sub> = 100 μA<br>I <sub>O</sub> = 12 mA<br>I <sub>O</sub> = 24 mA                               | 2.7 to 3.6          | −                      | −    | 0.3  | V    |
|                                   |                                                   |                                                                                                                                                                  | 2.7                 | −                      | −    | 0.6  | V    |
|                                   |                                                   |                                                                                                                                                                  | 3.0                 | −                      | −    | 0.8  | V    |
| I <sub>LI</sub>                   | input leakage current                             | V <sub>I</sub> = 5.5 V or GND                                                                                                                                    | 3.6                 | −                      | −    | ±20  | μA   |
| I <sub>OZ</sub>                   | 3-state output OFF-state current                  | V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> ;<br>V <sub>O</sub> = 5.5 V or GND                                                                           | 3.6                 | −                      | −    | ±20  | μA   |
| I <sub>off</sub>                  | power-off leakage supply                          | V <sub>I</sub> or V <sub>O</sub> = 5.5 V                                                                                                                         | 0.0                 | −                      | −    | ±20  | μA   |
| I <sub>CC</sub>                   | quiescent supply current                          | V <sub>I</sub> = V <sub>CC</sub> or GND;<br>I <sub>O</sub> = 0                                                                                                   | 3.6                 | −                      | −    | 40   | μA   |
| ΔI <sub>CC</sub>                  | additional quiescent supply current per input pin | V <sub>I</sub> = V <sub>CC</sub> − 0.6 V;<br>I <sub>O</sub> = 0                                                                                                  | 2.7 to 3.6          | −                      | −    | 5000 | μA   |

**Note**

1. All typical values are measured at V<sub>CC</sub> = 3.3 V and T<sub>amb</sub> = 25 °C.



# Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger; 3-state

74LVC374A

## AC CHARACTERISTICS

GND = 0 V;  $t_r = t_f \leq 2.5$  ns;  $C_L = 50$  pF;  $R_L = 500 \Omega$ .

| SYMBOL                                  | PARAMETER                               | TEST CONDITIONS |                     | MIN. | TYP. | MAX. | UNIT |
|-----------------------------------------|-----------------------------------------|-----------------|---------------------|------|------|------|------|
|                                         |                                         | WAVEFORM        | V <sub>CC</sub> (V) |      |      |      |      |
| T <sub>amb</sub> = −40 to +85 °C; note1 |                                         |                 |                     |      |      |      |      |
| t <sub>PHL</sub> /t <sub>PLH</sub>      | propagation delay CP to Qn              | Figs 7 and 10   | 1.2                 | –    | 16   | –    | ns   |
|                                         |                                         |                 | 2.7                 | 1.5  | 2.9  | 8.0  | ns   |
|                                         |                                         |                 | 3.0 to 3.6          | 1.5  | 2.7  | 7.0  | ns   |
| t <sub>PZH</sub> /t <sub>PZL</sub>      | 3-state output enable time<br>OE to Qn  | Figs 8 and 10   | 1.2                 | –    | 19   | –    | ns   |
|                                         |                                         |                 | 2.7                 | 1.5  | 4.1  | 8.5  | ns   |
|                                         |                                         |                 | 3.0 to 3.6          | 1.5  | 3.4  | 7.5  | ns   |
| t <sub>PHZ</sub> /t <sub>PLZ</sub>      | 3-state output disable time<br>OE to Qn | Figs 8 and 10   | 1.2                 | –    | 8.0  | –    | ns   |
|                                         |                                         |                 | 2.7                 | 1.5  | 2.7  | 7.0  | ns   |
|                                         |                                         |                 | 3.0 to 3.6          | 1.5  | 2.4  | 6.0  | ns   |
| t <sub>w</sub>                          | clock pulse width HIGH or LOW           | Fig.7           | 1.2                 | –    | –    | –    | ns   |
|                                         |                                         |                 | 2.7                 | 3.0  | –    | –    | ns   |
|                                         |                                         |                 | 3.0 to 3.6          | 3.0  | 1.5  | –    | ns   |
| t <sub>su</sub>                         | set-up time Dn to CP                    | Fig.9           | 1.2                 | –    | –    | –    | ns   |
|                                         |                                         |                 | 2.7                 | 2.0  | –    | –    | ns   |
|                                         |                                         |                 | 3.0 to 3.6          | 2.0  | 0    | –    | ns   |
| t <sub>h</sub>                          | hold time Dn to CP                      | Fig.9           | 1.2                 | –    | –    | –    | ns   |
|                                         |                                         |                 | 2.7                 | 1.5  | –    | –    | ns   |
|                                         |                                         |                 | 3.0 to 3.6          | 1.5  | 0.6  | –    | ns   |
| f <sub>max</sub>                        | maximum clock frequency                 | Fig.7           | 1.2                 | –    | –    | –    | MHz  |
|                                         |                                         |                 | 2.7                 | 80   | –    | –    | MHz  |
|                                         |                                         |                 | 3.0 to 3.6          | 100  | –    | –    | MHz  |
| t <sub>sk(0)</sub>                      | skew                                    | note 2          | 3.0 to 3.6          | –    | –    | 1.0  | ns   |

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74LVC374A

| SYMBOL                             | PARAMETER                               | TEST CONDITIONS |                     | MIN. | TYP. | MAX. | UNIT |
|------------------------------------|-----------------------------------------|-----------------|---------------------|------|------|------|------|
|                                    |                                         | WAVEFORM        | V <sub>CC</sub> (V) |      |      |      |      |
| T <sub>amb</sub> = −40 to +125 °C  |                                         |                 |                     |      |      |      |      |
| t <sub>PHL</sub> /t <sub>PLH</sub> | propagation delay CP to Qn              | Figs 7 and 10   | 1.2                 | –    | –    | –    | ns   |
|                                    |                                         |                 | 2.7                 | 1.5  | –    | 10.0 | ns   |
|                                    |                                         |                 | 3.0 to 3.6          | 1.5  | –    | 9.0  | ns   |
| t <sub>PZH</sub> /t <sub>PZL</sub> | 3-state output enable time<br>OE to Qn  | Figs 8 and 10   | 1.2                 | –    | –    | –    | ns   |
|                                    |                                         |                 | 2.7                 | 1.5  | –    | 11.0 | ns   |
|                                    |                                         |                 | 3.0 to 3.6          | 1.5  | –    | 9.5  | ns   |
| t <sub>PHZ</sub> /t <sub>PLZ</sub> | 3-state output disable time<br>OE to Qn | Figs 8 and 10   | 1.2                 | –    | –    | –    | ns   |
|                                    |                                         |                 | 2.7                 | 1.5  | –    | 9.0  | ns   |
|                                    |                                         |                 | 3.0 to 3.6          | 1.5  | –    | 7.5  | ns   |
| t <sub>w</sub>                     | clock pulse width HIGH or LOW           | Fig.7           | 1.2                 | –    | –    | –    | ns   |
|                                    |                                         |                 | 2.7                 | 4.5  | –    | –    | ns   |
|                                    |                                         |                 | 3.0 to 3.6          | 4.5  | –    | –    | ns   |
| t <sub>su</sub>                    | set-up time Dn to CP                    | Fig.9           | 1.2                 | –    | –    | –    | ns   |
|                                    |                                         |                 | 2.7                 | 2.0  | –    | –    | ns   |
|                                    |                                         |                 | 3.0 to 3.6          | 2.0  | –    | –    | ns   |
| t <sub>h</sub>                     | hold time Dn to CP                      | Fig.9           | 1.2                 | –    | –    | –    | ns   |
|                                    |                                         |                 | 2.7                 | 1.5  | –    | –    | ns   |
|                                    |                                         |                 | 3.0 to 3.6          | 1.5  | –    | –    | ns   |
| f <sub>max</sub>                   | maximum clock frequency                 | Fig.7           | 1.2                 | –    | –    | –    | MHz  |
|                                    |                                         |                 | 2.7                 | 64   | –    | –    | MHz  |
|                                    |                                         |                 | 3.0 to 3.6          | 80   | –    | –    | MHz  |
| t <sub>sk(0)</sub>                 | skew                                    | note 2          | 3.0 to 3.6          | –    | –    | 1.5  | ns   |

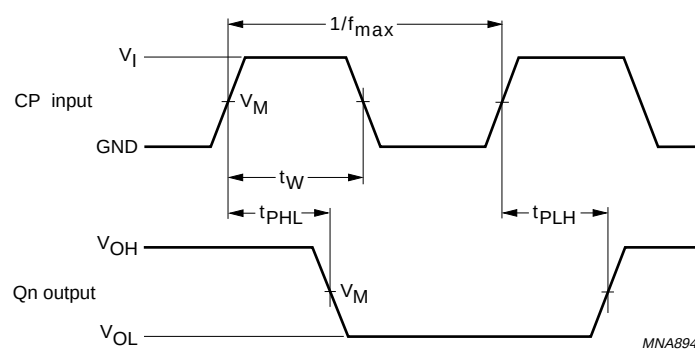
## Notes

1. All typical values are measured at V<sub>CC</sub> = 3.3 V and T<sub>amb</sub> = 25 °C.
2. Skew between any two outputs of the same package switching in the same direction. This parameter is guaranteed by design.

# Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger; 3-state

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## AC WAVEFORMS



$V_M = 1.5 \text{ V}$  at  $V_{CC} \geq 2.7 \text{ V}$ .

$V_M = 0.5V_{CC}$  at  $V_{CC} < 2.7 \text{ V}$ .

$V_{OL}$  and  $V_{OH}$  are the typical output voltage drop that occur with the output load.

Fig.7 Clock (CP) to output (Qn) propagation delays, the clock pulse width, output transition times and the maximum clock pulse frequency.

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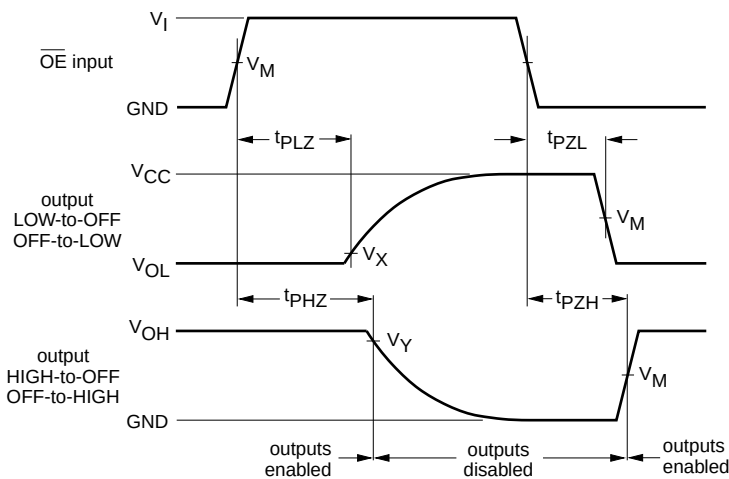
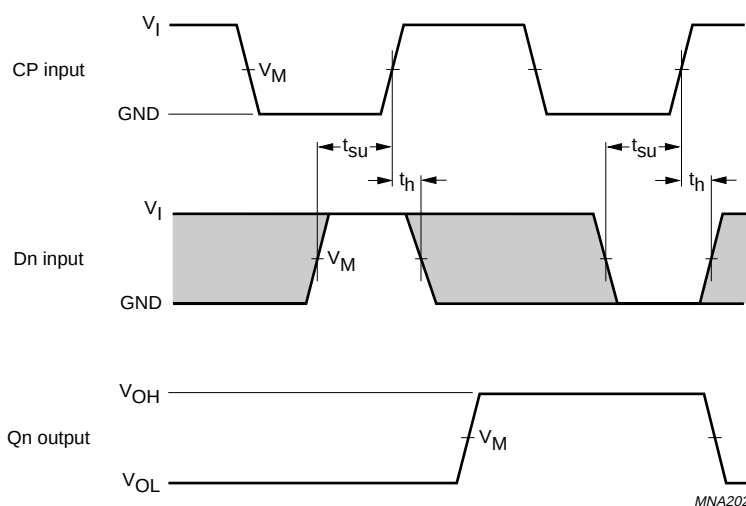

 $V_M = 1.5 \text{ V at } V_{CC} \geq 2.7 \text{ V};$ 
 $V_M = 0.5V_{CC} \text{ at } V_{CC} < 2.7 \text{ V};$ 
 $V_X = V_{OL} + 0.3 \text{ V at } V_{CC} \geq 2.7 \text{ V};$ 
 $V_X = V_{OL} + 0.1 V_{CC} \text{ at } V_{CC} < 2.7 \text{ V};$ 
 $V_Y = V_{OH} - 0.3 \text{ V at } V_{CC} \geq 2.7 \text{ V};$ 
 $V_Y = V_{OH} - 0.1 V_{CC} \text{ at } V_{CC} < 2.7 \text{ V}.$ 
 $V_{OL}$  and  $V_{OH}$  are the typical output voltage drop that occur with the output load.

Fig.8 3-state enable and disable times.

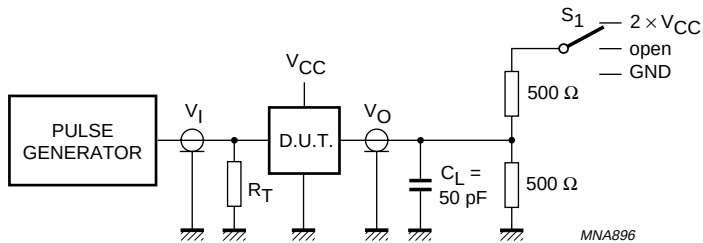

 $V_M = 1.5 \text{ V at } V_{CC} \geq 2.7 \text{ V};$ 
 $V_M = 0.5V_{CC} \text{ at } V_{CC} < 2.7 \text{ V};$ 
 $V_{OL}$  and  $V_{OH}$  are the typical output voltage drop that occur with the output load.

The shaded areas indicate when the input is permitted to change for predictable output performance.

Fig.9 Data setup and hold times for the Dn input to the CP input.

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| SWITCH POSITION                    |                     |
|------------------------------------|---------------------|
| TEST                               | S <sub>1</sub>      |
| t <sub>PLH</sub> /t <sub>PHL</sub> | open                |
| t <sub>PLZ</sub> /t <sub>PZL</sub> | 2 × V <sub>CC</sub> |
| t <sub>PHZ</sub> /t <sub>PZH</sub> | GND                 |

| V <sub>CC</sub> | V <sub>I</sub>  |
|-----------------|-----------------|
| < 2.7 V         | V <sub>CC</sub> |
| 2.7 to 3.6 V    | 2.7 V           |

Definitions for test circuit:  
R<sub>L</sub> = Load resistor.  
C<sub>L</sub> = Load capacitance including jig and probe capacitance.  
R<sub>T</sub> = Termination resistance should be equal to the output impedance Z<sub>o</sub> of the pulse generator.

Fig.10 Load circuitry for switching times.

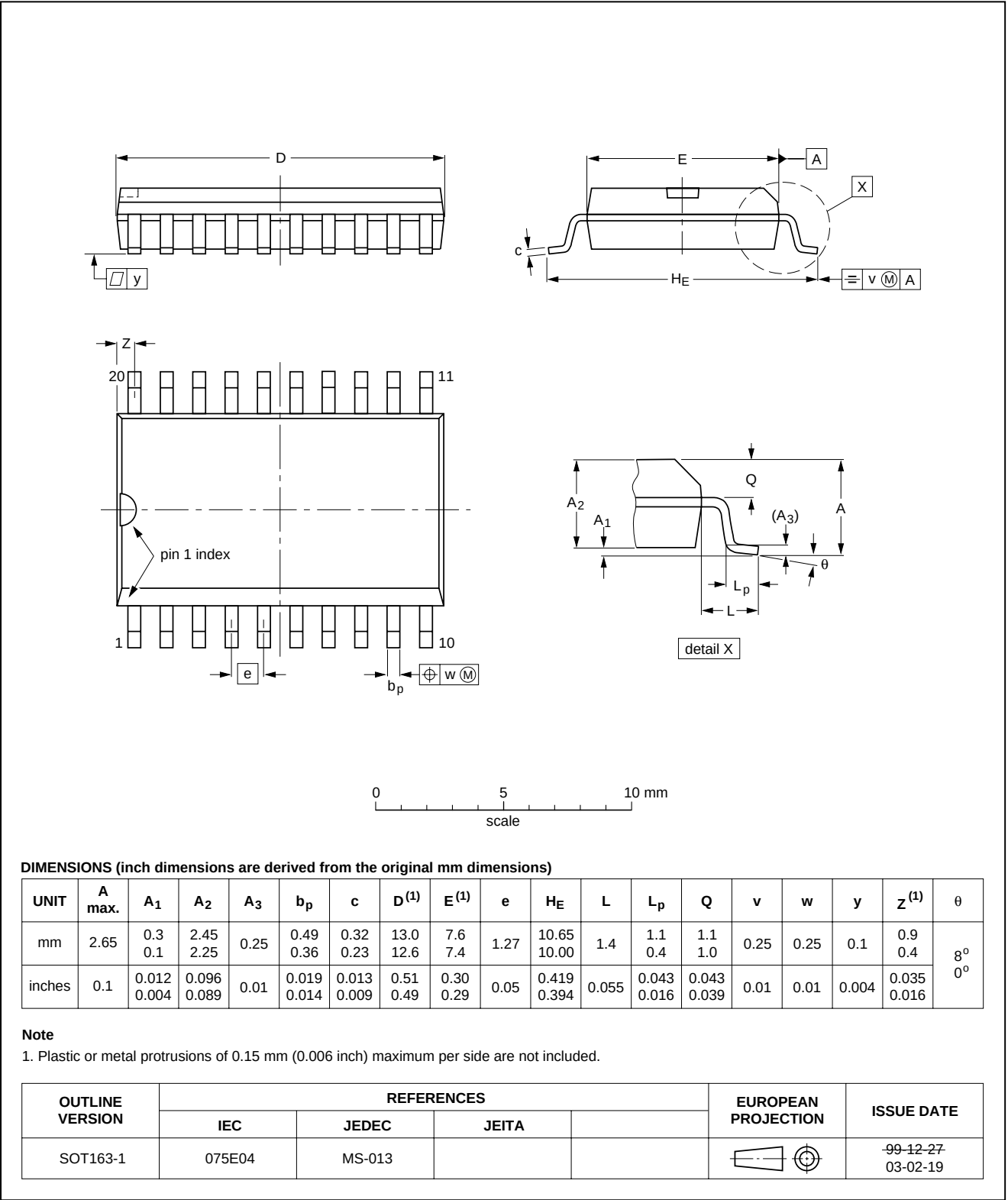
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PACKAGE OUTLINES

SO20: plastic small outline package; 20 leads; body width 7.5 mm

SOT163-1

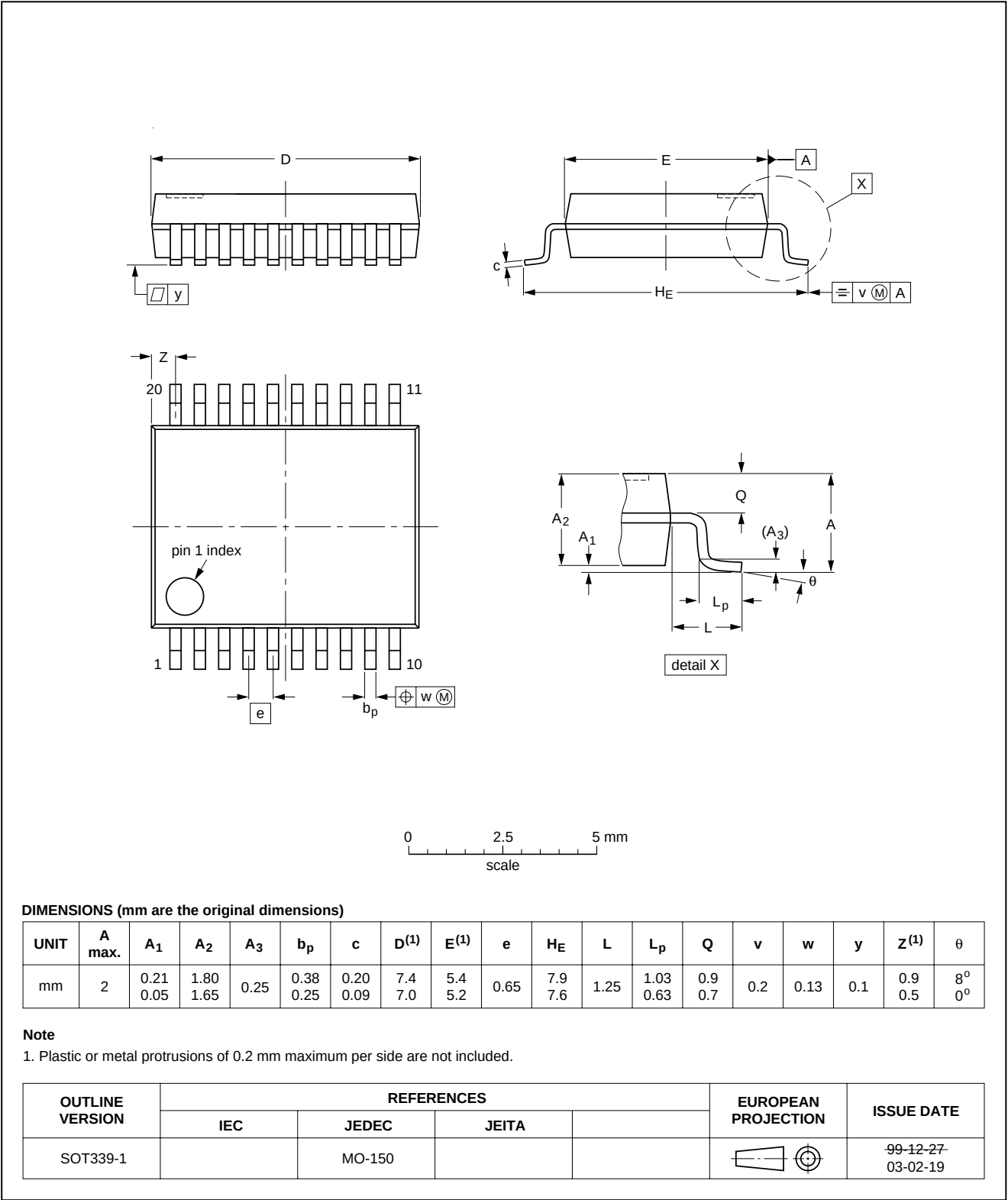


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SSOP20: plastic shrink small outline package; 20 leads; body width 5.3 mm

SOT339-1

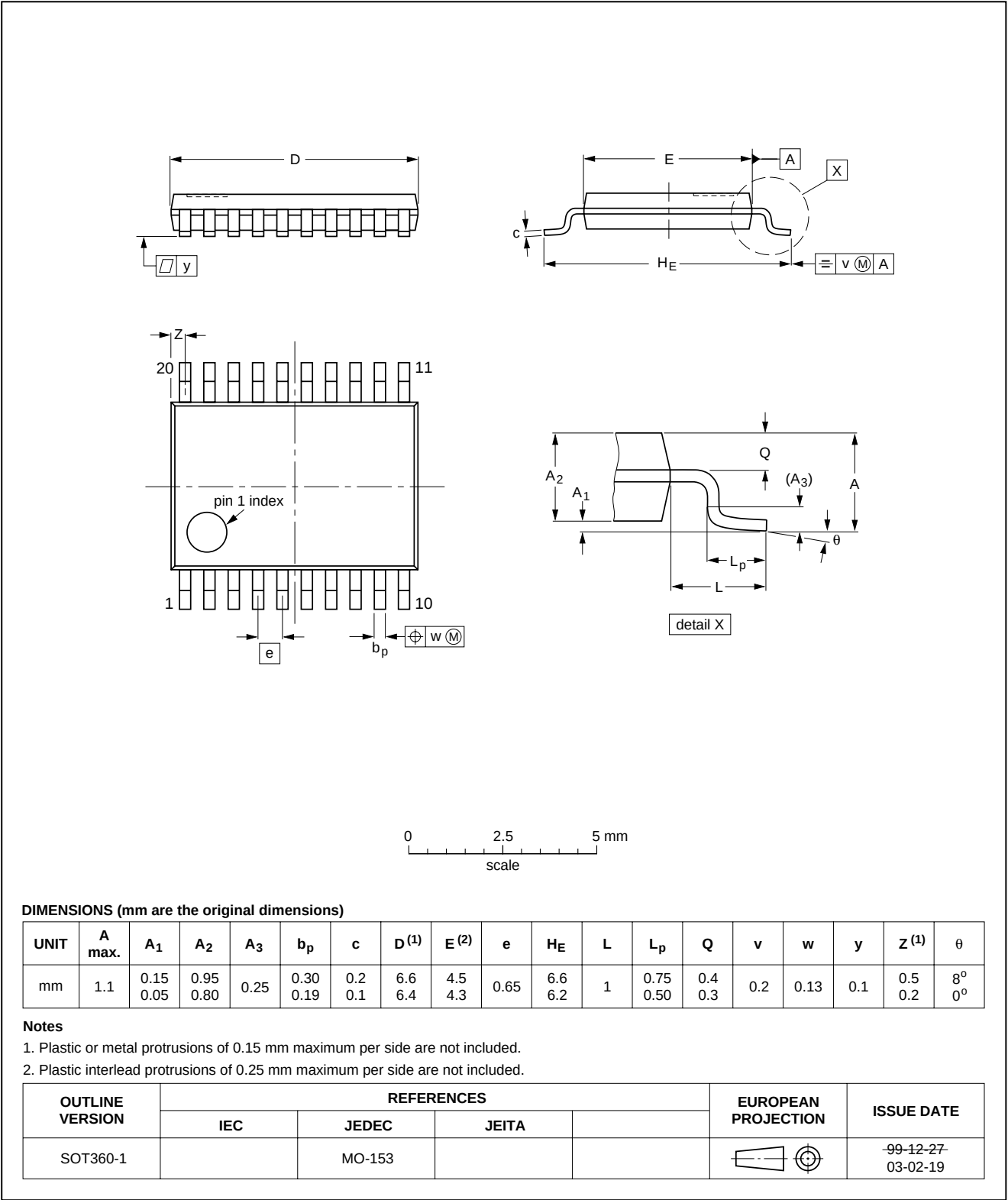


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TSSOP20: plastic thin shrink small outline package; 20 leads; body width 4.4 mm

SOT360-1



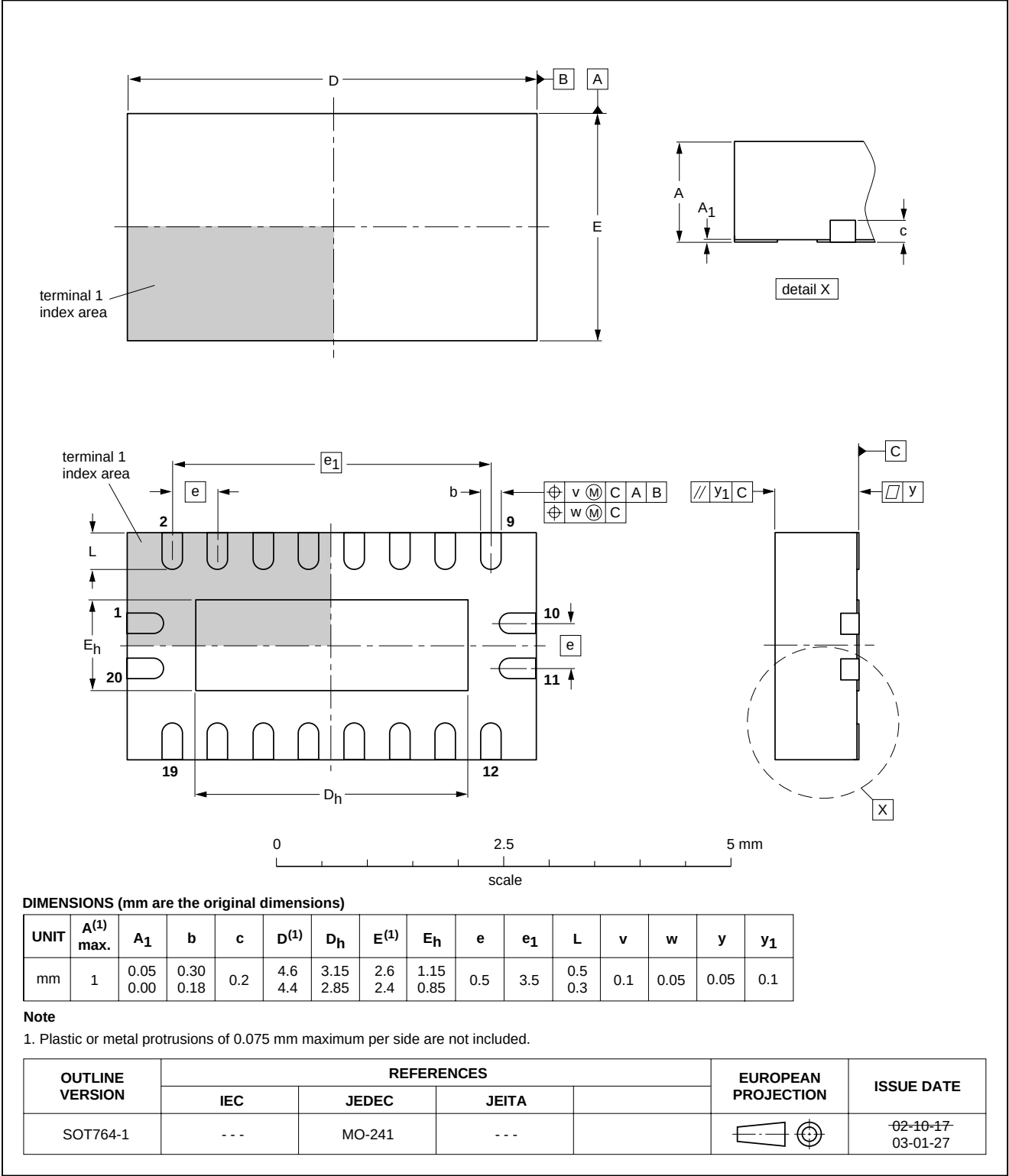


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DHVQFN20: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads;  
20 terminals; body 2.5 x 4.5 x 0.85 mm

SOT764-1



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### SOLDERING

#### Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering can still be used for certain surface mount ICs, but it is not suitable for fine pitch SMDs. In these situations reflow soldering is recommended.

#### Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several methods exist for reflowing; for example, convection or convection/infrared heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 250 °C. The top-surface temperature of the packages should preferably be kept:

- below 220 °C for all the BGA packages and packages with a thickness  $\geq 2.5$  mm and packages with a thickness  $< 2.5$  mm and a volume  $\geq 350$  mm<sup>3</sup> so called thick/large packages
- below 235 °C for packages with a thickness  $< 2.5$  mm and a volume  $< 350$  mm<sup>3</sup> so called small/thin packages.

#### Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
  - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
  - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

#### Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

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## Suitability of surface mount IC packages for wave and reflow soldering methods

| PACKAGE <sup>(1)</sup>                                                   | SOLDERING METHOD                  |                       |
|--------------------------------------------------------------------------|-----------------------------------|-----------------------|
|                                                                          | WAVE                              | REFLOW <sup>(2)</sup> |
| BGA, LBGA, LFBGA, SQFP, TFBGA, VFBGA                                     | not suitable                      | suitable              |
| DHVQFN, HBCC, HBGA, HLQFP, HSQFP, HSOP, HTQFP, HTSSOP, HVQFN, HVSON, SMS | not suitable <sup>(3)</sup>       | suitable              |
| PLCC <sup>(4)</sup> , SO, SOJ                                            | suitable                          | suitable              |
| LQFP, QFP, TQFP                                                          | not recommended <sup>(4)(5)</sup> | suitable              |
| SSOP, TSSOP, VSO, VSSOP                                                  | not recommended <sup>(6)</sup>    | suitable              |

### Notes

1. For more detailed information on the BGA packages refer to the “(LF)BGA Application Note” (AN01026); order a copy from your Philips Semiconductors sales office.
2. All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the “Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods”.
3. These packages are not suitable for wave soldering. On versions with the heatsink on the bottom side, the solder cannot penetrate between the printed-circuit board and the heatsink. On versions with the heatsink on the top side, the solder might be deposited on the heatsink surface.
4. If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
5. Wave soldering is suitable for LQFP, TQFP and QFP packages with a pitch (e) larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
6. Wave soldering is suitable for SSOP, TSSOP, VSO and VSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

# Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger; 3-state

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## DATA SHEET STATUS

| LEVEL | DATA SHEET STATUS <sup>(1)</sup> | PRODUCT STATUS <sup>(2)(3)</sup> | DEFINITION                                                                                                                                                                                                                                                                                     |
|-------|----------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I     | Objective data                   | Development                      | This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.                                                                                                    |
| II    | Preliminary data                 | Qualification                    | This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.             |
| III   | Product data                     | Production                       | This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN). |

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2. The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.
3. For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

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**Short-form specification** — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

**Limiting values definition** — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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**NOTES**

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