



## ST4G3234

### 4-BIT DUAL SUPPLY BUS BUFFER LEVEL TRANSLATOR WITH A SIDE SERIES RESISTOR

- HIGH SPEED:  $t_{PD} = 4.4ns$  (MAX.) at  $T_A=85^{\circ}C$   
 $V_{CCB} = 1.65V$ ;  $V_{CCA} = 3.0V$
- LOW POWER DISSIPATION:  
 $I_{CCA} = I_{CCB} = 5\mu A$  (MAX.) at  $T_A=85^{\circ}C$
- SYMMETRICAL OUTPUT IMPEDANCE:  
 $|I_{OHA}| = I_{OLA} = 10mA$  MIN at  
 $V_{CCA} = 3.0V$ ;  $V_{CCB} = 1.4V$  to  $3.6V$   
 $|I_{OHA}| = I_{OLA} = 8mA$  MIN at  
 $V_{CCA} = 2.3V$ ;  $V_{CCB} = 1.4$  to  $3.6V$
- BALANCED PROPAGATION DELAYS:  
 $t_{PLH} \cong t_{PHL}$
- POWER DOWN PROTECTION ON INPUTS  
AND OUTPUTS
- 26 $\Omega$  SERIES RESISTOR ON A SIDE OUTPUTS
- OPERATING VOLTAGE RANGE:  
 $V_{CCA}(OPR) = 1.4V$  to  $3.6V$  (1.2V Data Retent)  
 $V_{CCB}(OPR) = 1.4V$  to  $3.6V$  (1.2V Data Retent)
- MAX DATA RATES:  
380 Mbps (1.8V to 3.3V translation)  
260 Mbps (<1.8V to 3.3V translation)  
260 Mbps (Translate to 2.5V)  
210 Mbps (Translate to 1.5V)  
100 Mbps (Translate to 1.2V)
- LATCH-UP PERFORMANCE EXCEEDS  
500mA (JESD 17)
- ESD PERFORMANCE:  
HBM > 2000V (MIL STD 883 method 3015);  
MM > 200V
- R<sub>0</sub>HS Compliant for FLIPCHIP Package

#### DESCRIPTION

The ST4G3234 is a dual supply low voltage CMOS 4-BIT BUS BUFFER level translator fabricated with sub-micron silicon gate and five-layer metal wiring C<sup>2</sup>MOS technology. Designed for use as an interface between a 3.3V bus and a 2.5V or 1.8V bus in a mixed 3.3V/1.8V, 3.3V/2.5V, 1.8V/1.4V and 2.5V/1.8V supply systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

This IC is intended for one-way asynchronous communication between data buses. The input and output power down protections disable the device when both power supply are down, so that the buses are effectively isolated.

The input tolerant buffers allow to translate  $V_{CCB}$  compatible signals and greater signals than  $V_{CCB}$  up/down to  $V_{CCA}$ .

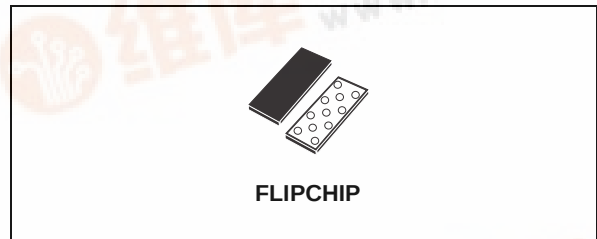


Table 1: Order Codes

| PACKAGE    | T & R       | Comments            |
|------------|-------------|---------------------|
| FLIPCHIP11 | ST4G3234BJR | 5000 parts per reel |

All inputs are equipped with protection circuits against static discharge, giving them ESD immunity and transient excess voltage.

Figure 1: Logic Diagram

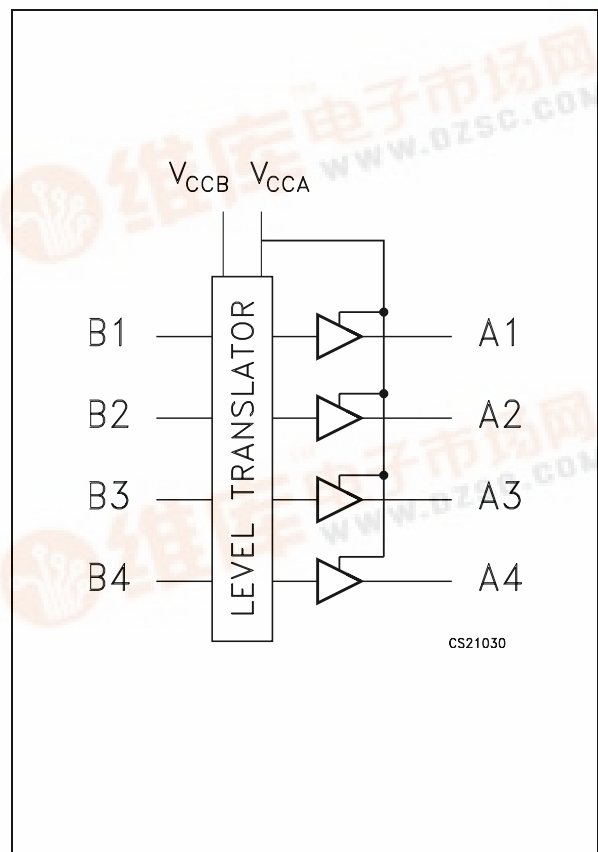


Figure 2: Input And Output Equivalent Circuit

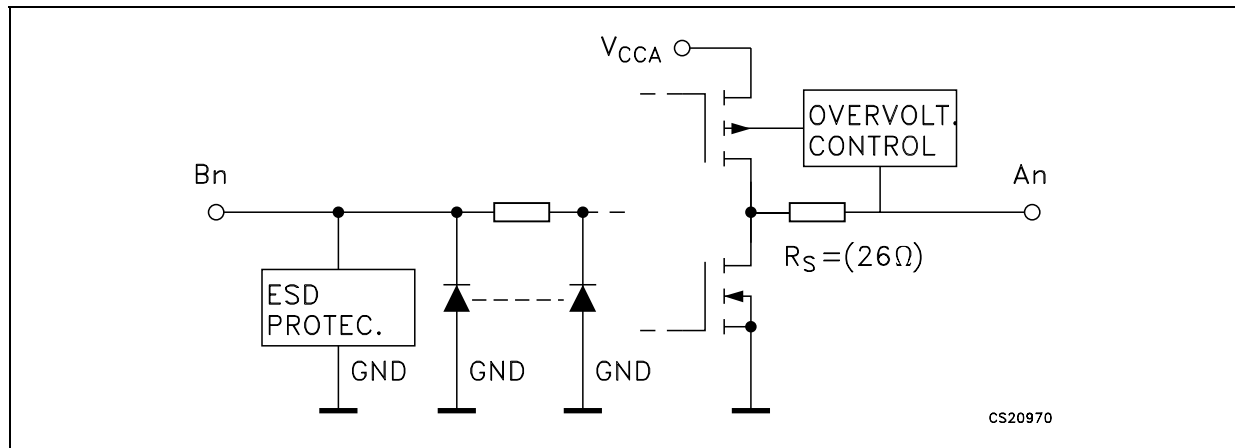


Table 2: Pin Description

| PIN° | SYMBOL           | NAME AND FUNCTION       |
|------|------------------|-------------------------|
| A1   | A4               | Data Output             |
| A3   | A3               | Data Output             |
| A5   | A2               | Data Output             |
| A7   | A1               | Data Output             |
| C1   | B4               | Data Input              |
| C3   | B3               | Data Input              |
| C5   | B2               | Data Input              |
| C7   | B1               | Data Input              |
| B2   | GND              | Ground (0V)             |
| B6   | V <sub>CCA</sub> | Positive Supply Voltage |
| B4   | V <sub>CCB</sub> | Positive Supply Voltage |

Figure 3: Pin Connection (top through view)

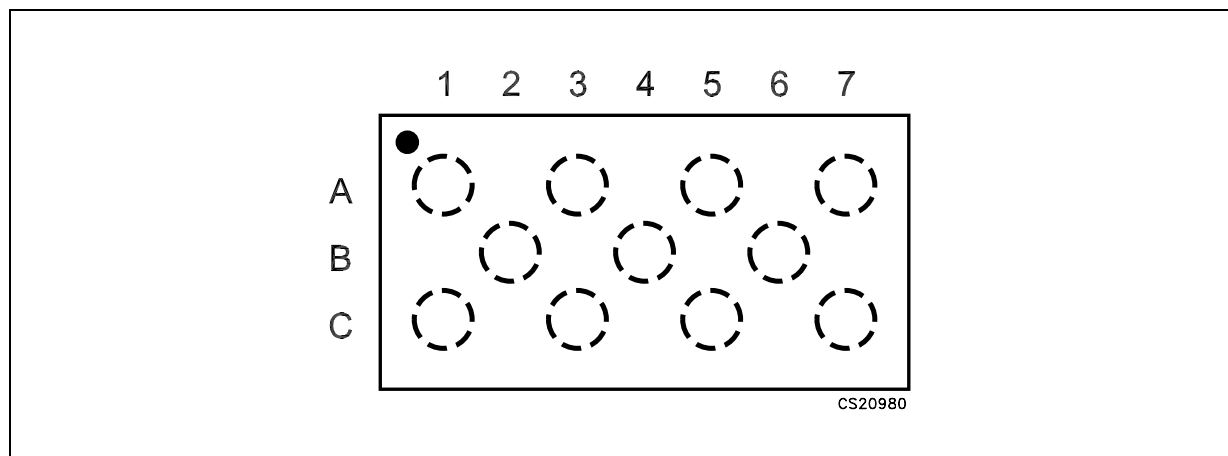


Table 3: Truth Table

| INPUTS Bn ( $V_{CCB}$ Referred) | OUTPUTS Bn ( $V_{CCA}$ Referred) |
|---------------------------------|----------------------------------|
| L                               | L                                |
| H                               | H                                |

Table 4: Absolute Maximum Ratings

| Symbol    | Parameter                                                   | Value                   | Unit |
|-----------|-------------------------------------------------------------|-------------------------|------|
| $V_{CCA}$ | Output Supply Voltage                                       | -0.5 to +4.6            | V    |
| $V_{CCB}$ | Input Supply Voltage                                        | -0.5 to +4.6            | V    |
| $V_{OA}$  | DC Output Voltage (Power Down Mode: $V_{CCA}=V_{CCB}=Gnd$ ) | -0.5 to +4.6            | V    |
| $V_{IB}$  | DC Input Voltage (Power Down Mode: $V_{CCA}=V_{CCB}=Gnd$ )  | -0.5 to +4.6            | V    |
| $V_{OA}$  | DC Output Voltage                                           | -0.5 to $V_{CCA} + 0.5$ | V    |
| $V_{IB}$  | DC Input Voltage                                            | -0.5 to +4.6            | V    |
| $I_{IK}$  | DC Input Diode Current                                      | - 20                    | mA   |
| $I_{OK}$  | DC Output Diode Current                                     | - 50                    | mA   |
| $I_{OA}$  | DC Output Current                                           | $\pm 50$                | mA   |
| $I_{CCA}$ | DC $V_{CCA}$ or Ground Current                              | $\pm 100$               | mA   |
| $I_{CCB}$ | DC $V_{CCB}$ or Ground Current                              | $\pm 100$               | mA   |
| $P_d$     | Power Dissipation                                           | 400                     | mW   |
| $T_{stg}$ | Storage Temperature                                         | -65 to +150             | °C   |
| $T_L$     | Lead Temperature (10 sec)                                   | 260                     | °C   |

Absolute Maximum Ratings are those value beyond which damage to the device may occur. Functional operation under these conditions is not implied

Table 5: Recommended Operating Conditions

| Symbol           | Parameter                         |                                 | Value                 | Unit |
|------------------|-----------------------------------|---------------------------------|-----------------------|------|
| V <sub>CCA</sub> | Supply Voltage                    |                                 | 1.4 to 3.6            | V    |
| V <sub>CCB</sub> | Supply Voltage                    |                                 | 1.4 to 3.6            | V    |
| V <sub>IB</sub>  | Input Voltage (Bn)                |                                 | 0 to V <sub>CCB</sub> | V    |
| V <sub>OA</sub>  | Output Voltage (An)               |                                 | 0 to V <sub>CCA</sub> | V    |
| T <sub>op</sub>  | Operating Temperature             |                                 | -40 to 85             | °C   |
| dt/dv            | Input Rise and Fall Time (note 1) | V <sub>CCB</sub> = 3.0 to 3.6V  | 0 to 10               | ns/V |
|                  |                                   | V <sub>CCB</sub> = 2.3 to 2.7V  | 0 to 20               | ns/V |
|                  |                                   | V <sub>CCB</sub> = 1.4 to 1.95V | 0 to 100              | ns/V |

1)  $V_I$  from 0.8V to 2.0V at  $V_{CC} = 3.0V$

Table 6: DC Specification

| Symbol             | Parameter                                     | Test Condition             |                            |                                                                                      | Value                  |      |                      |                      |                      | Unit |
|--------------------|-----------------------------------------------|----------------------------|----------------------------|--------------------------------------------------------------------------------------|------------------------|------|----------------------|----------------------|----------------------|------|
|                    |                                               | V <sub>CCB</sub><br>(V)(*) | V <sub>CCA</sub><br>(V)(*) |                                                                                      | T <sub>A</sub> = 25 °C |      |                      | -40 to 85 °C         |                      |      |
|                    |                                               |                            |                            |                                                                                      | Min.                   | Typ. | Max.                 | Min.                 | Max.                 |      |
| V <sub>IHB</sub>   | High Level Input Voltage (Bn)                 | 1.4                        | 1.4 to 3.6V                |                                                                                      | 0.65V <sub>CCB</sub>   |      |                      | 0.65V <sub>CCB</sub> |                      | V    |
|                    |                                               | 1.8                        |                            |                                                                                      | 0.65V <sub>CCB</sub>   |      |                      | 0.65V <sub>CCB</sub> |                      |      |
|                    |                                               | 2.5                        |                            |                                                                                      | 1.6                    |      |                      | 1.6                  |                      |      |
|                    |                                               | 3.3                        |                            |                                                                                      | 2.0                    |      |                      | 2.0                  |                      |      |
| V <sub>ILB</sub>   | Low Level Input Voltage (Bn)                  | 1.4                        | 1.4 to 3.6V                |                                                                                      |                        |      | 0.35V <sub>CCB</sub> |                      | 0.35V <sub>CCB</sub> | V    |
|                    |                                               | 1.8                        |                            |                                                                                      |                        |      | 0.35V <sub>CCB</sub> |                      | 0.35V <sub>CCB</sub> |      |
|                    |                                               | 2.5                        |                            |                                                                                      |                        |      | 0.7                  |                      | 0.7                  |      |
|                    |                                               | 3.3                        |                            |                                                                                      |                        |      | 0.8                  |                      | 0.8                  |      |
| V <sub>OHA</sub>   | High Level Output Voltage                     | 1.4 to 3.6V                | 1.4                        | I <sub>O</sub> =-100μA                                                               | 1.2                    |      |                      | 1.2                  |                      | V    |
|                    |                                               |                            | 2.75                       | I <sub>O</sub> =-10mA                                                                | 2.2                    |      |                      | 2.2                  |                      |      |
|                    |                                               |                            | 2.3                        | I <sub>O</sub> =-8mA                                                                 | 2.0                    |      |                      | 2.0                  |                      |      |
|                    |                                               |                            | 1.65                       | I <sub>O</sub> =-6mA                                                                 | 1.4                    |      |                      | 1.4                  |                      |      |
|                    |                                               |                            | 1.4                        | I <sub>O</sub> =-2mA                                                                 | 1.1                    |      |                      | 1.1                  |                      |      |
| V <sub>OLA</sub>   | Low Level Output Voltage                      | 1.4 to 3.6V                | 1.4                        | I <sub>O</sub> =100μA                                                                |                        |      | 0.2                  |                      | 0.2                  | V    |
|                    |                                               |                            | 2.75                       | I <sub>O</sub> =10mA                                                                 |                        |      | 0.55                 |                      | 0.55                 |      |
|                    |                                               |                            | 2.3                        | I <sub>O</sub> =8mA                                                                  |                        |      | 0.30                 |                      | 0.30                 |      |
|                    |                                               |                            | 1.65                       | I <sub>O</sub> =6mA                                                                  |                        |      | 0.25                 |                      | 0.25                 |      |
|                    |                                               |                            | 1.4                        | I <sub>O</sub> =2mA                                                                  |                        |      | 0.20                 |                      | 0.20                 |      |
| I <sub>IB</sub>    | Input Leakage Current                         | 2.7                        | 3.6                        | V <sub>IB</sub> =V <sub>CCB</sub> or GND                                             |                        |      | ± 0.5                |                      | ± 5                  | μA   |
|                    |                                               | 1.4                        | 2.7                        | V <sub>IB</sub> =3.6V or GND                                                         |                        |      | ± 0.5                |                      | ± 5                  | μA   |
| I <sub>OFF</sub>   | Power Off Leakage Current                     | 0                          | 0                          | V <sub>IB</sub> =GND to 3.6V<br>V <sub>OA</sub> =GND to 3.6V                         |                        |      | ± 1.0                |                      | ± 10                 | μA   |
| I <sub>CCIB</sub>  | Quiescent Supply Current                      | 1.4 to 3.6V                | 1.4 to 3.6V                | V <sub>IB</sub> =V <sub>CCB</sub> or GND                                             |                        |      | 0.5                  |                      | 5                    | μA   |
| I <sub>CCIA</sub>  | Quiescent Supply Current                      | 1.4 to 3.6V                | 1.4 to 3.6V                | V <sub>IB</sub> =V <sub>CCB</sub> or GND                                             |                        |      | 0.5                  |                      | 5                    | μA   |
| ΔI <sub>CCIB</sub> | Maximum Quiescent Supply Current / Input (Bn) | 2.7                        | 3.6                        | V <sub>IB</sub> =V <sub>CCB</sub> - 0.6V<br>V <sub>IB</sub> =V <sub>CCB</sub> or GND |                        |      |                      |                      | 0.75                 | mA   |
|                    |                                               | 1.95                       | 3.6                        |                                                                                      |                        |      |                      |                      |                      |      |
|                    |                                               | 1.95                       | 2.7                        |                                                                                      |                        |      |                      |                      |                      |      |

(\*)  $V_{CC}$  range =  $3.3 \pm 0.3$ ;  $2.5 \pm 0.2\text{V}$ ;  $1.8 \pm 0.15\text{V}$

Table 7: Dynamic Switching Characteristics

| Symbol            | Parameter                          | Test Condition          |                         |                                                                              | Value                  |       |      |              |      | Unit |
|-------------------|------------------------------------|-------------------------|-------------------------|------------------------------------------------------------------------------|------------------------|-------|------|--------------|------|------|
|                   |                                    | V <sub>CCB</sub><br>(V) | V <sub>CCA</sub><br>(V) |                                                                              | T <sub>A</sub> = 25 °C |       |      | -40 to 85 °C |      |      |
|                   |                                    |                         |                         |                                                                              | Min.                   | Typ.  | Max. | Min.         | Max. |      |
| V <sub>OLPA</sub> | Dynamic Low Level Quiet An Output  | 1.4                     | 1.8                     | C <sub>L</sub> =30pF<br>V <sub>IL</sub> =0V V <sub>IH</sub> =V <sub>CC</sub> |                        | 0.2   |      |              |      | V    |
|                   |                                    | 1.4-1.8                 | 2.5                     |                                                                              |                        | 0.25  |      |              |      |      |
|                   |                                    | 1.8-2.5                 | 3.3                     |                                                                              |                        | 0.35  |      |              |      |      |
| V <sub>OLVA</sub> | Dynamic Low Level Quiet An Output  | 1.4                     | 1.8                     | C <sub>L</sub> =30pF<br>V <sub>IL</sub> =0V V <sub>IH</sub> =V <sub>CC</sub> |                        | -0.2  |      |              |      | V    |
|                   |                                    | 1.4-1.8                 | 2.5                     |                                                                              |                        | -0.25 |      |              |      |      |
|                   |                                    | 1.8-2.5                 | 3.3                     |                                                                              |                        | -0.35 |      |              |      |      |
| V <sub>OHVA</sub> | Dynamic High Level Quiet An Output | 1.4                     | 1.8                     | C <sub>L</sub> =30pF<br>V <sub>IL</sub> =0V V <sub>IH</sub> =V <sub>CC</sub> |                        | 1.6   |      |              |      | V    |
|                   |                                    | 1.4-1.8                 | 2.5                     |                                                                              |                        | 2.1   |      |              |      |      |
|                   |                                    | 1.8-2.5                 | 3.3                     |                                                                              |                        | 2.7   |      |              |      |      |

Table 8: AC Electrical Characteristics

| Symbol                                 | Parameter                             | Test Condition          |                         |                                                  | Value        |      | Unit |
|----------------------------------------|---------------------------------------|-------------------------|-------------------------|--------------------------------------------------|--------------|------|------|
|                                        |                                       | V <sub>CCB</sub><br>(V) | V <sub>CCA</sub><br>(V) |                                                  | -40 to 85 °C |      |      |
|                                        |                                       |                         |                         |                                                  | Min.         | Max. |      |
| t <sub>PLH</sub><br>t <sub>PHL</sub>   | Propagation Delay Time Bn to An       | 2.3 to 3.6              | 1.4                     | C <sub>L</sub> = 10 pF                           | 2.0          | 5.5  | ns   |
|                                        |                                       | 1.4 to 1.95             | 1.4                     |                                                  | 2.0          | 5.5  |      |
|                                        |                                       | 2.3 to 3.6              | 1.65 to 1.95            |                                                  | 2.0          | 5.0  |      |
|                                        |                                       | 1.4 to 1.95             | 1.65 to 1.95            |                                                  | 2.0          | 5.2  |      |
|                                        |                                       | 1.4 to 1.95             | 2.3 to 2.7              |                                                  | 2.0          | 4.6  |      |
|                                        |                                       | 1.4 to 1.95             | 3.0 to 3.6              |                                                  | 2.0          | 4.3  |      |
|                                        |                                       | 2.3 to 2.7              | 3.0 to 3.6              |                                                  | 1.0          | 3.5  |      |
| t <sub>PLH</sub><br>t <sub>PHL</sub>   | Propagation Delay Time Bn to An       | 2.3 to 3.6              | 1.4                     | C <sub>L</sub> = 30 pF<br>R <sub>L</sub> = 500 Ω | 2.0          | 7.5  | ns   |
|                                        |                                       | 1.4 to 1.95             | 1.4                     |                                                  | 2.0          | 7.9  |      |
|                                        |                                       | 2.3 to 3.6              | 1.65 to 1.95            |                                                  | 2.0          | 6.0  |      |
|                                        |                                       | 1.4 to 1.95             | 1.65 to 1.95            |                                                  | 2.0          | 6.5  |      |
|                                        |                                       | 1.4 to 1.95             | 2.3 to 2.7              |                                                  | 2.0          | 5.7  |      |
|                                        |                                       | 1.4 to 1.95             | 3.0 to 3.6              |                                                  | 2.0          | 5.2  |      |
|                                        |                                       | 2.3 to 2.7              | 3.0 to 3.6              |                                                  | 1.0          | 4.6  |      |
| t <sub>OSLH</sub><br>t <sub>OSHL</sub> | Output To Output Skew Time (note1, 2) | 1.8 ± 0.15              | 2.5 ± 0.2               | C <sub>L</sub> = 30 pF<br>R <sub>L</sub> = 500 Ω |              | 0.5  | ns   |
|                                        |                                       | 1.8 ± 0.15              | 3.3 ± 0.3               |                                                  |              | 0.5  |      |
|                                        |                                       | 2.5 ± 0.2               | 3.3 ± 0.3               |                                                  |              | 0.75 |      |

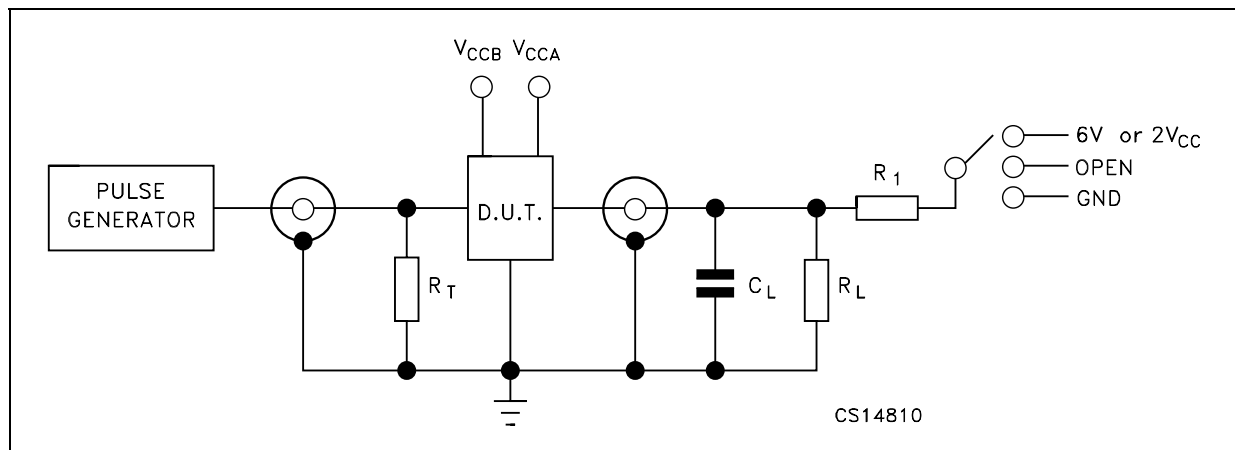
1) Skew is defined as the absolute value of the difference between the actual propagation delay for any two outputs of the same device switching in the same direction, either HIGH or LOW (t<sub>OSLH</sub> = |t<sub>PLHm</sub> - t<sub>PLHn</sub>|, t<sub>OSHL</sub> = |t<sub>PHLm</sub> - t<sub>PHLn</sub>|)  
 2) Parameter guaranteed by design

Table 9: Capacitance Characteristics

| Symbol           | Parameter                     | Test Condition          |                         |         | Value                  |      |      |              |      | Unit |
|------------------|-------------------------------|-------------------------|-------------------------|---------|------------------------|------|------|--------------|------|------|
|                  |                               | V <sub>CCB</sub><br>(V) | V <sub>CCA</sub><br>(V) |         | T <sub>A</sub> = 25 °C |      |      | -40 to 85 °C |      |      |
|                  |                               |                         |                         |         | Min.                   | Typ. | Max. | Min.         | Max. |      |
| C <sub>INB</sub> | Input Capacitance             | open                    | open                    |         |                        | 7    |      |              |      | pF   |
| C <sub>O</sub>   | Output Capacitance            | 2.5                     | 3.3                     |         |                        | 9    |      |              |      | pF   |
| C <sub>PD</sub>  | Power Dissipation Capacitance | 2.5                     | 3.3                     | f=10MHz |                        | 28   |      |              |      | pF   |
|                  |                               | 1.8                     | 3.3                     |         |                        | 28   |      |              |      |      |
|                  |                               | 1.4                     | 2.5                     |         |                        | 25   |      |              |      |      |
|                  |                               | 1.4                     | 1.8                     |         |                        | 21   |      |              |      |      |
|                  |                               | 3.3                     | 1.8                     |         |                        | 28   |      |              |      |      |

1) C<sub>PD</sub> is defined as the value of the IC's internal equivalent capacitance which is calculated from the operating current consumption without load. (Refer to Test Circuit). Average current can be obtained by the following equation.  $I_{CC(opr)} = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}/4$  (per circuit)

Figure 4: Test Circuit



| TEST                                | SWITCH |
|-------------------------------------|--------|
| t <sub>PLH</sub> , t <sub>PHL</sub> | Open   |

C<sub>L</sub> = 30pF or equivalent (includes jig and probe capacitance)  
R<sub>L</sub> = R<sub>1</sub> = 500Ω or equivalent  
R<sub>T</sub> = Z<sub>OUT</sub> of pulse generator (typically 50Ω)

Table 10: Waveform Symbol Value

| Symbol          | V <sub>CC</sub>       |                        |                        |
|-----------------|-----------------------|------------------------|------------------------|
|                 | 3.0 to 3.6V           | 2.3 to 2.7V            | 1.65 to 1.95V          |
| V <sub>IH</sub> | V <sub>CC</sub>       | V <sub>CC</sub>        | V <sub>CC</sub>        |
| V <sub>M</sub>  | 1.5V                  | V <sub>CC</sub> /2     | V <sub>CC</sub> /2     |
| V <sub>X</sub>  | V <sub>OL</sub> +0.3V | V <sub>OL</sub> +0.15V | V <sub>OL</sub> +0.15V |
| V <sub>Y</sub>  | V <sub>OL</sub> -0.3V | V <sub>OL</sub> -0.15V | V <sub>OL</sub> -0.15V |

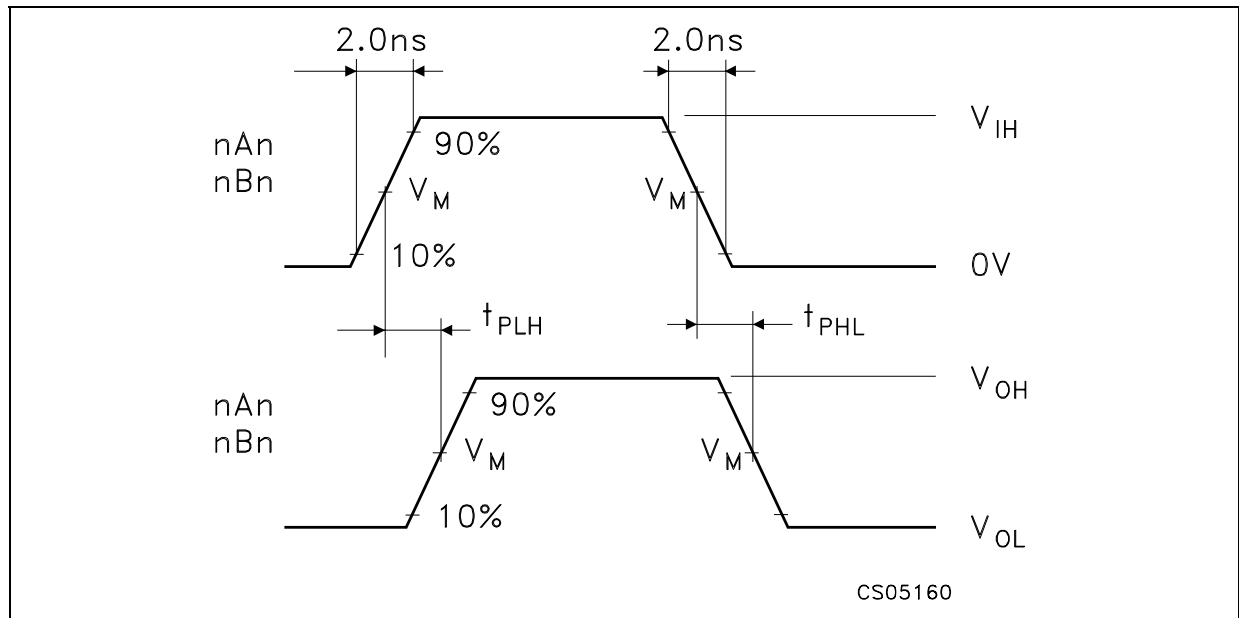
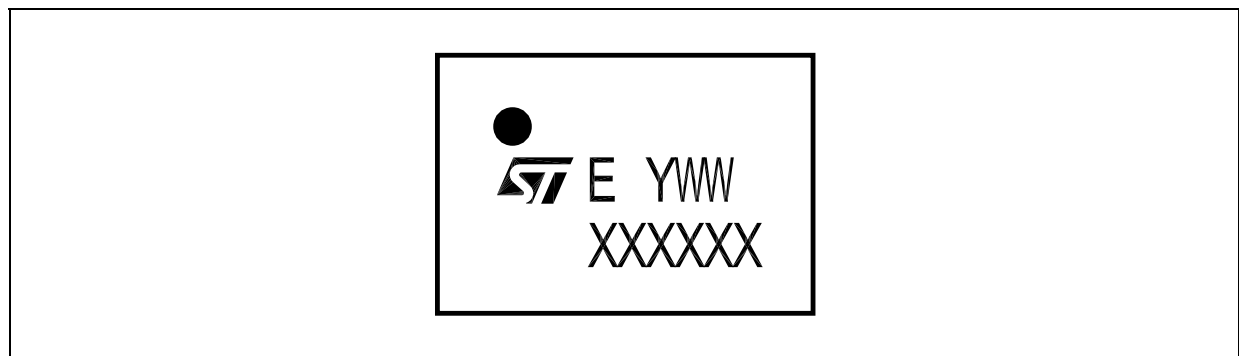
Figure 5: Waveform - Propagation Delay ( $f=1\text{MHz}$ ; 50% duty cycle)

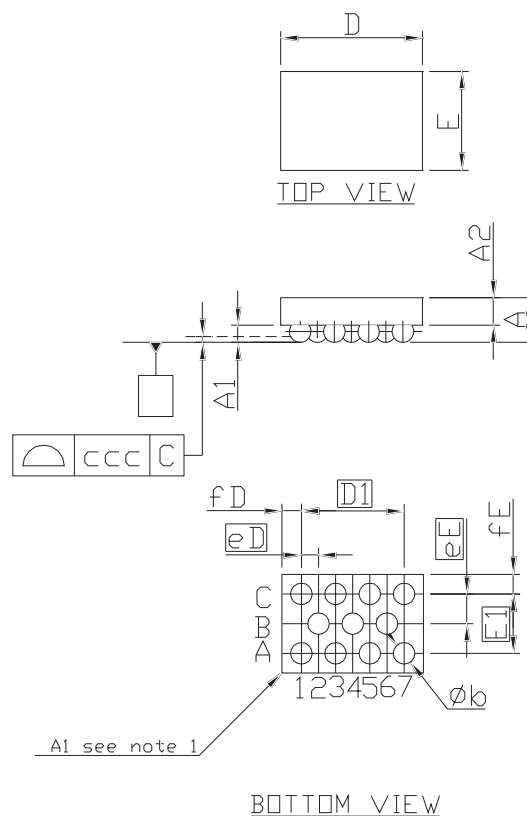
Figure 6: Marking



NOTE: E = Eco Level; Y = Assy Year; WW = Assy Week; X = Marking Area; Marking Code 9521

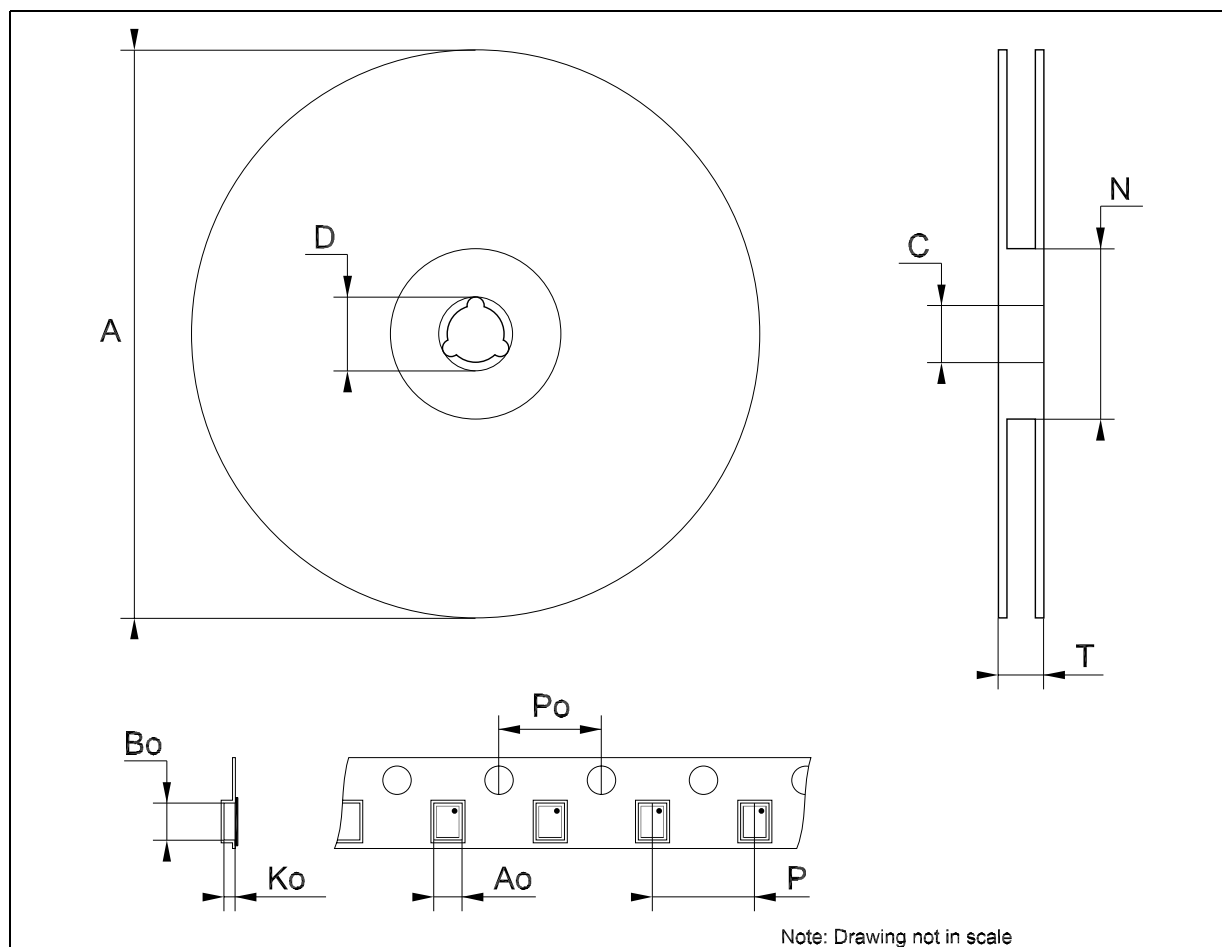
### Flip-Chip11 MECHANICAL DATA

| DIM. | mm.   |       |       | mils |      |      |
|------|-------|-------|-------|------|------|------|
|      | MIN.  | TYP   | MAX.  | MIN. | TYP. | MAX. |
| A    | 0.585 | 0.65  | 0.715 | 23.0 | 25.6 | 28.1 |
| A1   | 0.21  | 0.25  | 0.29  | 8.3  | 9.8  | 11.4 |
| A2   |       | 0.40  |       |      | 15.7 |      |
| b    | 0.265 | 0.315 | 0.365 | 10.4 | 12.4 | 14.4 |
| D    | 1.99  | 2.04  | 2.09  | 78.3 | 80.3 | 82.3 |
| D1   |       | 1.5   |       |      | 59.1 |      |
| E    | 1.36  | 1.41  | 1.46  | 53.5 | 55.5 | 57.5 |
| E1   |       | 0.866 |       |      | 34.1 |      |
| eD   | 0.2   | 0.25  | 0.30  | 7.9  | 9.8  | 11.8 |
| eE   | 0.383 | 0.433 | 0.483 | 15.1 | 17.0 | 19.0 |
| fD   |       | 0.270 |       |      | 10.6 |      |
| fE   |       | 0.272 |       |      | 10.7 |      |
| ccc  |       | 0.080 |       |      | 3.1  |      |



### Tape & Reel Flip-Chip 11 MECHANICAL DATA

| DIM. | mm.  |      |      | inch  |       |       |
|------|------|------|------|-------|-------|-------|
|      | MIN. | TYP  | MAX. | MIN.  | TYP.  | MAX.  |
| A    |      |      | 178  |       |       | 6.926 |
| C    | 12.8 |      | 13.2 | 0.504 |       | 0.519 |
| D    | 20.2 |      |      | 0.795 |       |       |
| N    | 49   | 50   | 51   | 1.929 | 1.969 | 2.008 |
| T    |      |      | 12.4 |       |       | 0.488 |
| Ao   | 2.29 | 2.34 | 2.39 | 0.090 | 0.092 | 0.094 |
| Bo   | 1.65 | 1.70 | 1.75 | 0.065 | 0.067 | 0.069 |
| Ko   | 0.76 | 0.81 | 0.86 | 0.030 | 0.032 | 0.034 |
| Po   | 3.9  | 4    | 4.1  | 0.153 | 0.157 | 0.161 |
| P    | 3.9  | 4    | 4.1  | 0.153 | 0.157 | 0.161 |



**Table 11: Revision History**

| Date        | Revision | Description of Changes                                     |
|-------------|----------|------------------------------------------------------------|
| 14-Oct-2004 | 1        | First Release.                                             |
| 26-Oct-2004 | 2        | Mechanical Data has been updated.                          |
| 18-Nov-2004 | 3        | Mistake $V_{OHA}$ on table 6.                              |
| 11-Feb-2005 | 4        | Add Tape & Reel and Figure 6.                              |
| 18-Feb-2005 | 5        | Table 1 has been updated from 4000 to 5000 parts per Reel. |
| 18-Mar-2005 | 6        | Add Features ==> Max Data Rates.                           |
| 09-May-2005 | 7        | Table 8 and Table 9 have been updated.                     |

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