

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

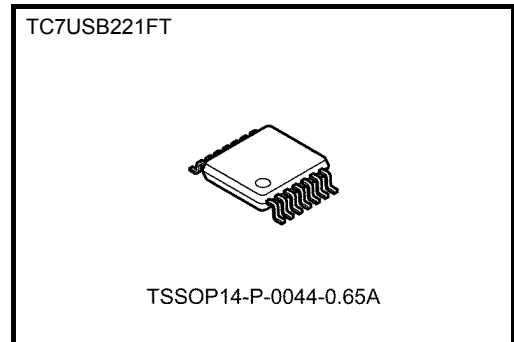
# TC7USB221FT

## Dual SPDT USB Switch

TC7USB221 is high-speed CMOS dual 1-2 multiplexer/demultiplexer. The low on resistance and the low capacitance of the switch allow connections to USB application.

This device consists of dual individual two-inputs multiplexer/demultiplexer with common select input (S) and output enable ( $\overline{OE}$ ). The D+/D- inputs is connected to the D1+/D1- or D2+/D2- outputs determined by the combination both the select input (S) and output enable ( $\overline{OE}$ ). When the output enable ( $\overline{OE}$ ) input is held "H" level, the switches are open with regardless the state of select inputs and a high-impedance state exists between the switches.

All inputs are equipped with protection circuits against static discharge.



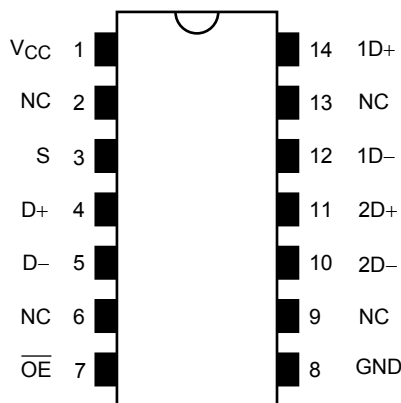
Weight  
TSSOP14-P-0044-0.65A: 0.06 g (typ.)

## Features

- Operating voltage:  $V_{CC} = 2.3$  to  $3.6$  V
- ON-capacitance:  $C_{I/O} = 7$  pF Switch ON (typ.) @  $V_{CC}=3.3$  V
- ON-resistance:  $R_{ON} = 6.5 \Omega$  (typ.) @  $V_{CC}=3$  V,  $V_{I/O}=0$  V
- $R_{ON}$  Flatness:  $R_{ON(Flat)} = 1.6 \Omega$  (typ.) @  $V_{CC}=3$  V
- Delta  $R_{ON}$ :  $\Delta R_{ON} = 0.5 \Omega$  (typ.) @  $V_{CC}=3$  V
- ESD performance: Machine model  $\geq \pm 200$  V  
Human body model  $\geq \pm 2000$  V
- Power-down protection for inputs ( $\overline{OE}$  and S, I/O)
- Package: TSSOP14

## Pin Assignment (top view)

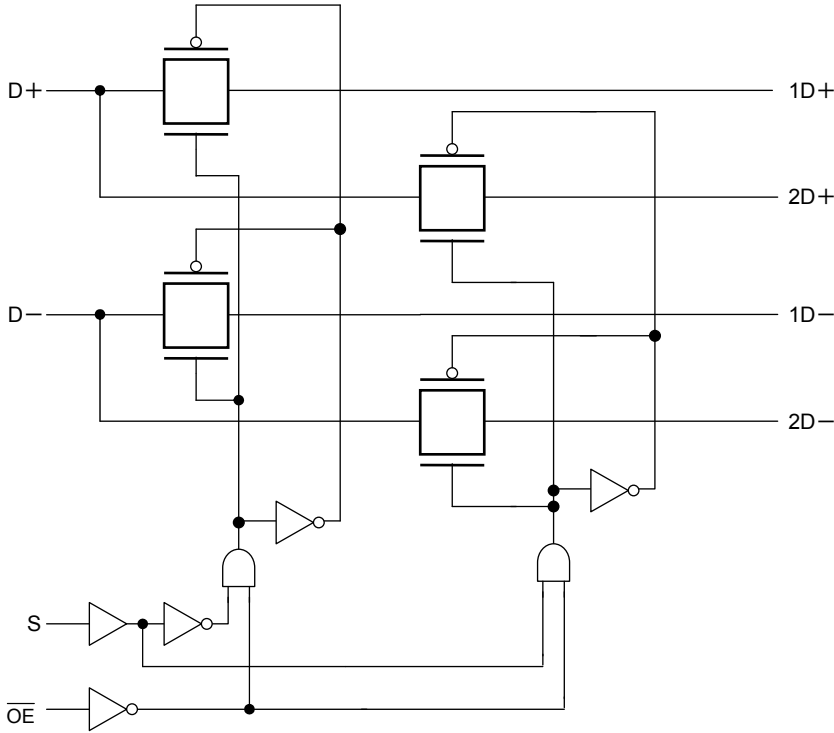
FT (TSSOP14-P-0044-0.65A)



**Truth Table**

| Inputs          |   | Function                               |
|-----------------|---|--|
| $\overline{OE}$ | S |  |
| L               | L | D+ port = 1D+ port, D- Port = 1D- Port |
| L               | H | D+ port = 2D+ port, D- Port = 2D- Port |
| H               | X | Disconnect                             |

**System Diagram**



## Absolute Maximum Ratings (Note)

| Characteristic                                   |                            | Symbol           | Rating               | Unit        |
|--|----------------------------|------------------|----------------------|-------------|
| Power supply range                               |                            | $V_{CC}$         | -0.5 to 4.6          | V           |
| Control pin input voltage ( $\overline{OE}$ , S) |                            | $V_{IN}$         | -0.5 to 4.6          | V           |
| Switch terminal I/O voltage                      | $V_{CC}=0$ V or Switch=Off | $V_S$            | -0.5 to 4.6          | V           |
|  | Switch=On                  |                  | -0.5 to $V_{CC}+0.5$ |             |
| Clump diode current                              | Control input              | $I_{IK}$         | -50                  | mA          |
|  | Switch                     |                  | $\pm 50$             |             |
| Switch I/O current                               |                            | $I_S$            | 50                   | mA          |
| Power dissipation                                |                            | $P_D$            | 180                  | mW          |
| DC $V_{CC}/GND$ current                          |                            | $I_{CC}/I_{GND}$ | $\pm 100$            | mA          |
| Storage temperature                              |                            | $T_{stg}$        | -65 to 150           | $^{\circ}C$ |

Note: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction. Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc.).

## Operating Ranges (Note)

| Characteristic                                   |                            | Symbol    | Rating        | Unit        |
|--|----------------------------|-----------|---------------|-------------|
| Power supply voltage                             |                            | $V_{CC}$  | 2.3 to 3.6    | V           |
| Control pin input voltage ( $\overline{OE}$ , S) |                            | $V_{IN}$  | 0 to 3.6      | V           |
| Switch I/O voltage                               | $V_{CC}=0$ V or Switch=Off | $V_S$     | 0 to 3.6      | V           |
|  | Switch=On                  |           | 0 to $V_{CC}$ |             |
| Operating temperature                            |                            | $T_{opr}$ | -40 to 85     | $^{\circ}C$ |
| Input rise and fall time                         |                            | dt/dv     | 0 to 10       | ns/V        |

Note: The operating ranges must be maintained to ensure the normal operation of the device. Unused inputs must be tied to either  $V_{CC}$  or GND.

## Electrical Characteristics

### DC Characteristics (Ta = -40 to 85°C)

| Characteristics                                 | Symbol                | Test Condition  | V <sub>CC</sub> (V) | Min        | Typ.                   | Max | Unit                   |    |
|---|-----------------------|---|---------------------|------------|------------------------|-----|------------------------|----|
|   |                       |   |                     |            |                        |     |                        |    |
| Input voltage<br>( $\overline{OE}$ , S)         | "H" level             | V <sub>IH</sub>   | —                   | 2.3 to 3.6 | 0.46 × V <sub>CC</sub> | —   | —                      | V  |
|   | "L" level             | V <sub>IL</sub>   | —                   | 2.3 to 3.6 | —                      | —   | 0.25 × V <sub>CC</sub> |    |
| Input leakage current<br>( $\overline{OE}$ , S) | I <sub>IN</sub>       | V <sub>IN</sub> = 0 to 3.6 V                                      |                     | 2.3 to 3.6 | —                      | —   | ±1.0                   | μA |
| Power-off leakage current                       | I <sub>OFF</sub>      | V <sub>IN</sub> = 0 to 3.6 V                                      |                     | 0          | —                      | —   | ±5.0                   | μA |
| Off-state leakage current<br>(switch off)       | I <sub>SZ</sub>       | D+, D- = 0 to V <sub>CC</sub> , $\overline{OE}$ = V <sub>CC</sub> |                     | 2.3 to 3.6 | —                      | —   | ±5.0                   | μA |
| ON resistance<br>(Note2)                        | R <sub>ON</sub>       | V <sub>IS</sub> = 0 V, I <sub>IS</sub> = 30 mA (Note1)            | 3.0                 | —          | 6.5                    | 10  | Ω                      |    |
|   |                       | V <sub>IS</sub> = 0.4 V, I <sub>IS</sub> = 30 mA (Note1)          | 3.0                 | —          | 7.0                    | 11  |                        |    |
|   |                       | V <sub>IS</sub> = 3.0 V, I <sub>IS</sub> = 30 mA (Note1)          | 3.0                 | —          | 13                     | 19  |                        |    |
| Delta R <sub>ON</sub>                           | Δ R <sub>ON</sub>     | V <sub>IS</sub> = 0.4 V, 1.0 V, I <sub>IS</sub> = 30 mA           |                     | 3.0        | —                      | 0.5 | —                      | Ω  |
| On-Resistance Flatness                          | R <sub>ON(flat)</sub> | V <sub>IN</sub> = 0 V to 1.0 V, I <sub>IS</sub> = 30 mA           |                     | 3.0        | —                      | 1.6 | —                      | Ω  |
| Quiescent supply current                        | I <sub>CC</sub>       | V <sub>IN</sub> = V <sub>CC</sub> or GND, I <sub>OUT</sub> = 0    |                     | 3.6        | —                      | —   | 2.0                    | μA |
| Increase in I <sub>CC</sub> per input           | Δ I <sub>CC</sub>     | V <sub>IN</sub> = 1.8 V   |                     | 3.6        | —                      | —   | 10.0                   | μA |

Note1: All typical values are at Ta = 25°C.

Note2: Measured by the voltage drop between D+/D- and 1D+/1D-, 2D+/2D- pins at the indicated current through the switch. ON resistance is determined by the lower of the voltages on the two pins.

## AC Characteristics $V_{CC}=3.3V \pm 10\%$ ( $T_a = -40$ to $85^\circ C$ )

| Characteristics   | Symbol             | Test Condition                             | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|--------------------|--|--------------|-----|------|-----|------|
|   |                    |  |              |     |      |     |      |
| Propagation Delay Time (Note)   | t <sub>pd</sub>    | C <sub>L</sub> =5 pF                       | 3.3 ± 0.3    | —   | 0.25 | —   | ns   |
| Turn ON Time (S, $\overline{OE}$ to Output)   | t <sub>ON</sub>    | R <sub>L</sub> =50 Ω, C <sub>L</sub> =5 pF | 3.3 ± 0.3    | —   | 7.5  | 17  | ns   |
| Turn OFF Time (S, $\overline{OE}$ to Output)  | t <sub>OFF</sub>   | R <sub>L</sub> =50 Ω, C <sub>L</sub> =5 pF | 3.3 ± 0.3    | —   | 3.3  | 10  | ns   |
| Break Before Make   | TBBM               | R <sub>L</sub> =50 Ω, C <sub>L</sub> =5 pF | 3.3 ± 0.3    | 2   | —    | 7.0 | ns   |
| Output skew between center port to any other port (Note)                                      | t <sub>SK(O)</sub> | C <sub>L</sub> =5 pF                       | 3.3 ± 0.3    | —   | 0.1  | —   | ns   |
| Skew of Opposite Transitions of the same output (t <sub>PHL</sub> - t <sub>PLH</sub> ) (Note) | t <sub>SK(P)</sub> | C <sub>L</sub> =5 pF                       | 3.3 ± 0.3    | —   | 0.1  | —   | ns   |
| Off Isolation (Non-Adjacent)  | OIRR               | R <sub>T</sub> =50 Ω, f=240 MHz            | 3.3 ± 0.3    | —   | -36  | —   | dB   |
| Crosstalk(Non-Adjacent)   | XTalk              | R <sub>T</sub> =50 Ω, f=240 MHz            | 3.3 ± 0.3    | —   | -36  | —   | dB   |
| -3dB Bandwidth  | BW                 | R <sub>T</sub> =50 Ω, C <sub>L</sub> =0 pF | 3.3 ± 0.3    | —   | 720  | —   | MHz  |

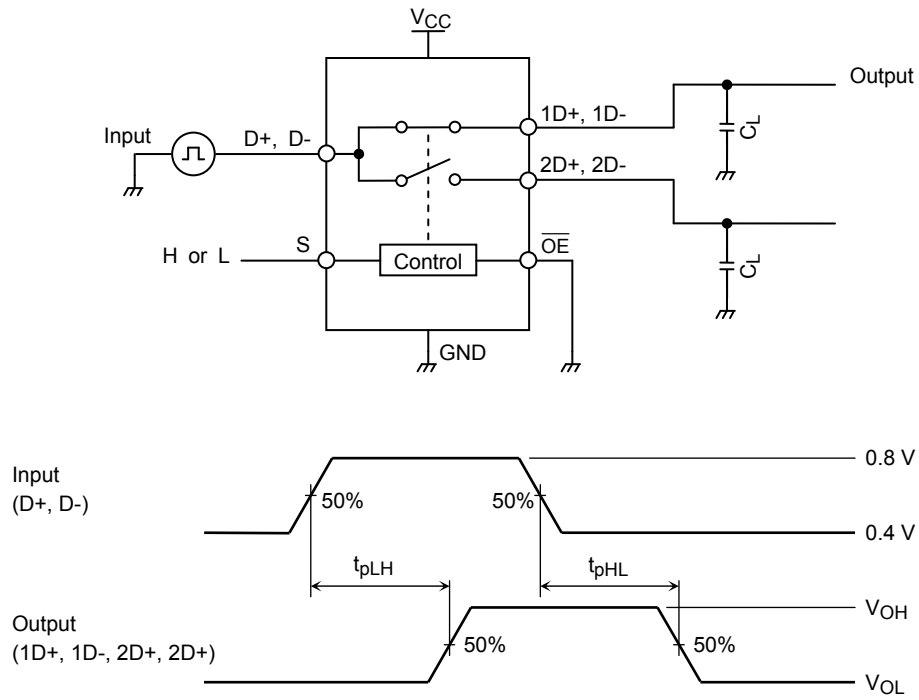
Note: This parameter is guaranteed by design.

## Capacitive Characteristics ( $T_a = 25^\circ C$ )

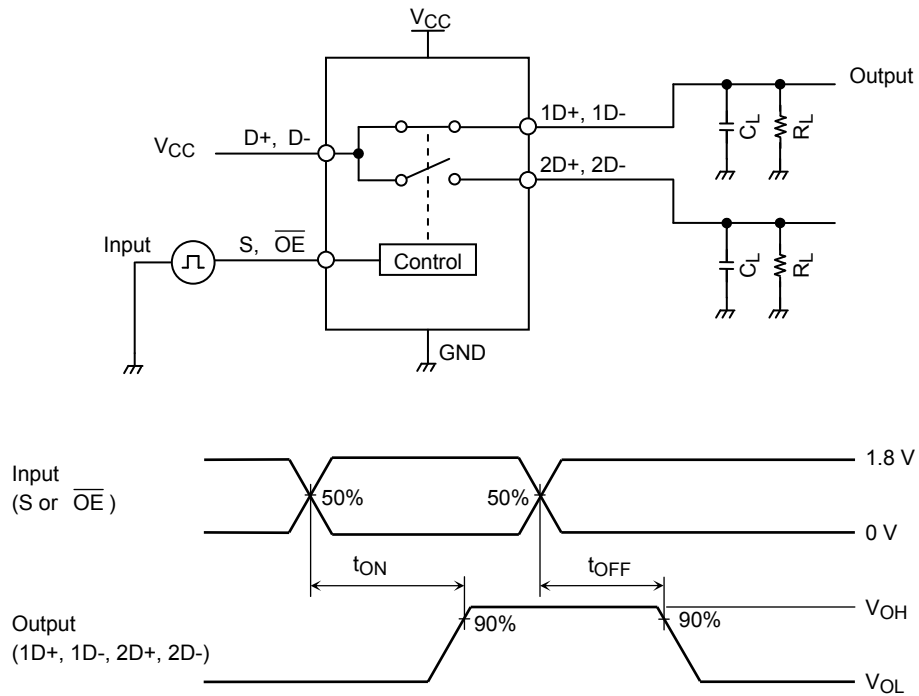
| Characteristics                                      | Symbol           | Test Condition   | $V_{CC}$ (V) | Typ. | Unit |
|--|------------------|--|--------------|------|------|
|  |                  |  |              |      |      |
| Control pin input capacitance ( $\overline{OE}$ , S) | C <sub>IN</sub>  | V <sub>IN</sub> = 0 V (Note)                           | 3.3          | 4    | pF   |
| Switch terminal Off capacitance (D+, D-)             | C <sub>I/O</sub> | V <sub>IS</sub> = 0 V, $\overline{OE} = V_{CC}$ (Note) | 3.3          | 4    | pF   |
| Switch terminal Off capacitance (1D+, 1D-, 2D+, 2D-) | C <sub>I/O</sub> | V <sub>IS</sub> = 0 V, $\overline{OE} = V_{CC}$ (Note) | 3.3          | 3    | pF   |
| Switch terminal On capacitance                       | C <sub>I/O</sub> | V <sub>IS</sub> = 0 V, $\overline{OE} = GND$ (Note)    | 3.3          | 7    | pF   |

Note: This parameter is guaranteed by design.

**AC Test Circuit Load/Waveform**



**Figure 1 : Propagation Delay Time ( $t_{pLH}$ ,  $t_{pHL}$ )**



**Figure 2 : Turn ON/Turn OFF ( $t_{ON}$ ,  $t_{OFF}$ )**

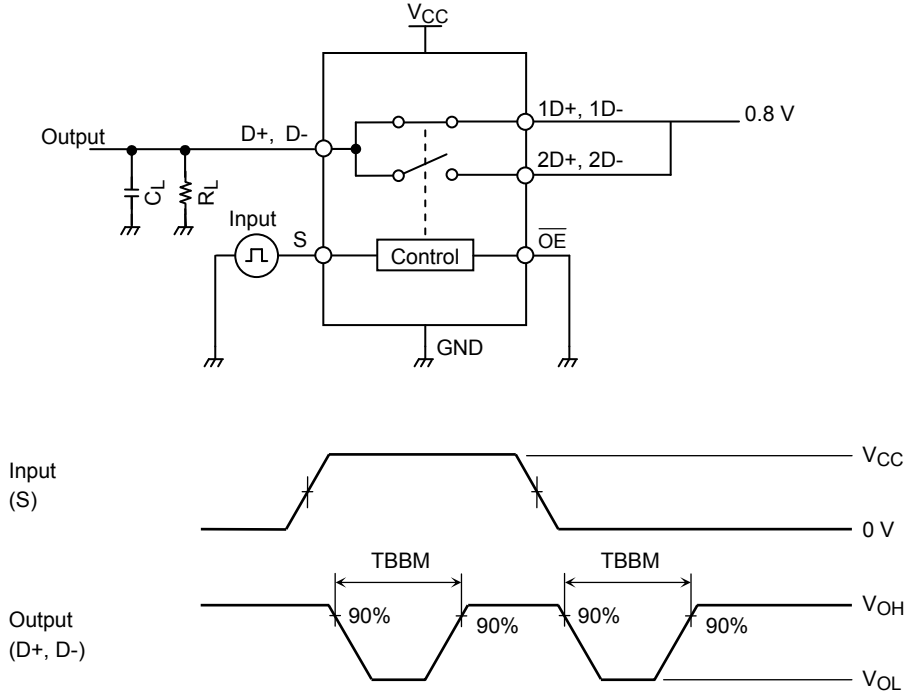
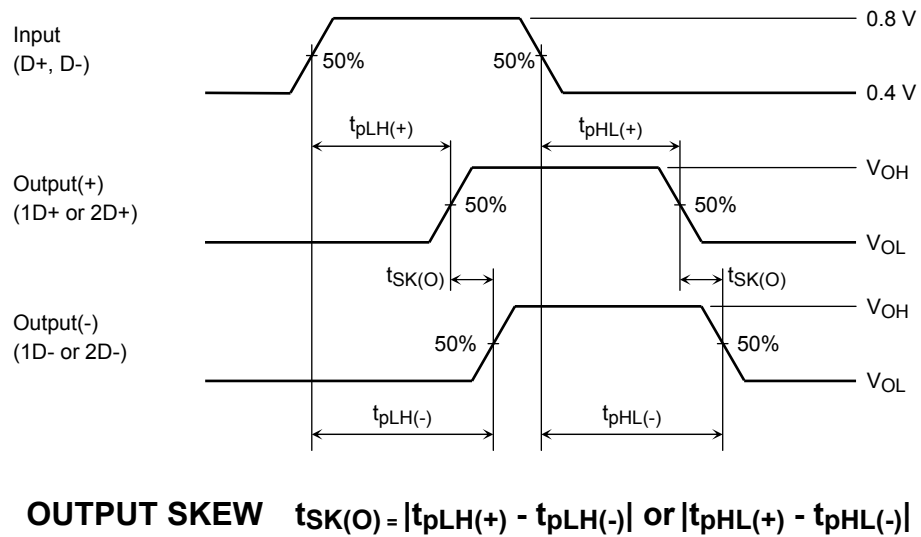
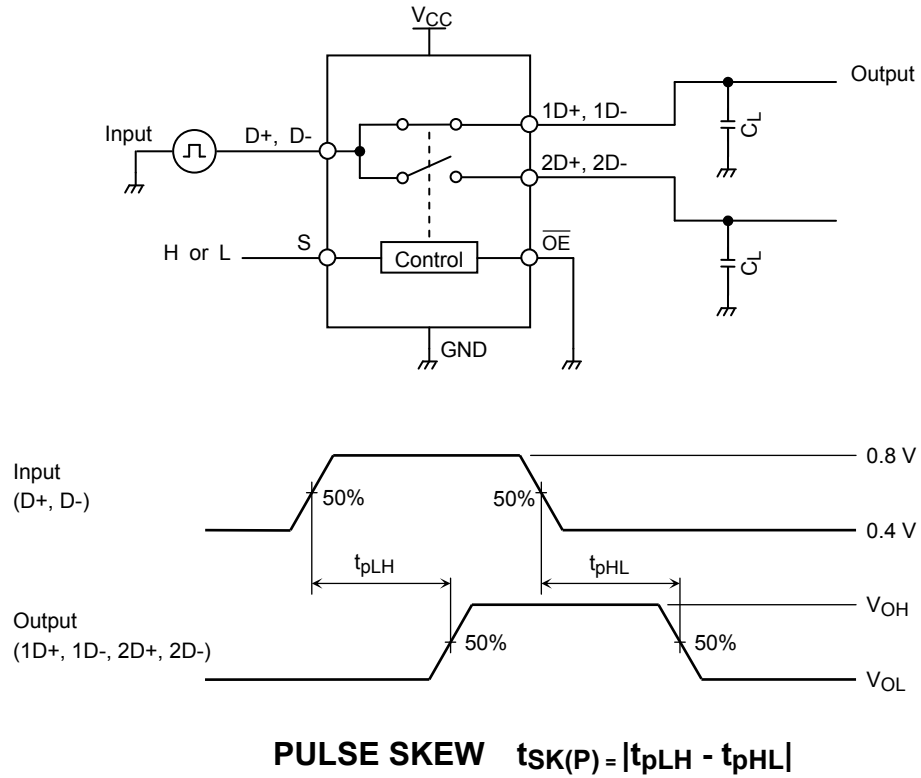
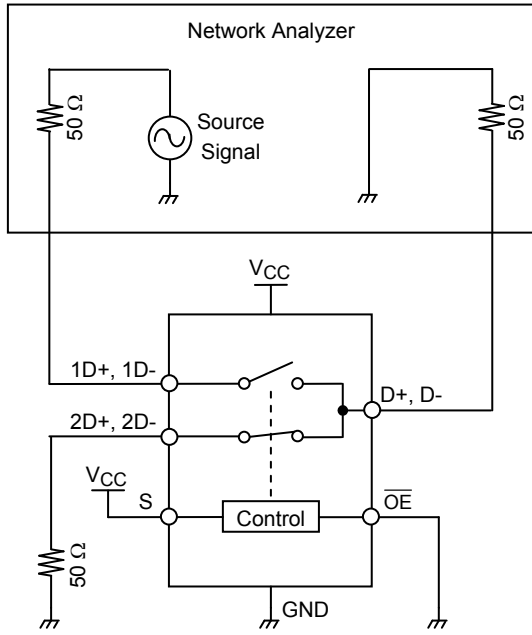


Figure 3 : Break Before Make (TBBM)

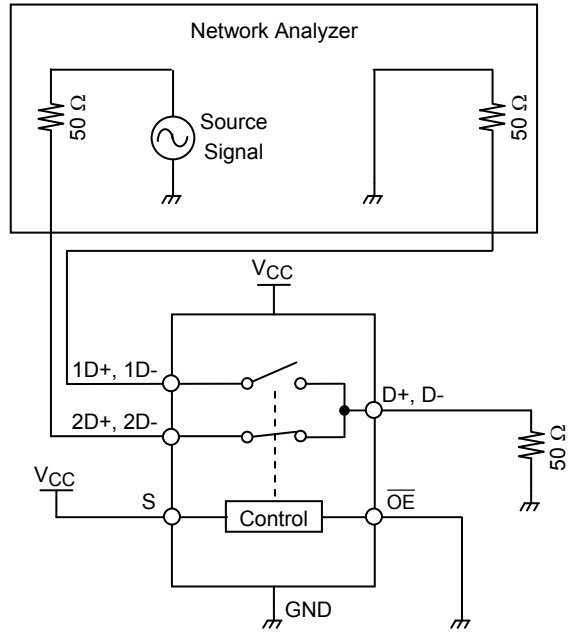


**Figure 4 : Skew of Opposite Transitions of the same output, Output skew**

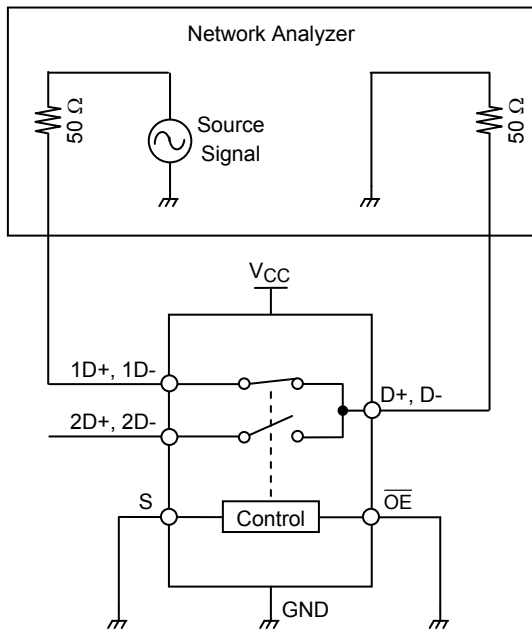




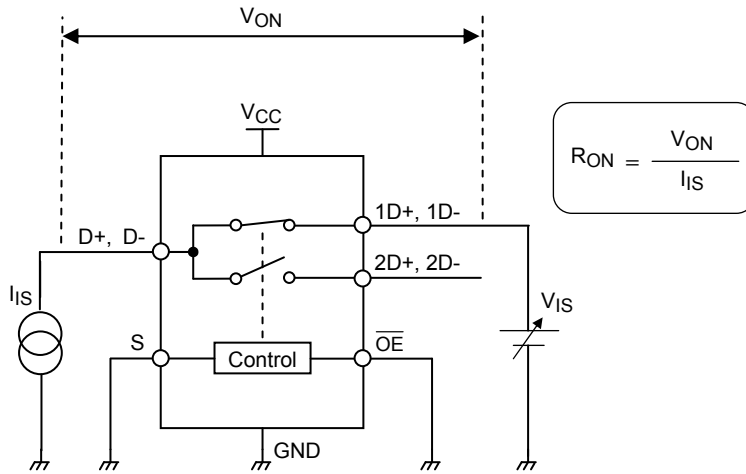
**Figure 5 : Channel OFF Isolation**



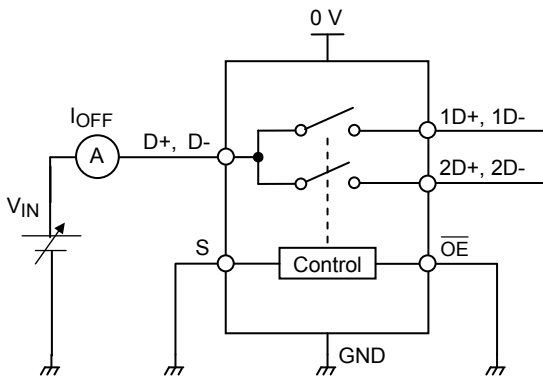
**Figure 6 : Crosstalk**



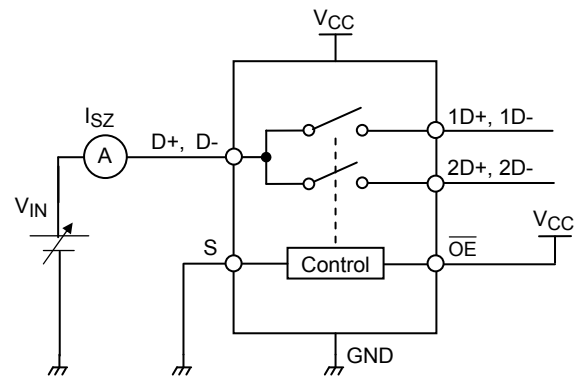
**Figure 7 : -3dB Bandwidth**



**Figure 8 : ON Resistance**



**Figure 9 : Power off Leakage Current**

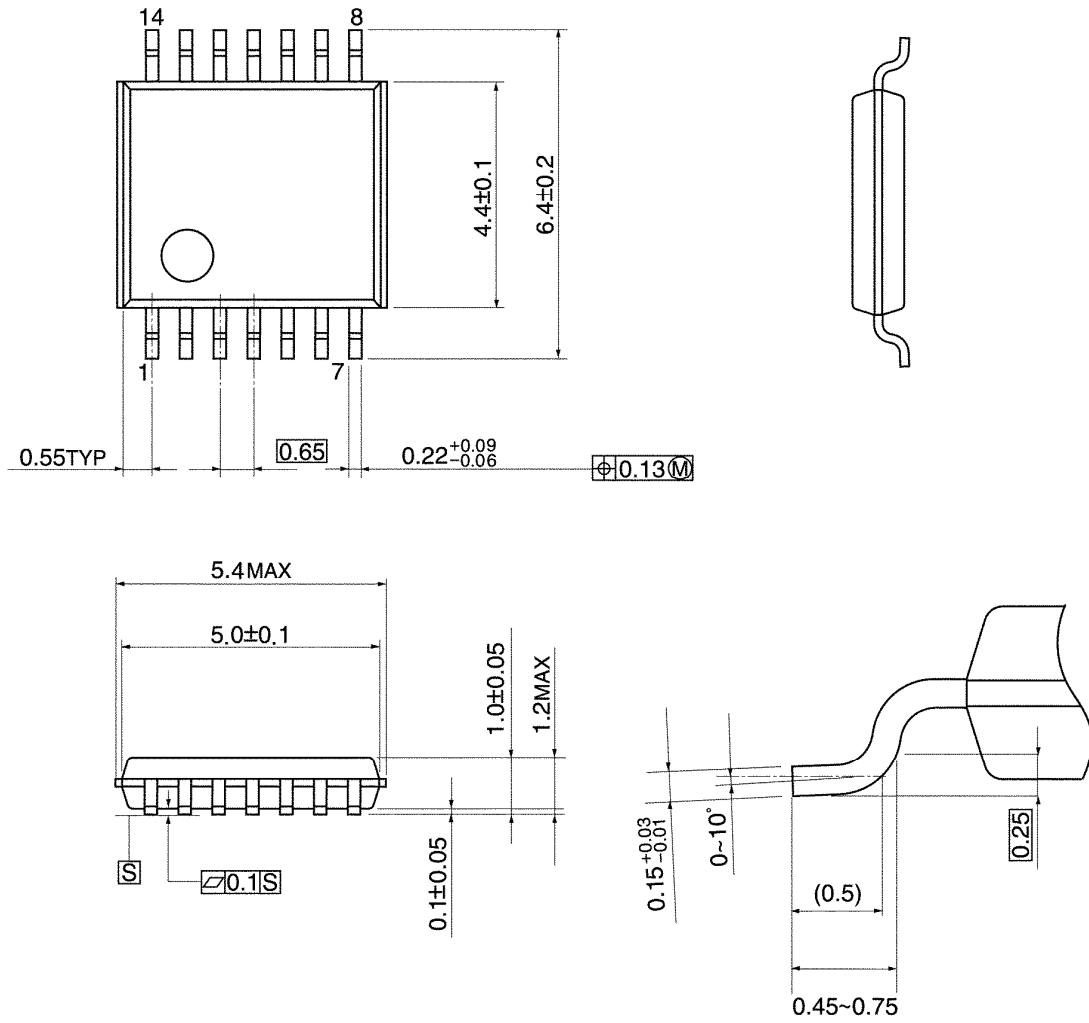


**Figure 10 : Off-State Leakage current**

**Package Dimension**

TSSOP14-P-0044-0.65A

Unit: mm



Weight: 0.06 g (Typ.)

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