

# DATA SHEET

**74F166**

8-bit bidirectional universal shift register

Product specification

1991 Feb 14

IC15 Data Handbook

## 8-bit bidirectional universal shift register

74F166

## FEATURES

- High impedance NPN base inputs for reduced loading (20 $\mu$ A in high and low states)
- Synchronous parallel to serial applications
- Synchronous serial data input for easy expansion
- Clock enable for "do nothing" mode
- Asynchronous master reset
- Expandable to 16 bits in 8-bit increments
- Industrial temperature range available (-40°C to +85°C)

## DESCRIPTION

The 74F166 is a high speed 8-bit shift register that has fully synchronous serial parallel data entry selected by an active low parallel enable ( $\overline{PE}$ ) input. When the  $\overline{PE}$  is low one setup time before the low-to-high clock transition, parallel data is entered into the register.

When  $\overline{PE}$  is high, data is entered into internal bit position Q0 from serial data input (Ds), and the remaining bits are shifted one place to the right (Q0  $\rightarrow$  Q1  $\rightarrow$  Q2, etc.) with each positive going clock transition.

For expansion of the register in parallel to serial converters, the Q7 output is connected to the Ds input of the succeeding stage. The clock input is gated OR structure which allows one input to be used as an active-low clock enable ( $\overline{CE}$ ) input. The pin assignment for the CP and  $\overline{CE}$  inputs is arbitrary and can be reversed for layout convenience. The low-to-high transition of  $\overline{CE}$  input should only take place while the CP is high for predictable operation. A low on the master reset ( $\overline{MR}$ ) input overrides all other inputs and clears the register asynchronously, forcing all bit positions to a low state.

| TYPE   | TYPICAL $f_{max}$ | TYPICAL SUPPLY CURRENT( TOTAL) |
|--------|-------------------|--------------------------------|
| 74F166 | 175MHz            | 50mA                           |

## ORDERING INFORMATION

| DESCRIPTION        | ORDER CODE   |  | PKG DWG # |
|--------------------|--|--|-----------|
|                    | COMMERCIAL RANGE<br>$V_{CC} = 5V \pm 10\%$ ,<br>$T_{amb} = 0^{\circ}C$ to $+70^{\circ}C$ | INDUSTRIAL RANGE<br>$V_{CC} = 5V \pm 10\%$ ,<br>$T_{amb} = -40^{\circ}C$ to $+85^{\circ}C$ |           |
| 16-pin plastic DIP | N74F166N   | I74F166N   | SOT38-4   |
| 16-pin plastic SO  | N74F166D   | I74F166D   | SOT109-1  |

## INPUT AND OUTPUT LOADING AND FAN OUT TABLE

| PINS            | DESCRIPTION                        | 74F (U.L.) HIGH/LOW | LOAD VALUE HIGH/LOW   |
|-----------------|------------------------------------|---------------------|-----------------------|
| D0 – D7         | Parallel data inputs               | 1.0/0.033           | 20 $\mu$ A/20 $\mu$ A |
| Ds              | Serial data input (shift right)    | 2.0/0.066           | 40 $\mu$ A/40 $\mu$ A |
| CP              | Clock input (active rising edge)   | 1.0/0.033           | 20 $\mu$ A/20 $\mu$ A |
| $\overline{CE}$ | Clock enable input (active low)    | 1.0/0.033           | 20 $\mu$ A/20 $\mu$ A |
| $\overline{PE}$ | Parallel enable input (active low) | 1.0/0.033           | 20 $\mu$ A/20 $\mu$ A |
| $\overline{MR}$ | Master reset input (active low)    | 2.0/0.066           | 40 $\mu$ A/40 $\mu$ A |
| Q7              | Data output                        | 50/33               | 1.0mA/20mA            |

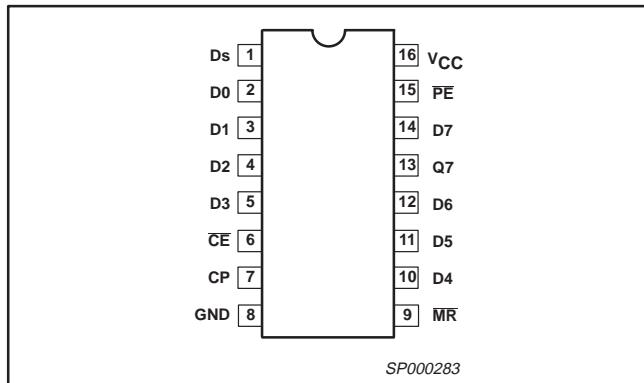
## Note to input and output loading and fan out table

1. One (1.0) FAST unit load is defined as: 20 $\mu$ A in the high state and 0.6mA in the low state.

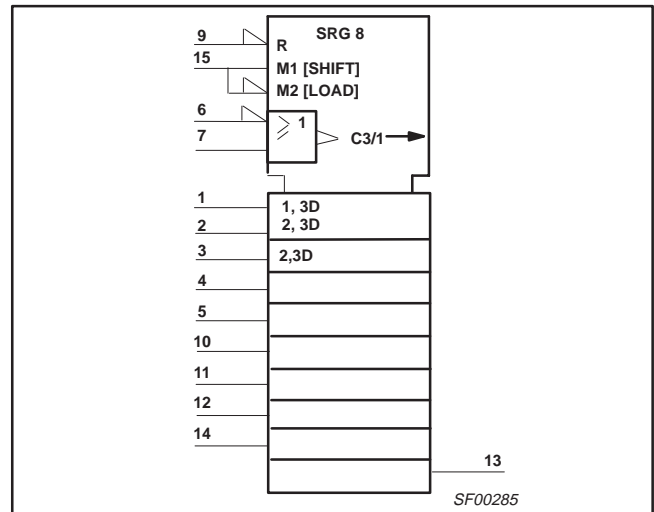
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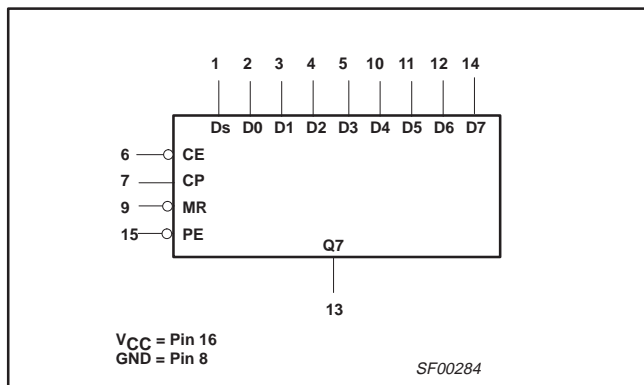
## PIN CONFIGURATION



## IEC/IEEE SYMBOL



## LOGIC SYMBOL



## FUNCTION TABLE

| INPUTS |    |    |    |         | Qn REGISTER |         | OUTPUT | OPERATING MODE    |
|--------|----|----|----|---------|-------------|---------|--------|-------------------|
| PE     | CE | CP | DS | D0 - D7 | Q0          | Q1 - Q6 | Q7     |                   |
| l      | l  | ↑  | X  | l - l   | L           | L - L   | L      | Parallel load     |
| l      | l  | ↑  | X  | h - h   | H           | H - H   | H      |                   |
| h      | l  | ↑  | l  | X - X   | L           | q0 - q5 | q6     | Serial shift      |
| h      | l  | ↑  | h  | X - X   | H           | q0 - q5 | q6     |                   |
| X      | h  | X  | X  | X - X   | qn          | q1 - q6 | q7     | Hold (do nothing) |

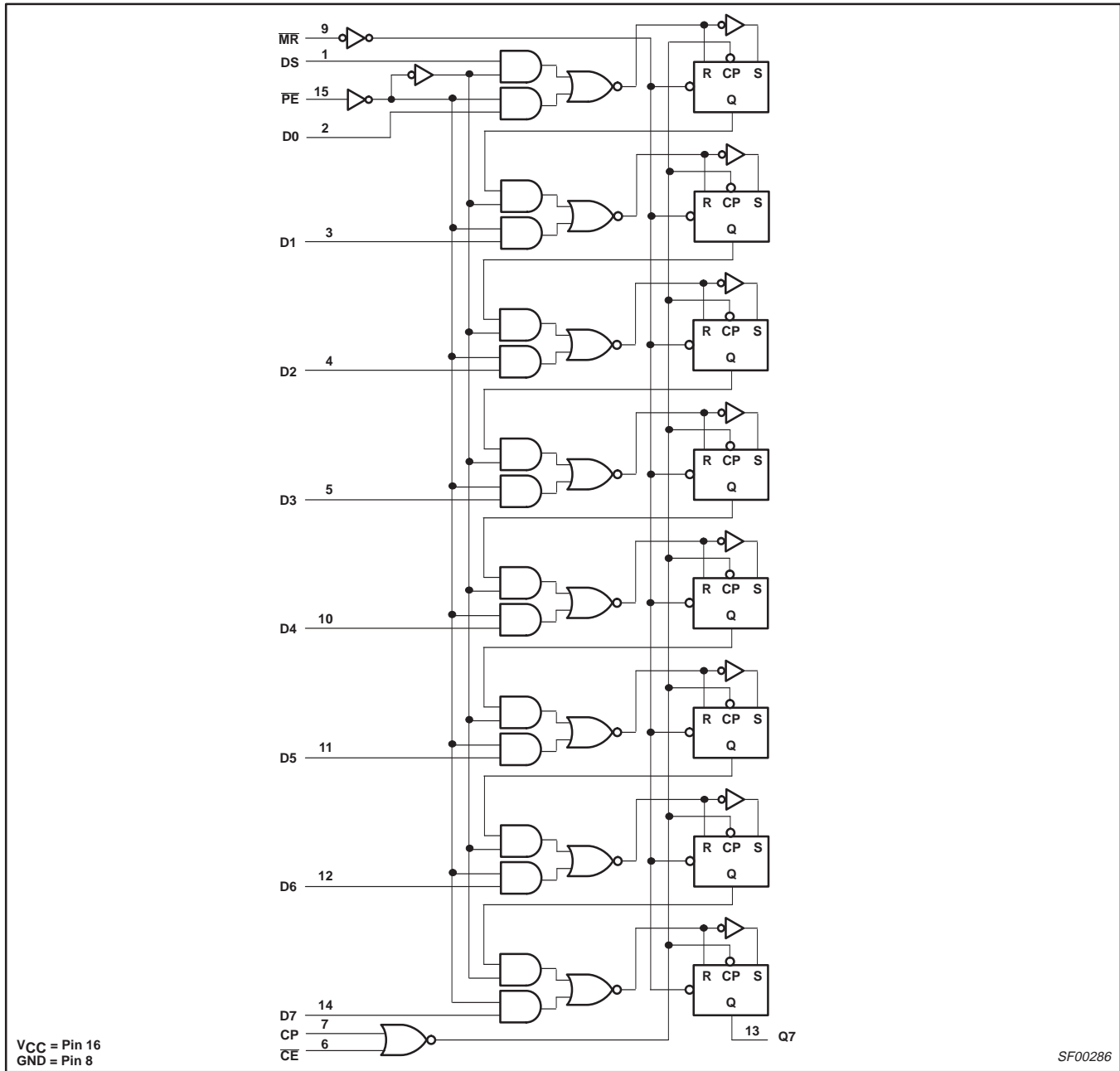
### Notes to function table

1. H = High-voltage level
2. h = High voltage level one setup time before the low-to-high clock transition
3. L = Low-voltage level
4. l = Low voltage level one setup time before the low-to-high clock transition
5. qn = Lower case letters indicate the state of the referenced input (or output) one setup time prior to the low-to-high clock transition
6. X = Don't care
7. ↑ = Low-to-high clock transition

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## LOGIC DIAGRAM



## 8-bit bidirectional universal shift register

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**ABSOLUTE MAXIMUM RATINGS**

(Operation beyond the limit set forth in this table may impair the useful life of the device. Unless otherwise noted these limits are over the operating free air temperature range.)

| SYMBOL           | PARAMETER                                      | RATING                  | UNIT       |    |
|------------------|--|-------------------------|------------|----|
| V <sub>CC</sub>  | Supply voltage                                 | -0.5 to +7.0            | V          |    |
| V <sub>IN</sub>  | Input voltage                                  | -0.5 to +7.0            | V          |    |
| I <sub>IN</sub>  | Input current                                  | -30 to +5               | mA         |    |
| V <sub>OUT</sub> | Voltage applied to output in high output state | -0.5 to V <sub>CC</sub> | V          |    |
| I <sub>OUT</sub> | Current applied to output in low output state  | 40                      | mA         |    |
| T <sub>amb</sub> | Operating free air temperature range           | Commercial range        | 0 to +70   | °C |
|                  |  | Industrial range        | -40 to +85 | °C |
| T <sub>stg</sub> | Storage temperature range                      | -65 to +150             | °C         |    |

**RECOMMENDED OPERATING CONDITIONS**

| SYMBOL           | PARAMETER                            | LIMITS           |     |     | UNIT |    |
|------------------|--------------------------------------|------------------|-----|-----|------|----|
|                  |                                      | MIN              | NOM | MAX |      |    |
| V <sub>CC</sub>  | Supply voltage                       | 4.5              | 5.0 | 5.5 | V    |    |
| V <sub>IN</sub>  | High-level input voltage             | 2.0              |     |     | V    |    |
| V <sub>IL</sub>  | Low-level input voltage              |                  |     | 0.8 | V    |    |
| I <sub>Ik</sub>  | Input clamp current                  |                  |     | -18 | mA   |    |
| I <sub>OH</sub>  | High-level output current            |                  |     | -1  | mA   |    |
| I <sub>OL</sub>  | Low-level output current             |                  |     | 20  | mA   |    |
| T <sub>amb</sub> | Operating free air temperature range | Commercial range | 0   |     | +70  | °C |
|                  |                                      | Industrial range | -40 |     | +85  | °C |

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**DC ELECTRICAL CHARACTERISTICS**

(Over recommended operating free-air temperature range unless otherwise noted.)

| SYMBOL          | PARAMETER                                 |                               | TEST CONDITIONS <sup>1</sup>   |                       | LIMITS              |                  |      | UNIT |    |
|-----------------|---|-------------------------------|--|-----------------------|---------------------|------------------|------|------|----|
|                 |   |                               |  |                       | MIN                 | TYP <sup>2</sup> | MAX  |      |    |
| V <sub>OH</sub> | High-level output voltage                 |                               | V <sub>CC</sub> = MIN, V <sub>IL</sub> = MAX,<br>V <sub>IH</sub> = MIN | I <sub>OH</sub> = MAX | ±10%V <sub>CC</sub> | 2.5              |      |      | V  |
|                 |   |                               |  |                       | ±5%V <sub>CC</sub>  | 2.7              | 3.4  |      | V  |
| V <sub>OL</sub> | Low-level output voltage                  |                               | V <sub>CC</sub> = MIN, V <sub>IL</sub> = MAX,<br>V <sub>IH</sub> = MIN | I <sub>OL</sub> = MAX | ±10%V <sub>CC</sub> |                  | 0.30 | 0.50 | V  |
|                 |   |                               |  |                       | ±5%V <sub>CC</sub>  |                  | 0.30 | 0.50 | V  |
| V <sub>IK</sub> | Input clamp voltage                       |                               | V <sub>CC</sub> = MIN, I <sub>I</sub> = I <sub>IK</sub>                |                       |                     | -0.73            | -1.2 | V    |    |
| I <sub>I</sub>  | Input current at maximum input voltage    | others<br>CE, CP <sup>3</sup> | V <sub>CC</sub> = 0.0V, V <sub>I</sub> = 7.0V                          |                       |                     |                  | 100  | μA   |    |
| I <sub>IH</sub> | High-level input current                  | others                        | V <sub>CC</sub> = MAX, V <sub>I</sub> = 2.7V                           |                       |                     |                  | 20   | μA   |    |
|                 |   | MR, Ds                        |  |                       |                     |                  | 40   | μA   |    |
|                 |   | Industrial only               |  |                       | others              |                  |      | 40   | μA |
|                 |   |                               |  |                       | MR, Ds              |                  |      | 80   | μA |
| I <sub>IL</sub> | Low-level input current                   | others                        | V <sub>CC</sub> = MAX, V <sub>I</sub> = 0.5V                           |                       |                     |                  | -20  | μA   |    |
|                 |   | MR, Ds                        |  |                       |                     |                  | -40  | μA   |    |
| I <sub>OS</sub> | Short-circuit output current <sup>4</sup> |                               | V <sub>CC</sub> = MAX  |                       |                     | -60              | -150 | mA   |    |
| I <sub>CC</sub> | Supply current (total)                    |                               | V <sub>CC</sub> = MAX, PE = CE = Dn = GND,<br>MR = Ds = 4.5V, CP = ↑   |                       |                     | 50               | 70   | mA   |    |

**Notes to DC electrical characteristics**

- For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable type.
- All typical values are at V<sub>CC</sub> = 5V, T<sub>amb</sub> = 25°C.
- When testing CP, CE must remain in high state, whereas CP must remain in high state when testing CE.
- Not more than one output should be shorted at a time. For testing I<sub>OS</sub>, the use of high-speed test apparatus and/or sample-and-hold techniques are preferable in order to minimize internal heating and more accurately reflect operational values. Otherwise, prolonged shorting of a high output may raise the chip temperature well above normal and thereby cause invalid readings in other parameter tests. In any sequence of parameter tests, I<sub>OS</sub> tests should be performed last.

**AC ELECTRICAL CHARACTERISTICS**

| SYMBOL                               | PARAMETER                     | TEST CONDITION | LIMITS                   |            |             |                                 |             |                                   | UNIT        |     |
|--------------------------------------|-------------------------------|----------------|--------------------------|------------|-------------|---------------------------------|-------------|-----------------------------------|-------------|-----|
|                                      |                               |                | T <sub>amb</sub> = +25°C |            |             | T <sub>amb</sub> = 0°C to +70°C |             | T <sub>amb</sub> = -40°C to +85°C |             |     |
|                                      |                               |                | MIN                      | TYP        | MAX         | MIN                             | MAX         | MIN                               |             | MAX |
| f <sub>max</sub>                     | Maximum clock frequency       | Waveform 1     | 135                      | 175        |             | 110                             |             | 100                               |             | ns  |
| t <sub>PLH</sub><br>t <sub>PHL</sub> | Propagation delay<br>CP to Q7 | Waveform 1     | 5.0<br>4.0               | 7.5<br>6.0 | 10.0<br>8.0 | 5.0<br>3.5                      | 12.0<br>9.0 | 5.0<br>3.5                        | 13.0<br>9.0 | ns  |
| t <sub>PHL</sub>                     | Propagation delay<br>MR to Q7 | Waveform 2     | 4.0                      | 6.5        | 8.5         | 4.0                             | 9.5         | 4.0                               | 9.5         | ns  |

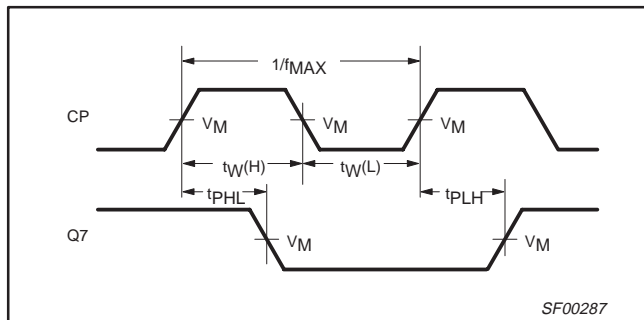
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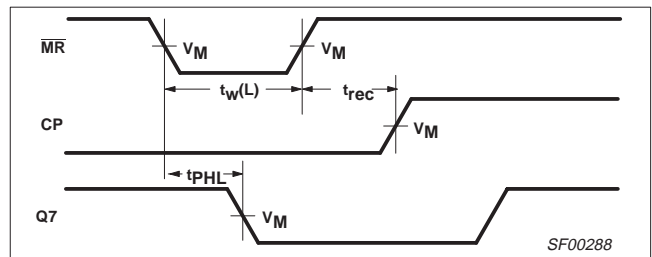
## AC SETUP REQUIREMENTS

| SYMBOL                     | PARAMETER  | TEST CONDITION | LIMITS                          |     |     |   |     |   | UNIT       |     |
|----------------------------|--|----------------|---------------------------------|-----|-----|---|-----|---|------------|-----|
|                            |  |                | $T_{amb} = +25^{\circ}\text{C}$ |     |     | $T_{amb} = 0^{\circ}\text{C to } +70^{\circ}\text{C}$ |     | $T_{amb} = -40^{\circ}\text{C to } +85^{\circ}\text{C}$ |            |     |
|                            |  |                | MIN                             | TYP | MAX | MIN   | MAX | MIN   |            | MAX |
| $t_{su}(H)$<br>$t_{su}(L)$ | Setup time, high or low<br>Dn, Ds to CP, $\overline{CE}$ | Waveform 3     | 3.0<br>2.5                      |     |     | 4.0<br>3.0  |     |   | 4.0<br>3.0 | ns  |
| $t_h(H)$<br>$t_h(L)$       | Hold time, high or low<br>Dn, Ds to CP                   | Waveform 3     | 0.0<br>0.0                      |     |     | 1.0<br>0.0  |     |   | 1.0<br>0.0 | ns  |
| $t_h(H)$<br>$t_h(L)$       | Hold time, high or low<br>Dn, Ds to $\overline{CE}$      | Waveform 3     | 1.5<br>0.0                      |     |     | 2.0<br>0.0  |     |   | 2.0<br>0.0 | ns  |
| $t_{su}(L)$                | Setup time, low<br>$\overline{CE}$ to CP                 | Waveform 3     | 5.0                             |     |     | 6.0   |     |   | 6.0        | ns  |
| $t_h(H)$                   | Hold time, high<br>$\overline{CE}$ to CP                 | Waveform 3     | 0.0                             |     |     | 0.0   |     |   | 0.0        | ns  |
| $t_{su}(H)$<br>$t_{su}(L)$ | Setup time, high or low<br>PE to CP, $\overline{CE}$     | Waveform 3     | 3.0<br>3.0                      |     |     | 4.0<br>4.0  |     |   | 4.0<br>6.0 | ns  |
| $t_h(H)$<br>$t_h(L)$       | Hold time, high or low<br>PE to CP                       | Waveform 3     | 0.0<br>0.0                      |     |     | 0.0<br>0.0  |     |   | 0.0<br>0.0 | ns  |
| $t_w(H)$<br>$t_w(L)$       | CP pulse width,<br>high or low                           | Waveform 1     | 3.0<br>4.5                      |     |     | 3.5<br>5.0  |     |   | 3.5<br>6.0 | ns  |
| $t_w(L)$                   | $\overline{MR}$ pulse width, low                         | Waveform 2     | 4.0                             |     |     | 4.0   |     |   | 4.0        | ns  |
| $t_{rec}$                  | Recovery time: $\overline{MR}$ to CP                     | Waveform 2     | 4.0                             |     |     | 4.5   |     |   | 4.5        | ns  |

## AC WAVEFORMS



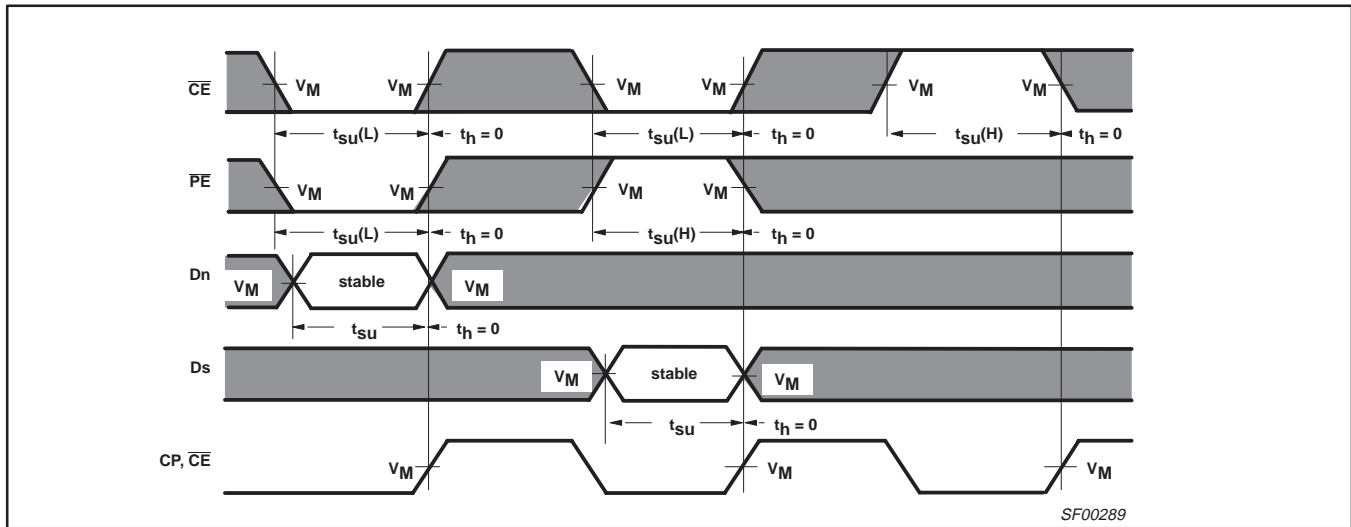
Waveform 1. Propagation delay for clock input to output, clock pulse width, and maximum clock frequency



Waveform 2. Master reset pulse width, master reset to output delay and master reset to clock recovery time

# 8-bit bidirectional universal shift register

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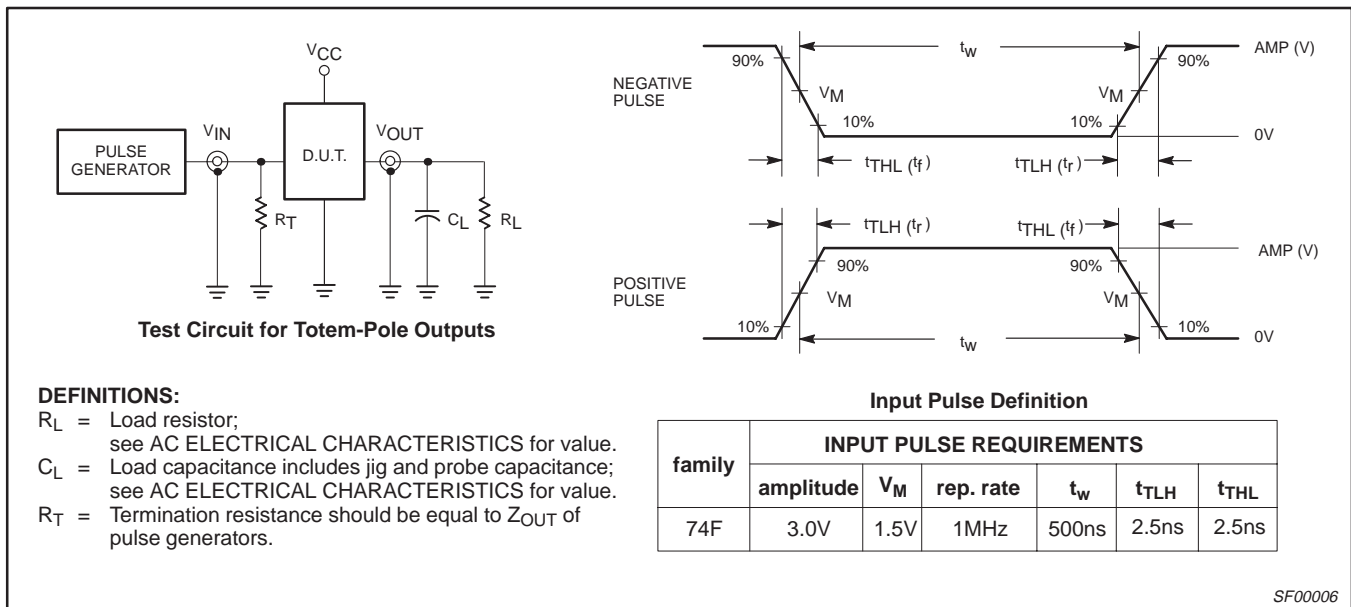


Waveform 3. Setup and hold times

**Notes to AC waveforms**

1. For all waveforms,  $V_M = 1.5V$ .
2. The shaded areas indicate when the input is permitted to change for predictable output performance.

**TEST CIRCUIT AND WAVEFORMS**



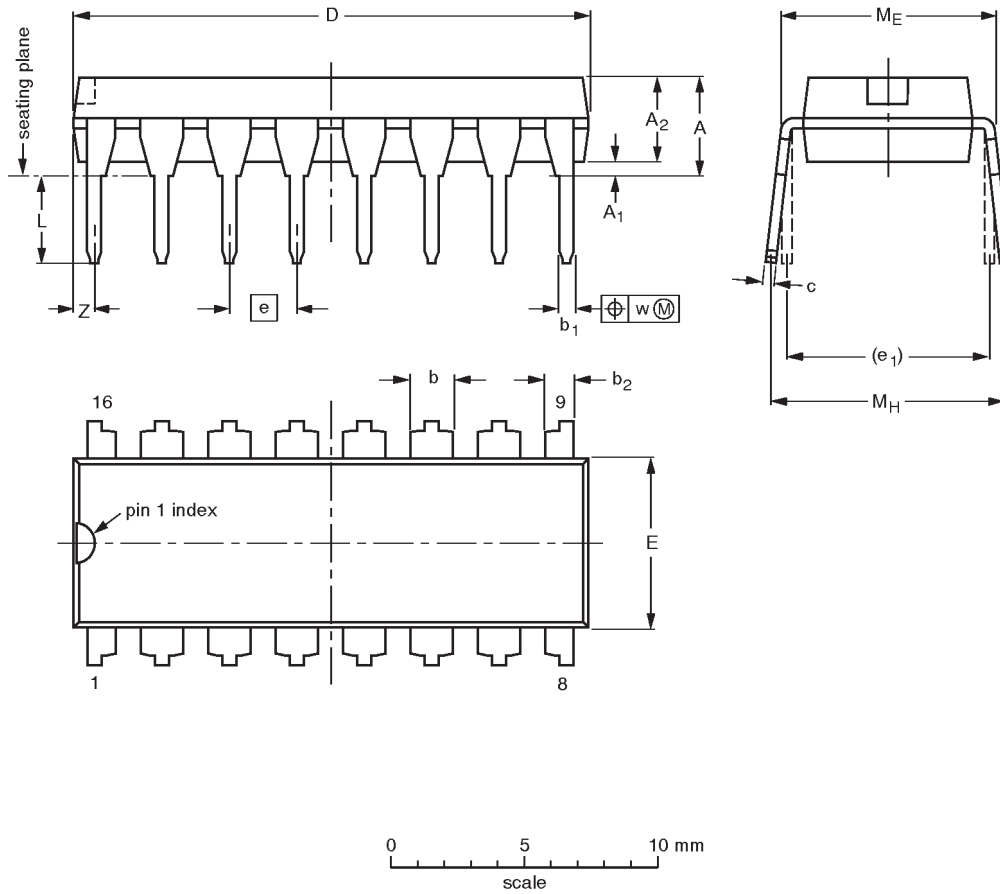


# 8-bit bidirectional universal shift register

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DIP16: plastic dual in-line package; 16 leads (300 mil)

SOT38-4



**DIMENSIONS** (inch dimensions are derived from the original mm dimensions)

| UNIT   | A max. | A <sub>1</sub> min. | A <sub>2</sub> max. | b              | b <sub>1</sub> | b <sub>2</sub> | c              | D <sup>(1)</sup> | E <sup>(1)</sup> | e    | e <sub>1</sub> | L            | M <sub>E</sub> | M <sub>H</sub> | w     | Z <sup>(1)</sup> max. |
|--------|--------|---------------------|---------------------|----------------|----------------|----------------|----------------|------------------|------------------|------|----------------|--------------|----------------|----------------|-------|-----------------------|
| mm     | 4.2    | 0.51                | 3.2                 | 1.73<br>1.30   | 0.53<br>0.38   | 1.25<br>0.85   | 0.36<br>0.23   | 19.50<br>18.55   | 6.48<br>6.20     | 2.54 | 7.62           | 3.60<br>3.05 | 8.25<br>7.80   | 10.0<br>8.3    | 0.254 | 0.76                  |
| inches | 0.17   | 0.020               | 0.13                | 0.068<br>0.051 | 0.021<br>0.015 | 0.049<br>0.033 | 0.014<br>0.009 | 0.77<br>0.73     | 0.26<br>0.24     | 0.10 | 0.30           | 0.14<br>0.12 | 0.32<br>0.31   | 0.39<br>0.33   | 0.01  | 0.030                 |

**Note**

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

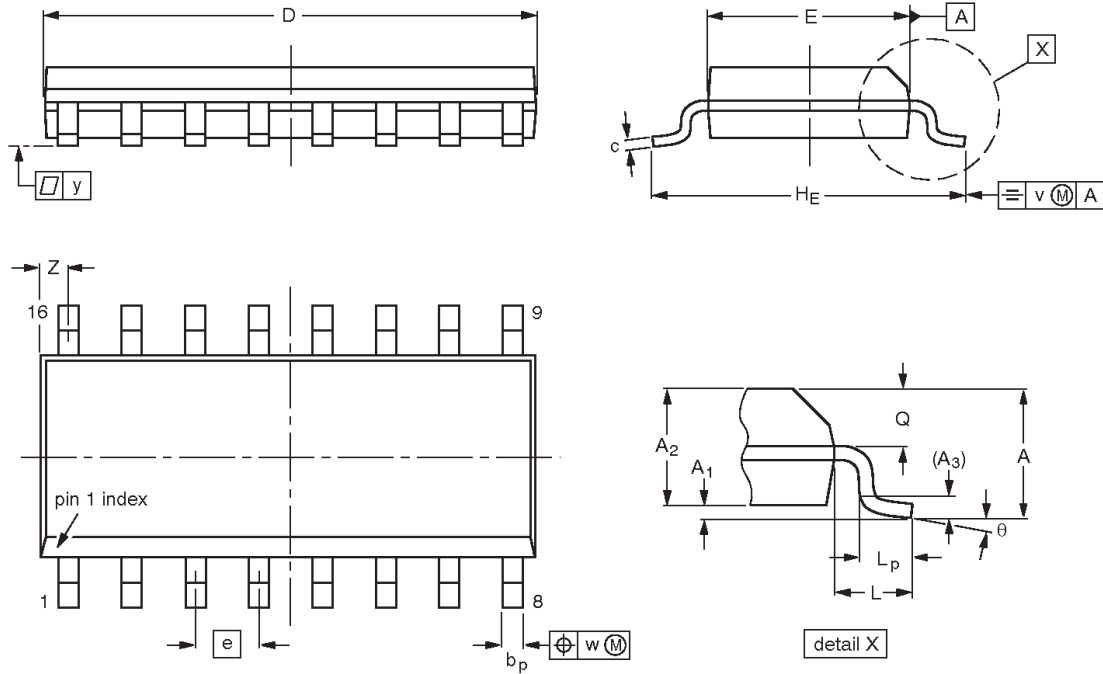
| OUTLINE VERSION | REFERENCES |       |      |  | EUROPEAN PROJECTION | ISSUE DATE            |
|-----------------|------------|-------|------|--|---------------------|-----------------------|
|                 | IEC        | JEDEC | EIAJ |  |                     |                       |
| SOT38-4         |            |       |      |  |                     | -92-11-17<br>95-01-14 |

# 8-bit bidirectional universal shift register

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**SO16: plastic small outline package; 16 leads; body width 3.9 mm**

**SOT109-1**



**DIMENSIONS (inch dimensions are derived from the original mm dimensions)**

| UNIT   | A max.         | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c                | D <sup>(1)</sup> | E <sup>(1)</sup> | e     | H <sub>E</sub> | L     | L <sub>p</sub> | Q              | v    | w    | y     | Z <sup>(1)</sup> | θ        |
|--------|----------------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|-------|----------------|-------|----------------|----------------|------|------|-------|------------------|----------|
| mm     | 1.75<br>0.10   | 0.25<br>1.25   | 1.45<br>0.049  | 0.25           | 0.49<br>0.36   | 0.25<br>0.19     | 10.0<br>9.8      | 4.0<br>3.8       | 1.27  | 6.2<br>5.8     | 1.05  | 1.0<br>0.4     | 0.7<br>0.6     | 0.25 | 0.25 | 0.1   | 0.7<br>0.3       | 8°<br>0° |
| inches | 0.069<br>0.004 | 0.010<br>0.049 | 0.057<br>0.014 | 0.01           | 0.019<br>0.014 | 0.0100<br>0.0075 | 0.39<br>0.38     | 0.16<br>0.15     | 0.050 | 0.244<br>0.228 | 0.041 | 0.039<br>0.016 | 0.028<br>0.020 | 0.01 | 0.01 | 0.004 | 0.028<br>0.012   |          |

**Note**

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES |          |      |  | EUROPEAN PROJECTION | ISSUE DATE           |
|-----------------|------------|----------|------|--|---------------------|----------------------|
|                 | IEC        | JEDEC    | EIAJ |  |                     |                      |
| SOT109-1        | 076E07S    | MS-012AC |      |  |                     | 95-01-23<br>97-05-22 |

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8-bit bidirectional universal shift register

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**NOTES**

## 8-bit bidirectional universal shift register

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## Data sheet status

| Data sheet status         | Product status | Definition [1]   |
|---------------------------|----------------|--|
| Objective specification   | Development    | This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.  |
| Preliminary specification | Qualification  | This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product. |
| Product specification     | Production     | This data sheet contains final specifications. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.   |

[1] Please consult the most recently issued datasheet before initiating or completing a design.

## Definitions

**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 134). 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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