



## ST2349A

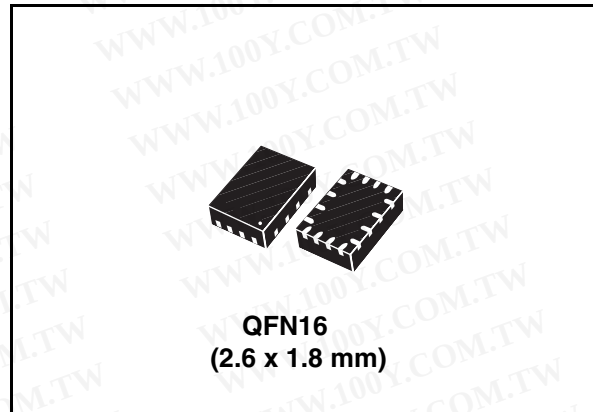
### 4-bit dual supply level translator without direction control pin

#### Features

- 18 Mbps (max) data rate when driven by a totem pole driver
- 6.8 Mbps (max) data rate when driven by an open drain pole driver
- Bi-directional level translation without direction control pin
- Wide  $V_L$  voltage range of 1.65 to 3.6 V
- Wide  $V_{CC}$  voltage range of 1.80 to 5.5 V
- Power down mode feature – when either supply is off, all I/Os are in high impedance
- Low quiescent current (max 8  $\mu$ A)
- Able to be driven by totem pole and open drain drivers
- 5.5 V tolerant enable pin
- ESD performance on all pins:  $\pm 2$  kV HBM
- Small package and footprint  
QFN16 (2.6 x 1.8 mm) package

#### Applications

- Low voltage system level translation
- Mobile phones and other mobile devices
- I<sup>2</sup>C level translation
- UART level translation



#### Description

The ST2349A is a 4-bit dual supply level translator which provides the level shifting capability to allow data transfer in a multi-voltage system. Externally applied voltages,  $V_{CC}$  and  $V_L$ , set the logic levels on either side of the device. It utilizes transmission gate-based design that allows bi-directional level translation without a control pin.

The ST2349A accepts a  $V_L$  from 1.65 to 3.6 V and  $V_{CC}$  from 1.80 to 5.5 V, making it ideal for data transfer between low-voltage ASICs/PLD and higher voltage systems. This device has a tri-state output mode which can be used to disable all I/Os.

The ST2349A supports power down mode when  $V_{CC}$  is grounded/floating and the device is disabled via the OE pin.

Table 1. Device summary

| Order code | Package              | Packaging                           |
|------------|----------------------|-------------------------------------|
| ST2349AQTR | QFN16 (2.6 x 1.8 mm) | Tape and reel (3000 parts per reel) |

# Contents

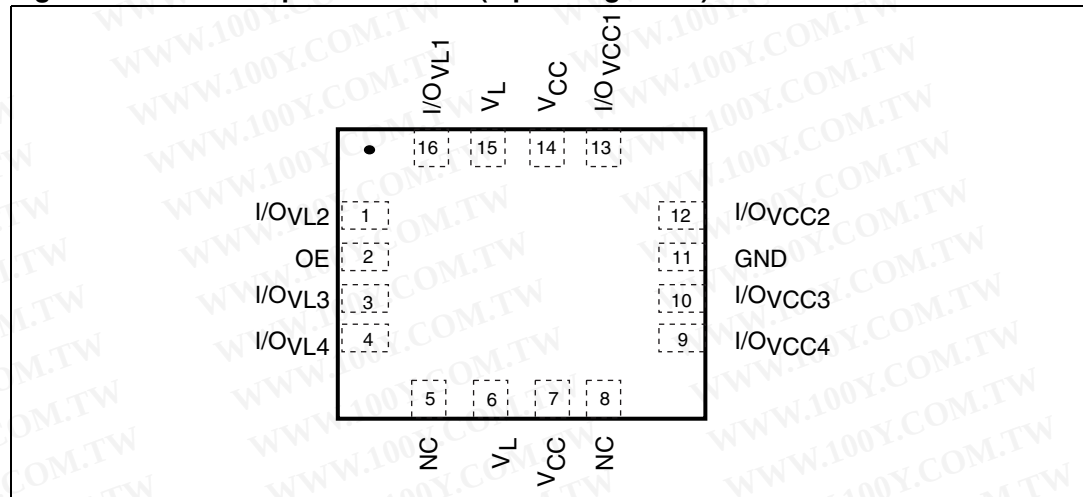
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# 1 Pin settings

## 1.1 Pin connection

Figure 1. ST2349A pin connection (top through view)



## 1.2 Pin description

Table 2. ST2349A pin description

| Pin number | Symbol  | Name and function |
|------------|---------|-------------------|
| 1          | I/OVL2  | Data input/output |
| 2          | OE      | Output enable     |
| 3          | I/OVL3  | Data input/output |
| 4          | I/OVL4  | Data input/output |
| 5          | NC      | No connection     |
| 6          | VL      | Supply voltage    |
| 7          | VCC     | Supply voltage    |
| 8          | NC      | No connection     |
| 9          | I/OVCC4 | Data input/output |
| 10         | I/OVCC3 | Data input/output |
| 11         | GND     | Ground            |
| 12         | I/OVCC2 | Data input/output |
| 13         | I/OVCC1 | Data input/output |
| 14         | VCC     | Supply voltage    |
| 15         | VL      | Supply voltage    |
| 16         | I/OVL1  | Data input/output |

## 2 Device block diagrams

Figure 2. ST2349A block diagram

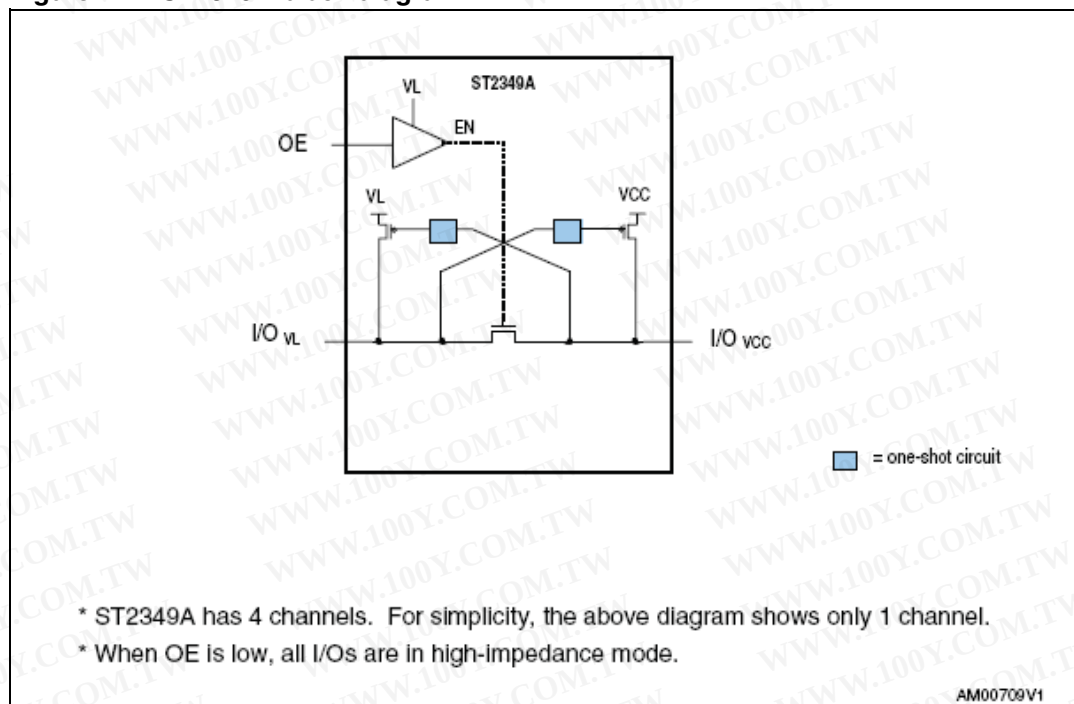
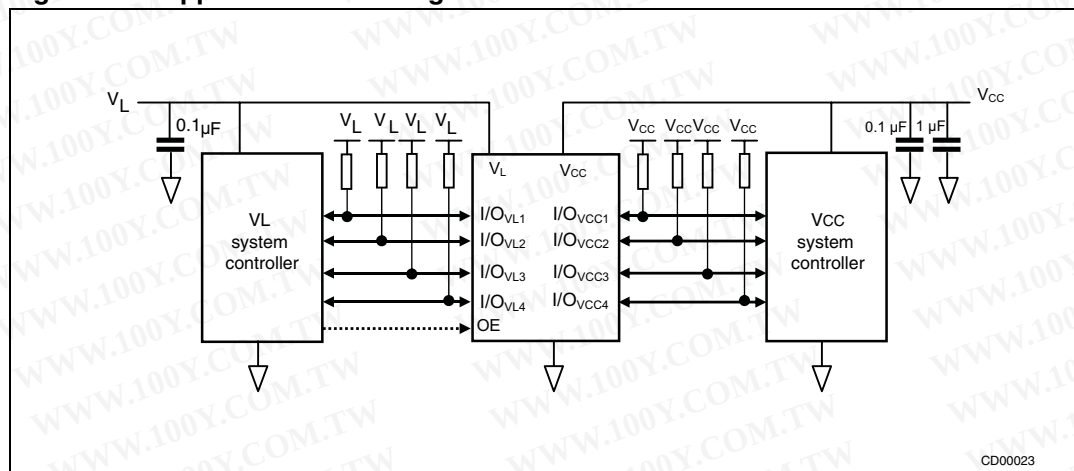


Figure 3. Application block diagram





### 3 Supplementary notes

#### 3.1 Driver requirement

The ST2349A may be driven by an open drain or totem pole driver and the nature of the device's output is "open drain". It must not be used to drive a pull-down resistor since the impedance of the output at HIGH state depends on the pull-up resistor placed at the I/Os.

As the device has pull-up resistors on both the I/O<sub>VCC</sub> and I/O<sub>VL</sub> ports, the user needs to ensure that the driver is able to sink the required amount of current. For example, if the settings are  $V_{CC} = 5.5\text{ V}$ ,  $V_L = 4.3\text{ V}$  and the pull-up resistor is  $10\text{ k}\Omega$  then the driver must be able to sink at least  $(5.5\text{ V}/10\text{ k}\Omega) + (4.3\text{ V}/10\text{ k}\Omega) = 1\text{ mA}$  and still meet the  $V_{IL}$  requirements of the ST2349A.

#### 3.2 Load driving capability

To support the open drain system, the one-shot transistor is turned on only during high transition at the output side. When it drives a high state, after the one-shot transistor is turned off, only the pull-up resistor is able to maintain the state. In this case, the resistive load is not recommended.

#### 3.3 Power off feature

In some applications where it might be required to turn off one of the power supplies powering up the level translator, the user may turn off the  $V_{CC}$  only when the OE pin is low (device is disabled). There will be no current consumption in  $V_L$  due to floating gates or other causes, and the I/Os are in a high-impedance state in this mode.

#### 3.4 Truth table

Table 3. Truth table

| Enable           | Bi-directional Input/Output |                   |
|------------------|-----------------------------|-------------------|
| OE               | I/O <sub>VCC</sub>          | I/O <sub>VL</sub> |
| H <sup>(1)</sup> | H <sup>(2)</sup>            | H <sup>(1)</sup>  |
| H <sup>(1)</sup> | L                           | L                 |
| L                | Z <sup>(3)</sup>            | Z <sup>(3)</sup>  |

1. High level  $V_L$  power supply referred
2. High level  $V_{CC}$  power supply referred
3. Z = high impedance

## 4 Maximum rating

Stressing the device above the rating listed in the “Absolute maximum ratings” table may cause permanent damage to the device. These are stress ratings only, and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**Table 4. Absolute maximum ratings**

| Symbol       | Parameter                                                | Value                  | Unit |
|--------------|----------------------------------------------------------|------------------------|------|
| $V_L$        | Supply voltage                                           | -0.3 to 4.6            | V    |
| $V_{CC}$     | Supply voltage                                           | -0.3 to 6.5            | V    |
| $V_{OE}$     | DC control input voltage                                 | -0.3 to 6.5            | V    |
| $V_{I/OVL}$  | DC I/O <sub>VL</sub> input voltage (OE = GND or $V_L$ )  | -0.3 to $V_L + 0.3$    | V    |
| $V_{I/OVCC}$ | DC I/O <sub>VCC</sub> input voltage (OE = GND or $V_L$ ) | -0.3 to $V_{CC} + 0.3$ | V    |
| $I_{IK}$     | DC input diode current                                   | -20                    | mA   |
| $I_{I/OVL}$  | DC output current                                        | ±25                    | mA   |
| $I_{I/OVCC}$ | DC output current                                        | ±258                   | mA   |
| $I_{SCTOUT}$ | Short circuit duration, continuous                       | 40                     | mA   |
| $P_D$        | Power dissipation <sup>(1)</sup>                         | 500                    | mW   |
| $T_{STG}$    | Storage temperature                                      | -65 to 150             | °C   |
| TL           | Lead temperature (10 seconds)                            | 300                    | °C   |
| ESD          | Electrostatic discharge protection (HBM)                 | ±2                     | kV   |

1. 500mW: 65 °C derated to 300 mW by 10W/°C: 65 °C to 85 °C

### 4.1 Recommended operating conditions

**Table 5. Recommended operating conditions**

| Symbol         | Parameter                                                            | Min  | Typ | Max      | Unit |
|----------------|----------------------------------------------------------------------|------|-----|----------|------|
| $V_L$          | Supply voltage                                                       | 1.65 |     | 3.6      | V    |
| $V_{CC}^{(1)}$ | Supply voltage                                                       | 1.8  |     | 5.5      | V    |
| $V_{OE}$       | Input voltage<br>(OE output enable pin, $V_L$ power supply referred) | 0    |     | 3.6      | V    |
| $V_{I/OVL}$    | I/O <sub>VL</sub> voltage                                            | 0    |     | $V_L$    | V    |
| $V_{I/OVCC}$   | I/O <sub>VCC</sub> voltage                                           | 0    |     | $V_{CC}$ | V    |
| $T_{op}$       | Operating temperature                                                | -40  |     | 85       | °C   |
| dt/dV          | Input rise and fall time                                             | 0    |     | 1        | ns/V |

1.  $V_{CC}$  must be greater than  $V_L$ .

## 5 Electrical characteristics

### 5.1 DC characteristics

Over recommended operating conditions unless otherwise noted. All typical values are at  $T_A = 25\text{ }^{\circ}\text{C}$ .

Table 6. DC characteristics

| Symbol             | Parameter                                      | V <sub>L</sub>          | V <sub>CC</sub>       | Test conditions | Value                  |     |     |              |     | Unit |
|--------------------|------------------------------------------------|-------------------------|-----------------------|-----------------|------------------------|-----|-----|--------------|-----|------|
|                    |                                                |                         |                       |                 | T <sub>A</sub> = 25 °C |     |     | -40 to 85 °C |     |      |
|                    |                                                |                         |                       |                 | Min                    | Typ | Max | Min          | Max |      |
| V <sub>IHL</sub>   | High level input voltage (I/O <sub>VL</sub> )  | 1.65                    | V <sub>L</sub> to 5.5 | —               | 1.4                    | —   | —   | 1.4          | —   | V    |
|                    |                                                | 2.0                     |                       |                 | 1.6                    | —   | —   | 1.6          | —   |      |
|                    |                                                | 2.5                     |                       |                 | 2.0                    | —   | —   | 2.0          | —   |      |
|                    |                                                | 3.0                     |                       |                 | 2.4                    | —   | —   | 2.4          | —   |      |
|                    |                                                | 3.6                     |                       |                 | 2.8                    | —   | —   | 2.8          | —   |      |
| V <sub>ILL</sub>   | Low level input voltage (I/O <sub>VL</sub> )   | 1.65                    | V <sub>L</sub> to 5.5 | —               | —                      | —   | 0.3 | —            | 0.3 | V    |
|                    |                                                | 2.0                     |                       |                 | —                      | —   | 0.4 | —            | 0.4 |      |
|                    |                                                | 2.5                     |                       |                 | —                      | —   | 0.5 | —            | 0.5 |      |
|                    |                                                | 3.0                     |                       |                 | —                      | —   | 0.6 | —            | 0.6 |      |
|                    |                                                | 3.6                     |                       |                 | —                      | —   | 0.8 | —            | 0.8 |      |
| V <sub>IHC</sub>   | High level input voltage (I/O <sub>VCC</sub> ) | 1.65 to V <sub>CC</sub> | 1.8                   | —               | 1.6                    | —   | —   | 1.6          | —   | V    |
|                    |                                                |                         | 2.5                   |                 | 2.3                    | —   | —   | 2.3          | —   |      |
|                    |                                                |                         | 3.0                   |                 | 2.7                    | —   | —   | 2.7          | —   |      |
|                    |                                                |                         | 3.6                   |                 | 3.3                    | —   | —   | 3.3          | —   |      |
|                    |                                                |                         | 4.3                   |                 | 3.5                    | —   | —   | 3.5          | —   |      |
|                    |                                                |                         | 5.5                   |                 | 4.2                    | —   | —   | 4.2          | —   |      |
| V <sub>ILC</sub>   | Low level input voltage (I/O <sub>VCC</sub> )  | 1.65 - 2.5              | 3 - 5.5               | —               | —                      | —   | —   | 0.3          | —   | V    |
|                    |                                                | 2.7 - 3.6               | 3.6 - 5.5             |                 | —                      | —   | —   | 0.5          | —   |      |
| V <sub>IH-OE</sub> | High level input voltage (OE)                  | 1.65                    | V <sub>L</sub> to 5.5 | —               | 1.0                    | —   | —   | 1.0          | —   | V    |
|                    |                                                | 2.0                     |                       |                 | 1.2                    | —   | —   | 1.2          | —   |      |
|                    |                                                | 2.5                     |                       |                 | 1.4                    | —   | —   | 1.4          | —   |      |
|                    |                                                | 3.0                     |                       |                 | 1.6                    | —   | —   | 1.6          | —   |      |
|                    |                                                | 3.6                     |                       |                 | 2.0                    | —   | —   | 2.0          | —   |      |

Table 6. DC characteristics (continued)

| Symbol              | Parameter                                                                | V <sub>L</sub> | V <sub>CC</sub>       | Test conditions                                     | Value                  |      |      |              |      | Unit |
|---------------------|--------------------------------------------------------------------------|----------------|-----------------------|-----------------------------------------------------|------------------------|------|------|--------------|------|------|
|                     |                                                                          |                |                       |                                                     | T <sub>A</sub> = 25 °C |      |      | -40 to 85 °C |      |      |
|                     |                                                                          |                |                       |                                                     | Min                    | Typ  | Max  | Min          | Max  |      |
| V <sub>IL-OE</sub>  | Low level input voltage (OE)                                             | 1.65           | V <sub>L</sub> to 5.5 | —                                                   | —                      | —    | 0.33 | —            | 0.33 | V    |
|                     |                                                                          | 2.0            |                       |                                                     | —                      | —    | 0.40 | —            | 0.40 |      |
|                     |                                                                          | 2.5            |                       |                                                     | —                      | —    | 0.50 | —            | 0.50 |      |
|                     |                                                                          | 3.0            |                       |                                                     | —                      | —    | 0.60 | —            | 0.60 |      |
|                     |                                                                          | 3.6            |                       |                                                     | —                      | —    | 0.75 | —            | 0.75 |      |
| V <sub>OLL</sub>    | Low level output voltage (I/O <sub>VL</sub> )                            | 1.65 to 3.6    | V <sub>L</sub> to 5.5 | IO = 1.0 mA<br>I/O <sub>VCC</sub> ≤ 0.15 V          | —                      | —    | 0.40 | —            | 0.40 | V    |
| V <sub>OLC</sub>    | Low level output voltage (I/O <sub>VCC</sub> )                           | 1.65 to 3.6    | V <sub>L</sub> to 5.5 | IO = 1.0 mA<br>I/O <sub>VL</sub> ≤ 0.15 V           | —                      | —    | 0.40 | —            | 0.40 | V    |
| I <sub>OE</sub>     | Control input leakage current (OE)                                       | 1.65 to 3.6    | V <sub>L</sub> to 5.5 | V <sub>OE</sub> = GND or V <sub>L</sub>             | —                      | —    | ±0.1 | —            | ±0.1 | µA   |
| I <sub>IO_LKG</sub> | High impedance leakage current (I/O <sub>VL</sub> , I/O <sub>VCC</sub> ) | 1.65 to 3.6    | V <sub>L</sub> to 5.5 | OE = GND                                            | —                      | —    | ±0.1 | —            | ±0.1 | µA   |
| I <sub>QVCC</sub>   | Quiescent supply current V <sub>CC</sub>                                 | 1.65 to 3.6    | V <sub>L</sub> to 5.5 | only pull-up resistor connected to I/O              | —                      | 6    | 6.5  | —            | 8    | µA   |
| I <sub>QVL</sub>    | Quiescent supply current V <sub>L</sub>                                  | 1.65 to 3.6    | V <sub>L</sub> to 5.5 | only pull-up resistor connected to I/O              | —                      | 0.01 | 0.1  | —            | 1    | µA   |
| I <sub>Z-VCC</sub>  | High impedance quiescent supply current V <sub>CC</sub>                  | 1.65 to 3.6    | V <sub>L</sub> to 5.5 | OE = GND;<br>only pull-up resistor connected to I/O | —                      | 6    | 6.5  | —            | 8    | µA   |
| I <sub>Z-VL</sub>   | High impedance quiescent supply current V <sub>L</sub>                   | 1.65 to 3.6    | V <sub>L</sub> to 5.5 | OE = GND;<br>only pull-up resistor connected to I/O | —                      | 0.01 | 0.1  | —            | 1    | µA   |



## 5.2 AC characteristics

### 5.2.1 Device driven by open drain driver

Load  $C_L = 15 \text{ pF}$ ;  $R_{up} = 4.7 \text{ k}\Omega$ ; driver  $t_r = t_f \leq 2 \text{ ns}$  over temperature range  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

**Table 7. AC characteristics - test conditions:  $V_L = 1.65 - 1.8 \text{ V}$**

| Symbol                                                                 | Parameter                                                                                                                |                  | V <sub>CC</sub> = 1.8 – 2.5 V |      | V <sub>CC</sub> = 2.7 – 3.6 V |      | V <sub>CC</sub> = 4.3 – 5.5 V |      | Unit |
|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------------|------|-------------------------------|------|-------------------------------|------|------|
|                                                                        |                                                                                                                          |                  | Min                           | Max  | Min                           | Max  | Min                           | Max  |      |
| t <sub>RVCC</sub>                                                      | Rise time I/O <sub>VCC</sub>                                                                                             |                  | —                             | 80   | —                             | 60   | —                             | 45   | ns   |
| t <sub>FVCC</sub>                                                      | Fall time I/O <sub>VCC</sub>                                                                                             |                  | —                             | 23.2 | —                             | 33.9 | —                             | 53.3 | ns   |
| t <sub>RVL</sub>                                                       | Rise time I/O <sub>VL</sub>                                                                                              |                  | —                             | 60   | —                             | 45   | —                             | 35   | ns   |
| t <sub>FVL</sub>                                                       | Fall time I/O <sub>VL</sub>                                                                                              |                  | —                             | 16.4 | —                             | 17.6 | —                             | 16.9 | ns   |
| t <sub>I/OVL-VCC</sub>                                                 | Propagation delay time<br>I/O <sub>VL-LH</sub> to I/O <sub>VCC-LH</sub><br>I/O <sub>VL-HL</sub> to I/O <sub>VCC-HL</sub> | t <sub>PLH</sub> | —                             | 3.4  | —                             | 2.0  | —                             | 2.0  | ns   |
|                                                                        |                                                                                                                          | t <sub>PHL</sub> | —                             | 13.9 | —                             | 19.1 | —                             | 30.2 | ns   |
| t <sub>I/OVCC-VL</sub>                                                 | Propagation delay time<br>I/O <sub>VCC-LH</sub> to I/O <sub>VL-LH</sub><br>I/O <sub>VCC-HL</sub> to I/O <sub>VL-LH</sub> | t <sub>PLH</sub> | —                             | 2.0  | —                             | 2.0  | —                             | 2.6  | ns   |
|                                                                        |                                                                                                                          | t <sub>PHL</sub> | —                             | 8.6  | —                             | 9.0  | —                             | 9.5  | ns   |
| t <sub>PZL</sub> t <sub>PZH</sub><br>t <sub>PLZ</sub> t <sub>PHZ</sub> | Output enable and<br>disable time                                                                                        | En               | —                             | 10   | —                             | 10   | —                             | 10   | ns   |
|                                                                        |                                                                                                                          | Dis              | —                             | 40   | —                             | 40   | —                             | 40   | ns   |
| D <sub>R</sub>                                                         | Data rate <sup>(1)</sup>                                                                                                 |                  | —                             | 1.8  | —                             | 2.2  | —                             | 3.4  | MHz  |

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

**Table 8. AC characteristics - test conditions:  $V_L = 2.5 - 2.7 \text{ V}$**

| Symbol                 | Parameter                                                                                                                    |                  | V <sub>CC</sub> = 2.7 –3.6 V |      | V <sub>CC</sub> = 4.3 – 5.5 V |      | Unit |
|------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------|------------------------------|------|-------------------------------|------|------|
|                        |                                                                                                                              |                  | Min                          | Max  | Min                           | Max  |      |
| t <sub>RVCC</sub>      | Rise time I/O <sub>VCC</sub>                                                                                                 |                  | —                            | 70.0 | —                             | 50   | ns   |
| t <sub>FVCC</sub>      | Fall time I/O <sub>VCC</sub>                                                                                                 |                  | —                            | 14.8 | —                             | 19.1 | ns   |
| t <sub>RVL</sub>       | Rise time I/O <sub>VL</sub>                                                                                                  |                  | —                            | 50.0 | —                             | 35   | ns   |
| t <sub>FVL</sub>       | Fall time I/O <sub>VL</sub>                                                                                                  |                  | —                            | 9.8  | —                             | 10   | ns   |
| t <sub>I/OVL-VCC</sub> | Propagation delay time<br>I/O <sub>VL</sub> -LH to I/O <sub>VCC</sub> -LH<br>I/O <sub>VL</sub> -HL to I/O <sub>VCC</sub> -HL | t <sub>PLH</sub> | —                            | 2.0  | —                             | 2.0  | ns   |
|                        |                                                                                                                              | t <sub>PHL</sub> | —                            | 8.2  | —                             | 11.6 | ns   |
| t <sub>I/OVCC-VL</sub> | Propagation delay time<br>I/O <sub>VCC</sub> -LH to I/O <sub>VL</sub> -LH<br>I/O <sub>VCC</sub> -HL to I/O <sub>VL</sub> -LH | t <sub>PLH</sub> | —                            | 2.0  | —                             | 2.0  | ns   |
|                        |                                                                                                                              | t <sub>PHL</sub> | —                            | 5.3  | —                             | 5.9  | ns   |

Table 8. AC characteristics - test conditions:  $V_L = 2.5 - 2.7 \text{ V}$  (continued)

| Symbol                                     | Parameter                      |     | $V_{CC} = 2.7 - 3.6 \text{ V}$ |     | $V_{CC} = 4.3 - 5.5 \text{ V}$ |     | Unit |
|--------------------------------------------|--------------------------------|-----|--------------------------------|-----|--------------------------------|-----|------|
|                                            |                                |     | Min                            | Max | Min                            | Max |      |
| $t_{PZL} \ t_{PZH}$<br>$t_{PLZ} \ t_{PHZ}$ | Output enable and disable time | En  | —                              | 6   | —                              | 6   | ns   |
|                                            |                                | Dis | —                              | 40  | —                              | 40  | ns   |
| $D_R$                                      | Data rate <sup>(1)</sup>       |     | —                              | 2.2 | —                              | 3.0 | MHz  |

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

Table 9. AC characteristics - test conditions:  $V_L = 2.7 - 3.6 \text{ V}$ 

| Symbol                                                                 | Parameter                                                                                                                    |                  | V <sub>CC</sub> = 4.3 – 5.5 V |      | Unit |
|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------------|------|------|
|                                                                        |                                                                                                                              |                  | Min                           | Max  |      |
| t <sub>RVCC</sub>                                                      | Rise time I/O <sub>VCC</sub>                                                                                                 |                  | —                             | 55.0 | ns   |
| t <sub>FVCC</sub>                                                      | Fall time I/O <sub>VCC</sub>                                                                                                 |                  | —                             | 17.2 | ns   |
| t <sub>RVL</sub>                                                       | Rise time I/O <sub>VL</sub>                                                                                                  |                  | —                             | 40.0 | ns   |
| t <sub>FVL</sub>                                                       | Fall time I/O <sub>VL</sub>                                                                                                  |                  | —                             | 9.7  | ns   |
| t <sub>I/OVL-VCC</sub>                                                 | Propagation delay time<br>I/O <sub>VL</sub> -LH to I/O <sub>VCC</sub> -LH<br>I/O <sub>VL</sub> -HL to I/O <sub>VCC</sub> -HL | t <sub>PLH</sub> | —                             | 2.0  | ns   |
|                                                                        |                                                                                                                              | t <sub>PHL</sub> | —                             | 10.6 | ns   |
| t <sub>I/OVCC-VL</sub>                                                 | Propagation delay time<br>I/O <sub>VCC</sub> -LH to I/O <sub>VL</sub> -LH<br>I/O <sub>VCC</sub> -HL to I/O <sub>VL</sub> -HL | t <sub>PLH</sub> | —                             | 2.0  | ns   |
|                                                                        |                                                                                                                              | t <sub>PHL</sub> | —                             | 4.8  | ns   |
| t <sub>PZL</sub> t <sub>PZH</sub><br>t <sub>PLZ</sub> t <sub>PHZ</sub> | Output enable and disable time                                                                                               | En               | —                             | 6    | ns   |
|                                                                        |                                                                                                                              | Dis              | —                             | 40   | ns   |
| D <sub>R</sub>                                                         | Data rate <sup>(1)</sup>                                                                                                     | —                | —                             | 3.0  | MHz  |

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

## 5.2.2 Device driven by totem pole driver

Load  $C_L = 15 \text{ pF}$ ;  $R_{up} = 10 \text{ k}\Omega$ ; driver  $t_r = t_f \leq 2 \text{ ns}$  over temperature range  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

**Table 10. AC characteristics - test conditions:  $V_L = 1.65 - 1.8 \text{ V}$**

| Symbol                                     | Parameter                                                                                    |           | $V_{CC} = 1.8 - 2.5 \text{ V}$ |      | $V_{CC} = 2.7 - 3.6 \text{ V}$ |      | $V_{CC} = 4.3 - 5.5 \text{ V}$ |      | Unit |
|--------------------------------------------|----------------------------------------------------------------------------------------------|-----------|--------------------------------|------|--------------------------------|------|--------------------------------|------|------|
|                                            |                                                                                              |           | Min                            | Max  | Min                            | Max  | Min                            | Max  |      |
| $t_{RVCC}$                                 | Rise time $I/O_{VCC}$                                                                        |           | —                              | 7.2  | —                              | 4.6  | —                              | 1.4  | ns   |
| $t_{FVCC}$                                 | Fall time $I/O_{VCC}$                                                                        |           | —                              | 23.2 | —                              | 33.9 | —                              | 53.3 | ns   |
| $t_{RVL}$                                  | Rise time $I/O_{VL}$                                                                         |           | —                              | 5.9  | —                              | 5.7  | —                              | 5.5  | ns   |
| $t_{FVL}$                                  | Fall time $I/O_{VL}$                                                                         |           | —                              | 16.4 | —                              | 17.6 | —                              | 16.9 | ns   |
| $t_{I/OVL-VCC}$                            | Propagation delay time<br>$I/O_{VL-LH}$ to $I/O_{VCC-LH}$<br>$I/O_{VL-HL}$ to $I/O_{VCC-HL}$ | $t_{PLH}$ | —                              | 5.5  | —                              | 4.1  | —                              | 3.6  | ns   |
|                                            |                                                                                              | $t_{PHL}$ | —                              | 13.9 | —                              | 19.1 | —                              | 30.2 | ns   |
| $t_{I/OVCC-VL}$                            | Propagation delay time<br>$I/O_{VCC-LH}$ to $I/O_{VL-LH}$<br>$I/O_{VCC-HL}$ to $I/O_{VL-HL}$ | $t_{PLH}$ | —                              | 4.5  | —                              | 3.9  | —                              | 3.6  | ns   |
|                                            |                                                                                              | $t_{PHL}$ | —                              | 8.6  | —                              | 9    | —                              | 9.5  | ns   |
| $t_{PZL}$ $t_{PZH}$<br>$t_{PLZ}$ $t_{PHZ}$ | Output enable and<br>disable time                                                            | En        | —                              | 10   | —                              | 10   | —                              | 10   | ns   |
|                                            |                                                                                              | Dis       | —                              | 40   | —                              | 40   | —                              | 40   | ns   |
| $D_R$                                      | Data rate <sup>(1)</sup>                                                                     |           | —                              | 6.4  | —                              | 4.5  | —                              | 3    | MHz  |

1. The data rate is guaranteed based on the condition that the output  $I/O$  signal rise/fall time is less than 15% of the input  $I/O$  signal period; the input  $I/O$  signal is at 50% duty cycle and the output  $I/O$  signal duty cycle deviation not less than 30%.

**Table 11. AC characteristics - test conditions:  $V_L = 2.5 - 2.7 \text{ V}$**

| Symbol          | Parameter                                                                                    |           | $V_{CC} = 2.7 - 3.6 \text{ V}$ |      | $V_{CC} = 4.3 - 5.5 \text{ V}$ |      | Unit |
|-----------------|----------------------------------------------------------------------------------------------|-----------|--------------------------------|------|--------------------------------|------|------|
|                 |                                                                                              |           | Min                            | Max  | Min                            | Max  |      |
| $t_{RVCC}$      | Rise time $I/O_{VCC}$                                                                        |           | —                              | 3.8  | —                              | 2.8  | ns   |
| $t_{FVCC}$      | Fall time $I/O_{VCC}$                                                                        |           | —                              | 14.8 | —                              | 19.1 | ns   |
| $t_{RVL}$       | Rise time $I/O_{VL}$                                                                         |           | —                              | 3.3  | —                              | 3.2  | ns   |
| $t_{FVL}$       | Fall time $I/O_{VL}$                                                                         |           | —                              | 9.8  | —                              | 10.0 | ns   |
| $t_{I/OVL-VCC}$ | Propagation delay time<br>$I/O_{VL-LH}$ to $I/O_{VCC-LH}$<br>$I/O_{VL-HL}$ to $I/O_{VCC-HL}$ | $t_{PLH}$ | —                              | 3.2  | —                              | 2.8  | ns   |
|                 |                                                                                              | $t_{PHL}$ | —                              | 8.2  | —                              | 11.6 | ns   |

Table 11. AC characteristics - test conditions:  $V_L = 2.5 - 2.7 \text{ V}$  (continued)

| Symbol                                     | Parameter                                                                                                                |           | $V_{CC} = 2.7 - 3.6 \text{ V}$ |     | $V_{CC} = 4.3 - 5.5 \text{ V}$ |     | Unit |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-----------|--------------------------------|-----|--------------------------------|-----|------|
|                                            |                                                                                                                          |           | Min                            | Max | Min                            | Max |      |
| $t_{I/OVCC-VL}$                            | Propagation delay time<br>I/O <sub>VCC-LH</sub> to I/O <sub>VL-LH</sub><br>I/O <sub>VCC-HL</sub> to I/O <sub>VL-HL</sub> | $t_{PLH}$ | —                              | 2.6 | —                              | 2.0 | ns   |
|                                            |                                                                                                                          |           |                                |     |                                |     | ns   |
|                                            |                                                                                                                          | $t_{PHL}$ | —                              | 5.3 | —                              | 5.9 | ns   |
|                                            |                                                                                                                          |           |                                |     |                                |     | ns   |
| $t_{PZL} \ t_{PZH}$<br>$t_{PLZ} \ t_{PHZ}$ | Output enable and disable time                                                                                           | En        | —                              | 6   | —                              | 6   | ns   |
|                                            |                                                                                                                          | Dis       | —                              | 40  | —                              | 40  | ns   |
| $D_R$                                      | Data rate <sup>(1)</sup>                                                                                                 |           | —                              | 9   | —                              | 6.8 | MHz  |

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.

Table 12. AC characteristics - test conditions:  $V_L = 2.7 - 3.6 \text{ V}$ 

| Symbol                                     | Parameter                                                                                                                |           | $V_{CC} = 4.3 - 5.5 \text{ V}$ |      | Unit |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-----------|--------------------------------|------|------|
|                                            |                                                                                                                          |           | Min                            | Max  |      |
| $t_{RVCC}$                                 | Rise time I/O <sub>VCC</sub>                                                                                             |           | —                              | 2.9  | ns   |
| $t_{FVCC}$                                 | Fall time I/O <sub>VCC</sub>                                                                                             |           | —                              | 17.2 | ns   |
| $t_{RVL}$                                  | Rise time I/O <sub>VL</sub>                                                                                              |           | —                              | 3.0  | ns   |
| $t_{FVL}$                                  | Fall time I/O <sub>VL</sub>                                                                                              |           | —                              | 9.7  | ns   |
| $t_{I/OVL-VCC}$                            | Propagation delay time<br>I/O <sub>VL-LH</sub> to I/O <sub>VCC-LH</sub><br>I/O <sub>VL-HL</sub> to I/O <sub>VCC-HL</sub> | $t_{PLH}$ | —                              | 2.7  | ns   |
|                                            |                                                                                                                          | $t_{PHL}$ | —                              | 10.6 | ns   |
| $t_{I/OVCC-VL}$                            | Propagation delay time<br>I/O <sub>VCC-LH</sub> to I/O <sub>VL-LH</sub><br>I/O <sub>VCC-HL</sub> to I/O <sub>VL-HL</sub> | $t_{PLH}$ | —                              | 1.9  | ns   |
|                                            |                                                                                                                          |           |                                |      | ns   |
|                                            |                                                                                                                          | $t_{PHL}$ | —                              | 4.8  | ns   |
|                                            |                                                                                                                          |           |                                |      | ns   |
| $t_{PZL} \ t_{PZH}$<br>$t_{PLZ} \ t_{PHZ}$ | Output enable and disable time                                                                                           | En        | —                              | 6    | ns   |
|                                            |                                                                                                                          | Dis       | —                              | 40   | ns   |
| $D_R$                                      | Data rate <sup>(1)</sup>                                                                                                 |           | —                              | 7.2  | MHz  |

1. The data rate is guaranteed based on the condition that the output I/O signal rise/fall time is less than 15% of the input I/O signal period; the input I/O signal is at 50% duty cycle and the output I/O signal duty cycle deviation not less than 30%.



# 6 Test circuit

Figure 4. Test circuit

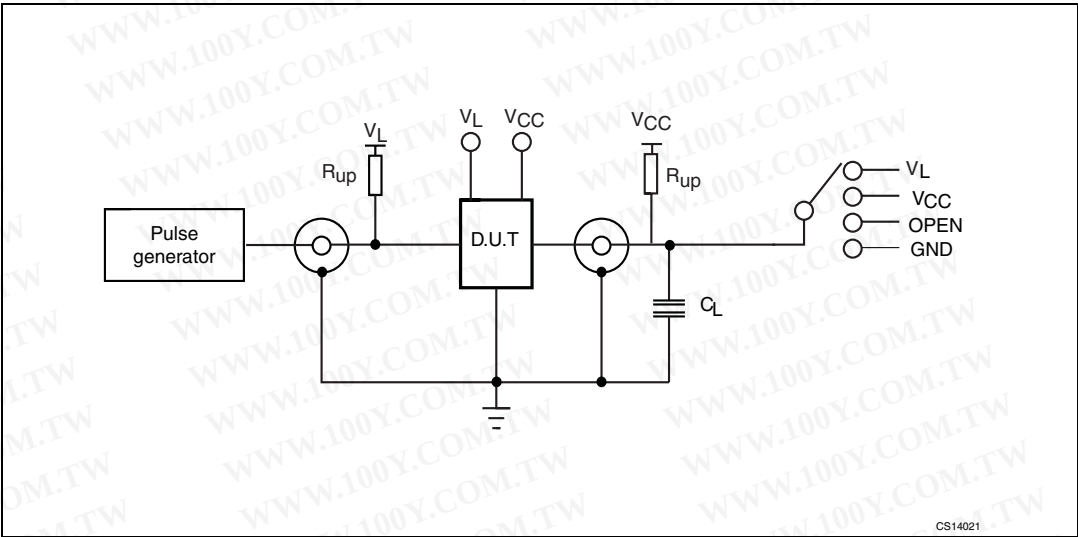


Table 13. Test circuit switches

| Test                  | Switch                               |                                       |                    |
|-----------------------|--------------------------------------|---------------------------------------|--------------------|
|                       | Driving I/O <sub>V<sub>L</sub></sub> | Driving I/O <sub>V<sub>CC</sub></sub> | Open drain driving |
| $t_{PLH}$ , $t_{PHL}$ | Open                                 | Open                                  | Open               |

Table 14. Waveform symbol value

| Symbol          | Driving I/O <sub>VL</sub>                             |                                                       | Driving I/O <sub>VCC</sub>                            |                                                       |
|-----------------|-------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|
|                 | $1.8\text{ V} \leq V_L \leq V_{CC} \leq 2.5\text{ V}$ | $3.3\text{ V} \leq V_L \leq V_{CC} \leq 5.0\text{ V}$ | $1.8\text{ V} \leq V_L \leq V_{CC} \leq 2.5\text{ V}$ | $3.3\text{ V} \leq V_L \leq V_{CC} \leq 5.0\text{ V}$ |
| V <sub>IH</sub> | V <sub>L</sub>                                        | V <sub>L</sub>                                        | V <sub>CC</sub>                                       | V <sub>CC</sub>                                       |
| V <sub>IM</sub> | 50% V <sub>L</sub>                                    | 50% V <sub>L</sub>                                    | 50% V <sub>CC</sub>                                   | 50% V <sub>CC</sub>                                   |
| V <sub>OM</sub> | 50% V <sub>CC</sub>                                   | 50% V <sub>CC</sub>                                   | 50% V <sub>L</sub>                                    | 50% V <sub>L</sub>                                    |
| V <sub>X</sub>  | V <sub>OL</sub> + 0.15V                               | V <sub>OL</sub> + 0.3V                                | V <sub>OL</sub> + 0.15V                               | V <sub>OL</sub> + 0.3V                                |
| V <sub>Y</sub>  | V <sub>OH</sub> - 0.15V                               | V <sub>OH</sub> - 0.3V                                | V <sub>OH</sub> - 0.15V                               | V <sub>OH</sub> - 0.3V                                |

Figure 5. Waveform - propagation delay (f = 1 MHz; 50% duty cycle)

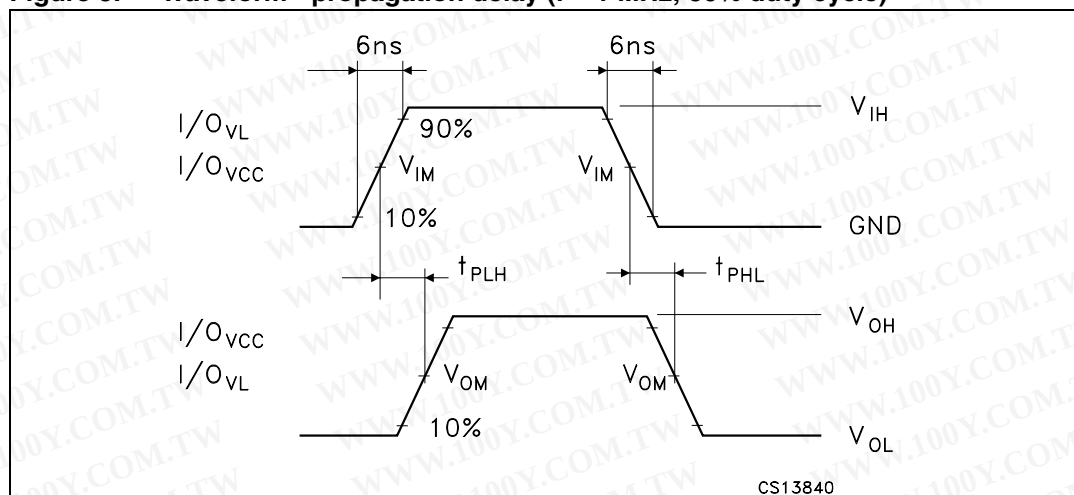
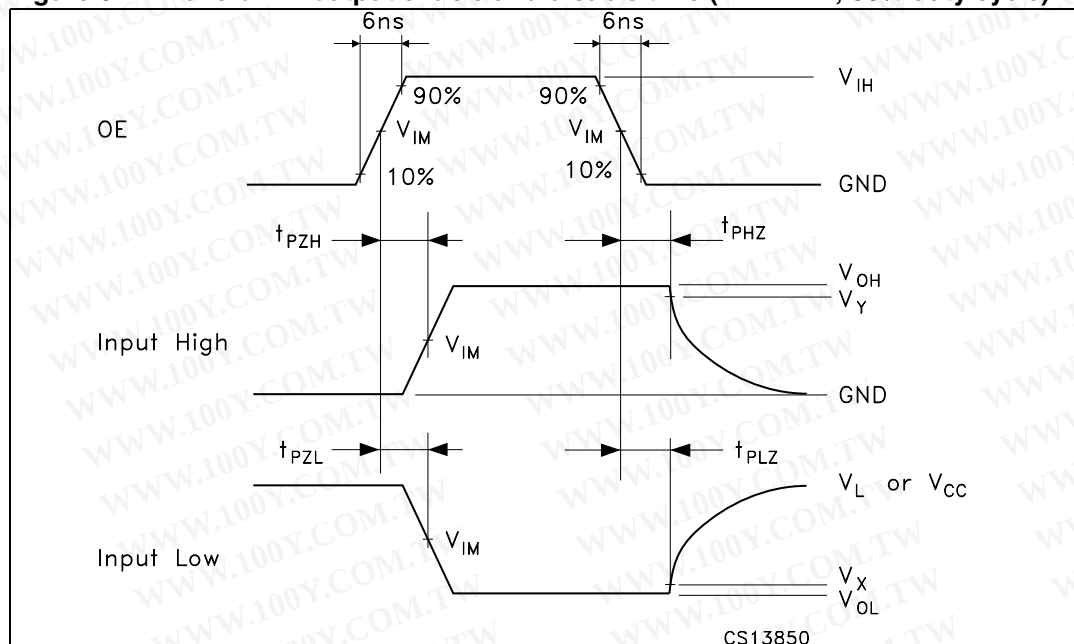


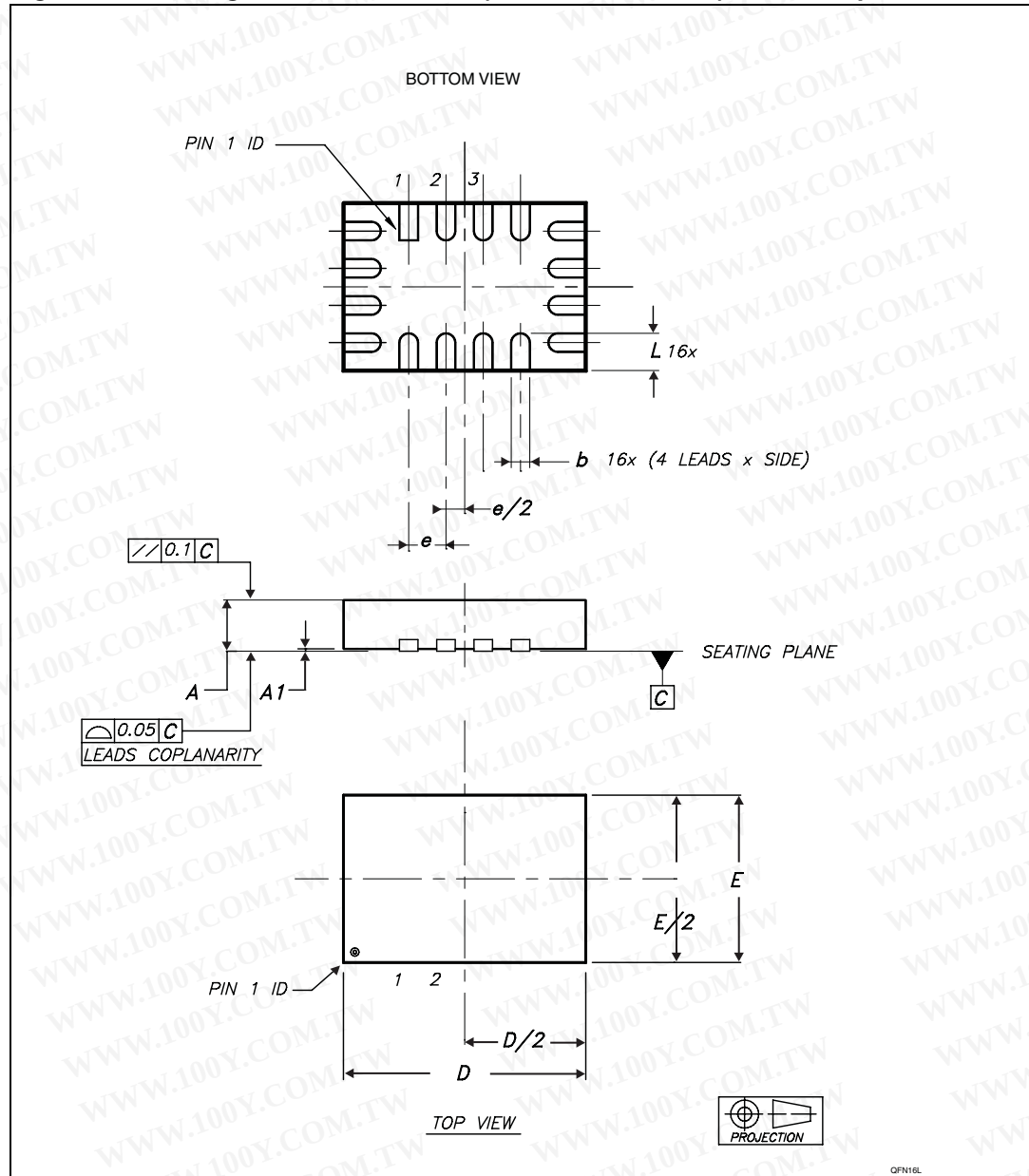
Figure 6. Waveform - output enable and disable time (f = 1 MHz; 50% duty cycle)



## 7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

**Figure 7. Package outline for QFN16 (2.6 x 1.8 x 0.55 mm) - 0.40 mm pitch**

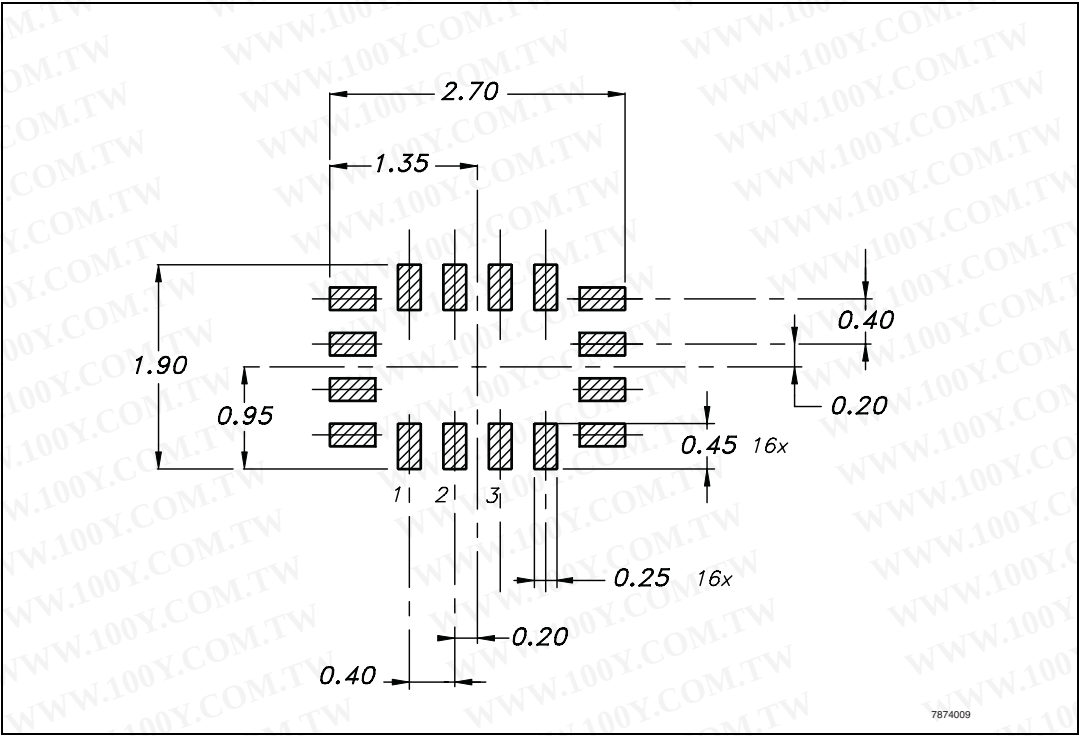


1. Drawing not to scale.
2. Dimensions are in millimeters.

Table 15. Mechanical data for QFN16 (2.6 x 1.8 x 0.55 mm) - 0.40 mm pitch

| Symbol | Millimeters |      |      |
|--------|-------------|------|------|
|        | Typ         | Min  | Max  |
| A      | 0.55        | 0.45 | 0.60 |
| A1     | 0.02        | 0    | 0.05 |
| b      | 0.20        | 0.15 | 0.25 |
| D      | 2.60        | 2.50 | 2.70 |
| E      | 1.80        | 1.70 | 1.90 |
| e      | 0.40        | —    | —    |
| L      | 0.40        | 0.35 | 0.45 |

Figure 8. Footprint recommendations for QFN16 (2.6 x 1.8 x 0.55 mm) - 0.40 mm pitch

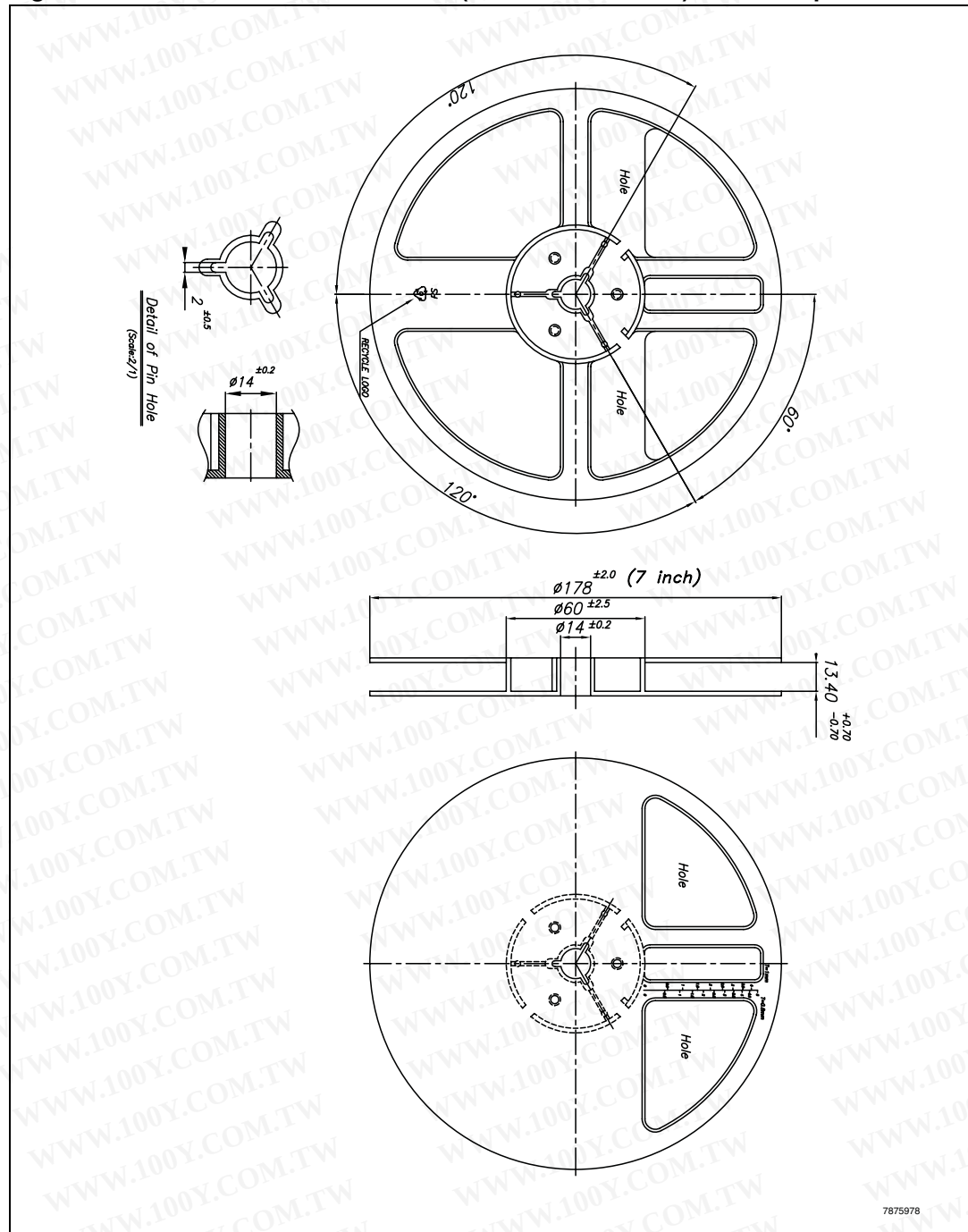


1. Drawing not to scale.
2. Dimensions are in millimeters.



[illegible]

Figure 10. Reel information for QFN16 (2.6 x 1.8 x 0.55 mm) - 0.40 mm pitch



1. Drawing not to scale.
2. Dimensions are in millimeters

## 8 Revision history

**Table 16. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16-Jul-2008 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                                                                           |
| 22-Jun-2009 | 2        | Document status promoted from Preliminary data to datasheet.<br>Content reworked to improve readability.<br>Updated: <a href="#">Table 7 on page 9</a> , <a href="#">Table 8 on page 9</a> , <a href="#">Table 9 on page 10</a> ,<br><a href="#">Table 10 on page 11</a> , <a href="#">Table 11 on page 11</a> and <a href="#">Table 12 on page 12</a> .<br>Modified: ECOPACK information. |

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