

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74VCX16835FT

## Low-Voltage 18-Bit Universal Bus Driver with 3.6-V Tolerant Inputs and Outputs

The TC74VCX16835FT is a high-performance CMOS 18-bit universal bus driver. Designed for use in 1.8-V, 2.5-V or 3.3-V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.

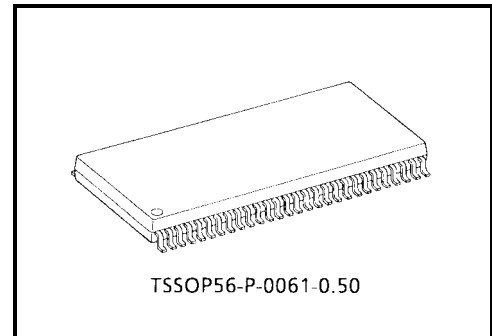
It is also designed with overvoltage tolerant inputs and outputs up to 3.6 V.

Data flow from A to Y is controlled by the output-enable ( $\overline{OE}$ ) input.

The device operates in the transparent mode when the latch-enable (LE) input is high. When LE is low, the A data is latched if the clock (CK) input is held at a high or low logic level. If LE is low, the A data is stored in the latch/flip-flop on the low-to-high transition of CK.

When  $\overline{OE}$  is high, the outputs are in the high-impedance state.

All inputs are equipped with protection circuits against static discharge.

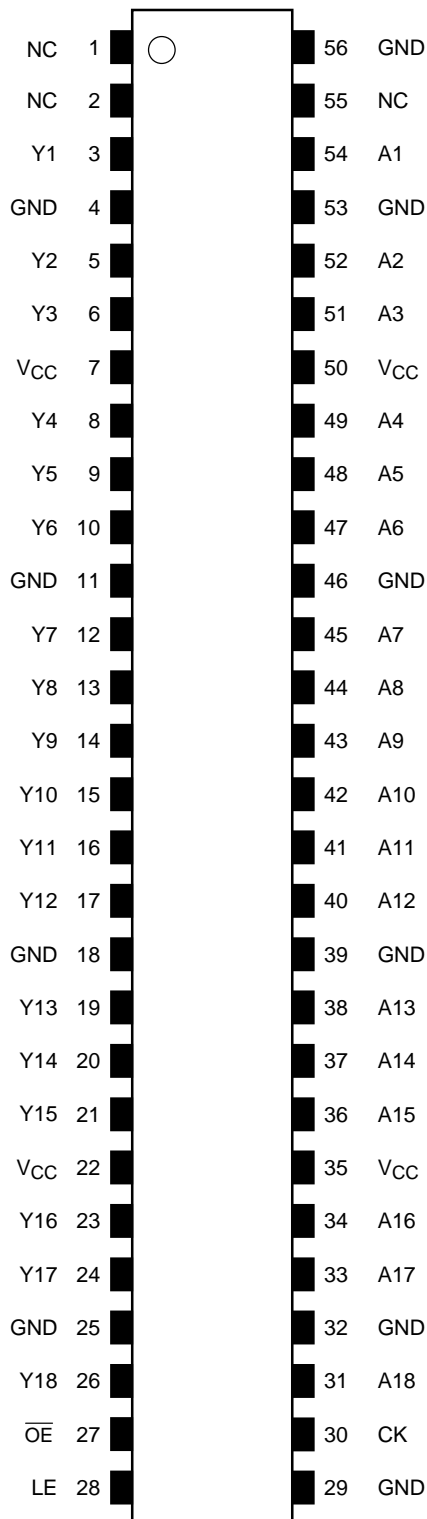


Weight: 0.25 g (typ.)

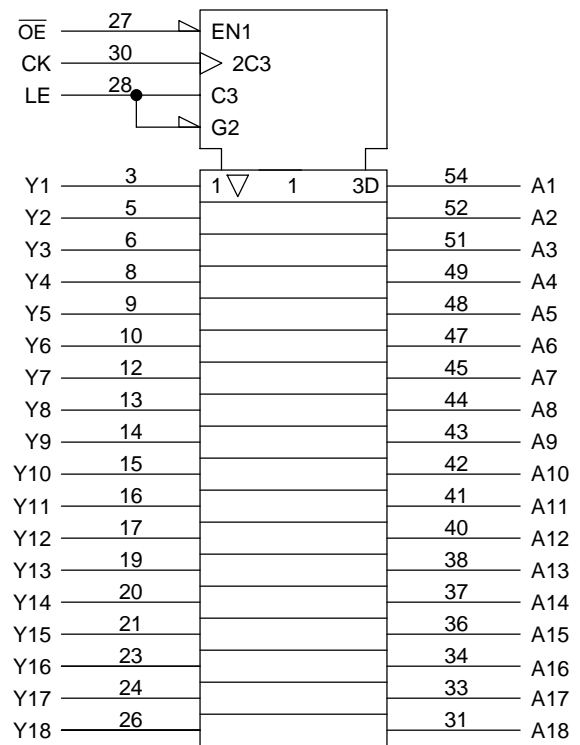
### Features

- Low-voltage operation:  $V_{CC} = 1.8$  to  $3.6$  V
- High-speed operation:  $t_{pd} = 3.3$  ns (max) ( $V_{CC} = 3.0$  to  $3.6$  V)  
:  $t_{pd} = 4.2$  ns (max) ( $V_{CC} = 2.3$  to  $2.7$  V)  
:  $t_{pd} = 8.4$  ns (max) ( $V_{CC} = 1.8$  V)
- Output current:  $I_{OH}/I_{OL} = \pm 24$  mA (min) ( $V_{CC} = 3.0$  V)  
:  $I_{OH}/I_{OL} = \pm 18$  mA (min) ( $V_{CC} = 2.3$  V)  
:  $I_{OH}/I_{OL} = \pm 6$  mA (min) ( $V_{CC} = 1.8$  V)
- Latch-up performance:  $\pm 300$  mA
- ESD performance: Machine model  $> \pm 200$  V  
: Human body model  $> \pm 2000$  V
- Package: TSSOP (thin shrink small outline package)
- 3.6-V tolerant function and power-down protection is provided on all inputs and outputs

## Pin Assignment (top view)



## IEC Logic Symbol



**Truth Table**

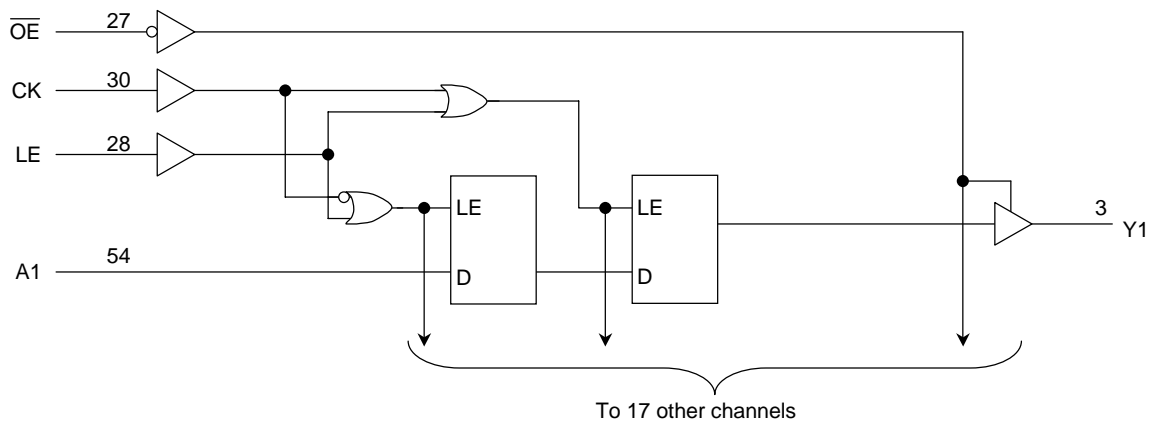
Inputs				Outputs Y
$\overline{OE}$	LE	CK	A	
H	X	X	X	Z
L	H	X	L	L
L	H	X	H	H
L	L	$\uparrow$	L	L
L	L	$\uparrow$	H	H
L	L	H	X	Y0 (Note 1)
L	L	L	X	Y0 (Note 1)

X: Don't care

Z: High impedance

Note 1: Output level before the indicated steady-state input conditions were established, provided that CK was high or low before LE went low.

**System Diagram**



## Maximum Ratings

Characteristics	Symbol	Rating	Unit
Power supply voltage	$V_{CC}$	-0.5 to 4.6	V
DC input voltage	$V_{IN}$	-0.5 to 4.6	V
DC output voltage	$V_{OUT}$	-0.5 to 4.6 (Note 2)	V
		-0.5 to $V_{CC} + 0.5$ (Note 3)	
Input diode current	$I_{IK}$	-50	mA
Output diode current	$I_{OK}$	$\pm 50$ (Note 4)	mA
DC output current	$I_{OUT}$	$\pm 50$	mA
Power dissipation	$P_D$	400	mW
DC $V_{CC}$ /ground current per supply pin	$I_{CC}/I_{GND}$	$\pm 100$	mA
Storage temperature	$T_{stg}$	-65 to 150	$^{\circ}C$

Note 2: OFF state

Note 3: High or low state.  $I_{OUT}$  absolute maximum rating must be observed.

Note 4:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## Recommended Operating Range

Characteristics	Symbol	Rating	Unit
Power supply voltage	$V_{CC}$	1.8 to 3.6	V
		1.2 to 3.6 (Note 5)	
Input voltage	$V_{IN}$	-0.3 to 3.6	V
Output voltage	$V_{OUT}$	0 to 3.6 (Note 6)	V
		0 to $V_{CC}$ (Note 7)	
Output current	$I_{OH}/I_{OL}$	$\pm 24$ (Note 8)	mA
		$\pm 18$ (Note 9)	
		$\pm 6$ (Note 10)	
Operating temperature	$T_{opr}$	-40 to 85	$^{\circ}C$
Input rise and fall time	$dt/dv$	0 to 10 (Note 11)	ns/V

Note 5: Data retention only

Note 6: OFF state

Note 7: High or low state

Note 8:  $V_{CC} = 3.0$  to  $3.6$  V

Note 9:  $V_{CC} = 2.3$  to  $2.7$  V

Note 10:  $V_{CC} = 1.8$  V

Note 11:  $V_{IN} = 0.8$  to  $2.0$  V,  $V_{CC} = 3.0$  V

**Electrical Characteristics**

**DC Characteristics (Ta = -40 to 85°C, 2.7 V < VCC ≤ 3.6 V)**

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V <sub>IH</sub>	—		2.7 to 3.6	2.0	—	V
	L-level	V <sub>IL</sub>	—		2.7 to 3.6	—	0.8	
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	2.7 to 3.6	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -12 mA	2.7	2.2	—	
				I <sub>OH</sub> = -18 mA	3.0	2.4	—	
				I <sub>OH</sub> = -24 mA	3.0	2.2	—	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	2.7 to 3.6	—	0.2	
				I <sub>OL</sub> = 12 mA	2.7	—	0.4	
				I <sub>OL</sub> = 18 mA	3.0	—	0.4	
				I <sub>OL</sub> = 24 mA	3.0	—	0.55	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		2.7 to 3.6	—	±5.0	μA
3-state output OFF state current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0 to 3.6 V		2.7 to 3.6	—	±10.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.7 to 3.6	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		2.7 to 3.6	—	±20.0	
Increase in I <sub>CC</sub> per input		ΔI <sub>CC</sub>	V <sub>IH</sub> = V <sub>CC</sub> - 0.6 V		2.7 to 3.6	—	750	

**DC Characteristics (Ta = -40 to 85°C, 2.3 V ≤ VCC ≤ 2.7 V)**

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V <sub>IH</sub>	—		2.3 to 2.7	1.6	—	V
	L-level	V <sub>IL</sub>	—		2.3 to 2.7	—	0.7	
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	2.3 to 2.7	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -6 mA	2.3	2.0	—	
				I <sub>OH</sub> = -12 mA	2.3	1.8	—	
				I <sub>OH</sub> = -18 mA	2.3	1.7	—	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	2.3 to 2.7	—	0.2	
				I <sub>OL</sub> = 12 mA	2.3	—	0.4	
				I <sub>OL</sub> = 18 mA	2.3	—	0.6	
				I <sub>OL</sub> = 18 mA	2.3	—	0.6	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		2.3 to 2.7	—	±5.0	μA
3-state output OFF state current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0 to 3.6 V		2.3 to 2.7	—	±10.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.3 to 2.7	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		2.3 to 2.7	—	±20.0	

**DC Characteristics (Ta = -40 to 85°C, 1.8 V ≤ VCC < 2.3 V)**

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V <sub>IH</sub>	—		1.8 to 2.3	0.7 × V <sub>CC</sub>	—	V
	L-level	V <sub>IL</sub>	—		1.8 to 2.3	—	0.2 × V <sub>CC</sub>	
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	1.8	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -6 mA	1.8	1.4	—	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	1.8	—	0.2	
				I <sub>OL</sub> = 6 mA	1.8	—	0.3	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		1.8	—	±5.0	μA
3-state output OFF state current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0 to 3.6 V		1.8	—	±10.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		1.8	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		1.8	—	±20.0	

## AC Characteristics (Ta = -40 to 85°C, input: tr = tf = 2.0 ns, CL = 30 pF, RL = 500 Ω)

Characteristics	Symbol	Test Condition	VCC (V)	Min	Max	Unit
Maximum clock frequency	f <sub>max</sub>	Figure 1, Figure 3	1.8	100	—	MHz
			2.5 ± 0.2	200	—	
			3.3 ± 0.3	250	—	
Propagation delay time (An-Yn)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.8	1.5	8.4	ns
			2.5 ± 0.2	0.8	4.2	
			3.3 ± 0.3	0.6	3.3	
Propagation delay time (CK-Yn)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 3	1.8	2.0	9.2	ns
			2.5 ± 0.2	1.5	5.2	
			3.3 ± 0.3	1.4	4.2	
Propagation delay time (LE-Yn)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 4	1.8	1.5	9.8	ns
			2.5 ± 0.2	0.8	4.9	
			3.3 ± 0.3	0.6	3.8	
Output enable time	t <sub>pZL</sub> t <sub>pZH</sub>	Figure 1, Figure 5	1.8	1.5	9.8	ns
			2.5 ± 0.2	0.8	4.9	
			3.3 ± 0.3	0.6	3.8	
Output disable time	t <sub>pLZ</sub> t <sub>pHZ</sub>	Figure 1, Figure 5	1.8	1.5	7.6	ns
			2.5 ± 0.2	0.8	4.5	
			3.3 ± 0.3	0.6	3.9	
Minimum pulse width	t <sub>W (H)</sub> t <sub>W (L)</sub>	Figure 1, Figure 3, Figure 4	1.8	4.0	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum setup time (An-CK, An-LE)	t <sub>s</sub>	Figure 1, Figure 3, Figure 4	1.8	2.5	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum hold time (An-CK, An-LE)	t <sub>h</sub>	Figure 1, Figure 3, Figure 4	1.8	1.0	—	ns
			2.5 ± 0.2	0.7	—	
			3.3 ± 0.3	0.7	—	
Output to output skew	t <sub>osLH</sub> t <sub>osHL</sub>	(Note 12)	1.8	—	0.5	ns
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

Note 12: Parameter guaranteed by design.

$$(t_{osLH} = |t_{pLHm} - t_{pLHn}|, t_{osHL} = |t_{pHLm} - t_{pHLn}|)$$

## AC Characteristics (Ta = 0 to 85°C, input: tr = tf = 2.0 ns, CL = 0 pF, RL = 500 Ω)

Characteristics	Symbol	Test Condition	VCC (V)	Min	Max	Unit
Propagation delay time (An-Yn)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2 (Note 13)	3.3 ± 0.15	0.9	2.0	ns
Propagation delay time (CK-Yn)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 3 (Note 13)	3.3 ± 0.15	1.5	2.9	ns
Propagation delay time (LE-Yn)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 4 (Note 13)	3.3 ± 0.15	0.7	2.6	ns
Output enable time	t <sub>pZL</sub> t <sub>pZH</sub>	Figure 1, Figure 5 (Note 13)	3.3 ± 0.15	0.7	2.6	ns
Output disable time	t <sub>pLZ</sub> t <sub>pHZ</sub>	Figure 1, Figure 5 (Note 13)	3.3 ± 0.15	0.7	2.7	ns
Minimum setup time (An-CK, An-LE)	t <sub>s</sub>	Figure 1, Figure 3, Figure 4 (Note 13)	3.3 ± 0.15	1.5	—	ns
Minimum hold time (An-CK, An-LE)	t <sub>h</sub>	Figure 1, Figure 3, Figure 4 (Note 13)	3.3 ± 0.15	0.7	—	ns

Note 13: TOSHIBA SPICE simulation data.

## AC Characteristics (Ta = 0 to 85°C, input: tr = tf = 2.0 ns, CL = 50 pF, RL = 500 Ω)

Characteristics	Symbol	Test Condition	VCC (V)	Min	Max	Unit
Propagation delay time (An-Yn)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	3.3 ± 0.15	1.0	3.6	ns
Propagation delay time (CK-Yn)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 3	3.3 ± 0.15	1.7	4.5	ns
Propagation delay time (LE-Yn)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 4	3.3 ± 0.15	1.0	4.1	ns
Output enable time	t <sub>pZL</sub> t <sub>pZH</sub>	Figure 1, Figure 5	3.3 ± 0.15	1.0	4.1	ns
Output disable time	t <sub>pLZ</sub> t <sub>pHZ</sub>	Figure 1, Figure 5	3.3 ± 0.15	1.0	4.2	ns
Minimum setup time (An-CK, An-LE)	t <sub>s</sub>	Figure 1, Figure 3, Figure 4	3.3 ± 0.15	1.5	—	ns
Minimum hold time (An-CK, An-LE)	t <sub>h</sub>	Figure 1, Figure 3, Figure 4	3.3 ± 0.15	0.7	—	ns



## Dynamic Switching Characteristics

( $T_a = 25^\circ\text{C}$ , input:  $t_r = t_f = 2.0 \text{ ns}$ ,  $C_L = 30 \text{ pF}$ ,  $R_L = 500 \Omega$ )

Characteristics	Symbol	Test Condition	V <sub>CC</sub> (V)	Typ.	Unit
Quiet output maximum dynamic V <sub>OL</sub>	V <sub>OLP</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note 14)	1.8	0.35	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note 14)	2.5	0.7	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note 14)	3.3	0.9	
Quiet output minimum dynamic V <sub>OL</sub>	V <sub>OLV</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note 14)	1.8	-0.35	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note 14)	2.5	-0.7	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note 14)	3.3	-0.9	
Quiet output minimum dynamic V <sub>OH</sub>	V <sub>OHV</sub>	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note 14)	1.8	1.3	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note 14)	2.5	1.7	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note 14)	3.3	2.0	

Note 14: Parameter guaranteed by design.

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

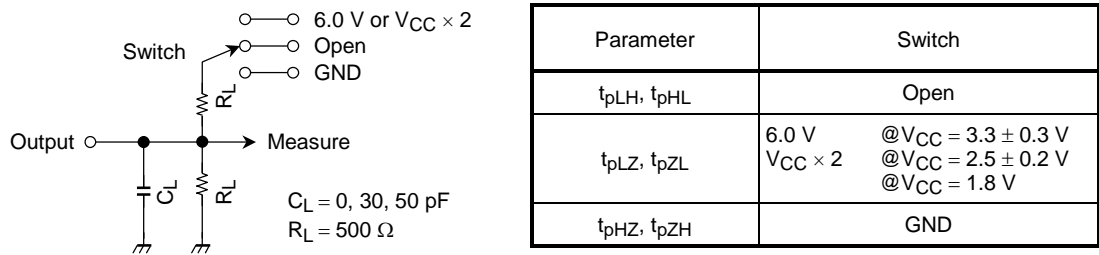
Characteristics	Symbol	Test Condition	V <sub>CC</sub> (V)	Typ.	Unit
Input capacitance	C <sub>IN</sub>	—	1.8, 2.5, 3.3	6	pF
Output capacitance	C <sub>OUT</sub>	—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C <sub>PD</sub>	f <sub>IN</sub> = 10 MHz (Note 15)	1.8, 2.5, 3.3	20	pF

Note 15: C<sub>PD</sub> is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation:

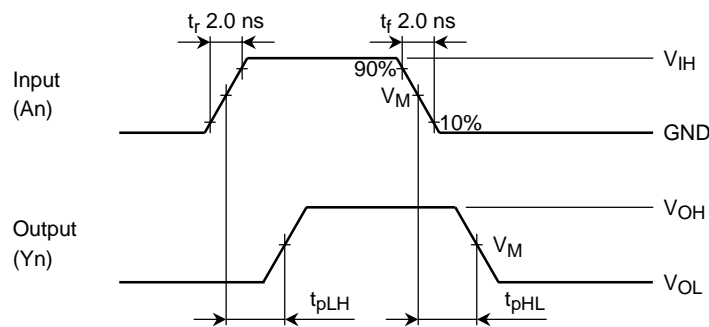
$$I_{CC(\text{opr})} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/18 \text{ (per bit)}$$

**AC Test Circuit**

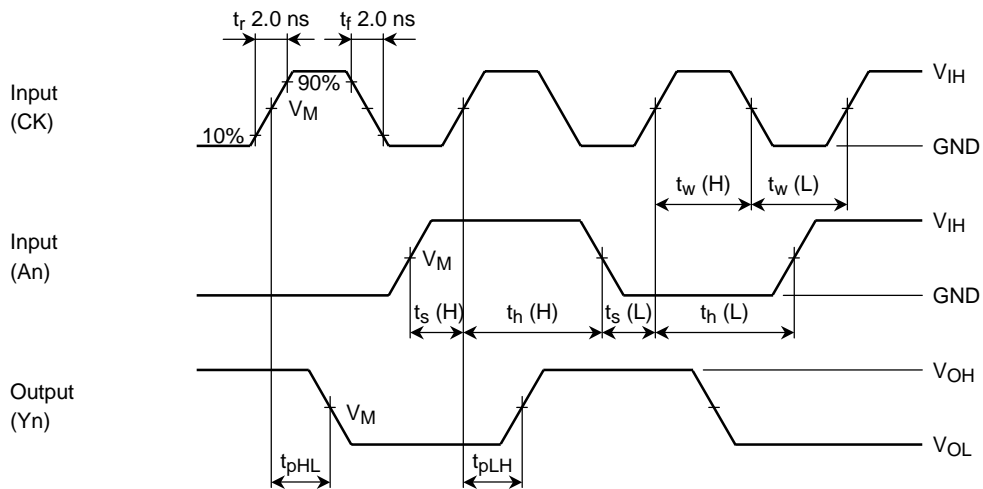


**Figure 1**

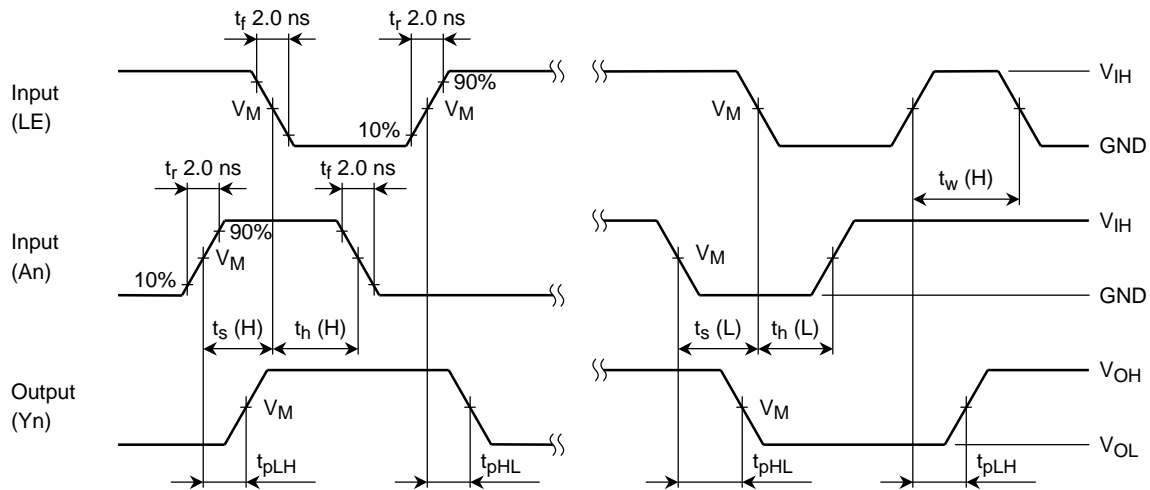
**AC Waveform**



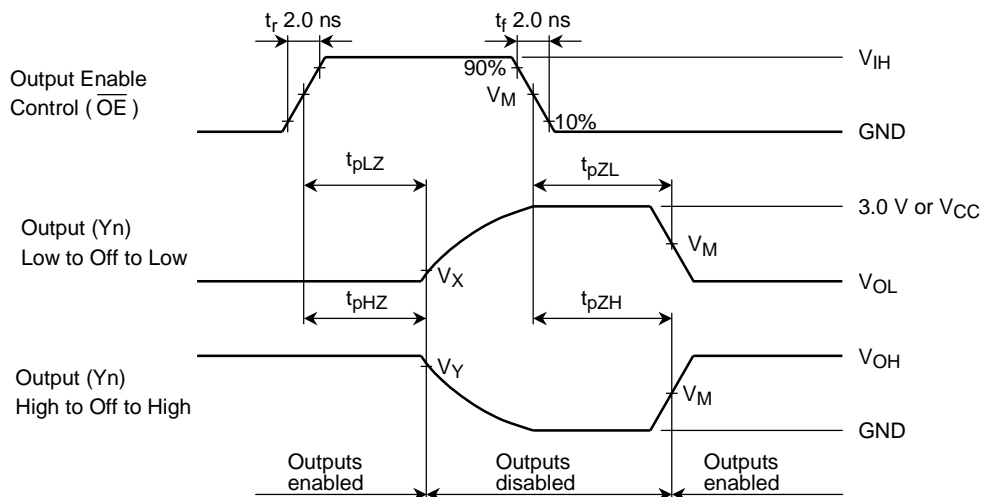
**Figure 2  $t_{pLH}$ ,  $t_{pHL}$**



**Figure 3  $t_{pLH}$ ,  $t_{pHL}$ ,  $t_w$ ,  $t_s$ ,  $t_h$**



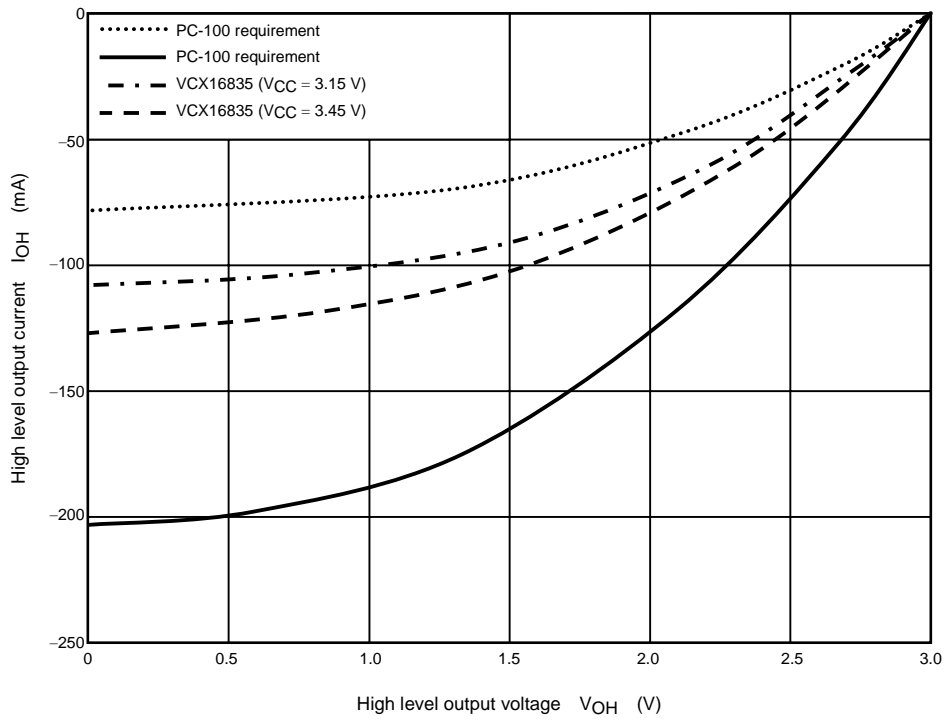
**Figure 4**  $t_{pLH}$ ,  $t_{pHL}$ ,  $t_w$ ,  $t_s$ ,  $t_h$



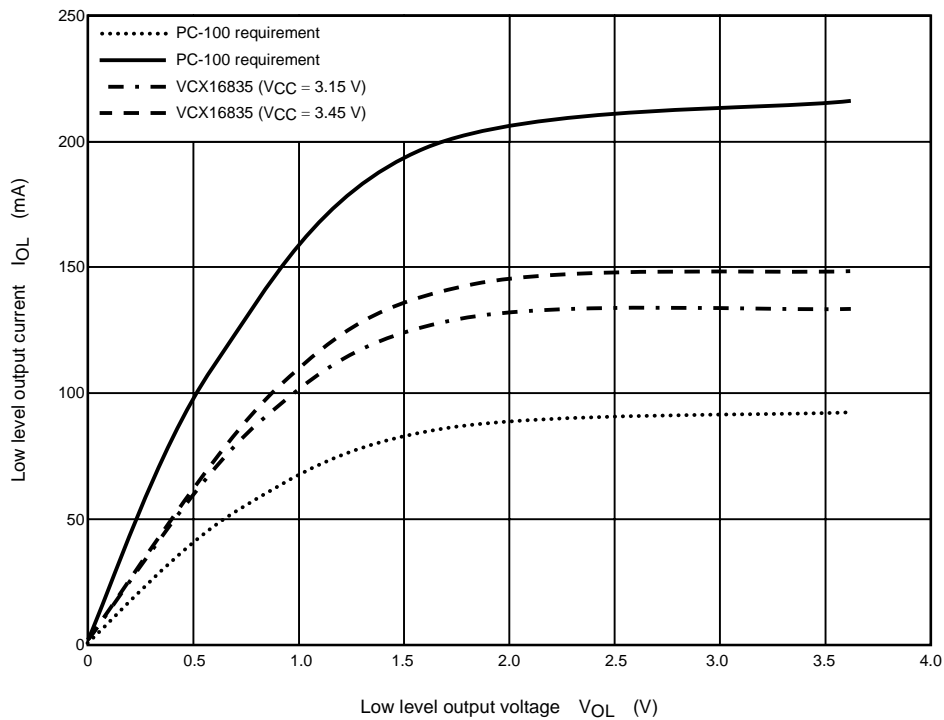
**Figure 5**  $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$

Symbol	$V_{CC}$		
	$3.3 \pm 0.3 \text{ V}$	$2.5 \pm 0.2 \text{ V}$	$1.8 \text{ V}$
$V_{IH}$	$2.7 \text{ V}$	$V_{CC}$	$V_{CC}$
$V_M$	$1.5 \text{ V}$	$V_{CC}/2$	$V_{CC}/2$
$V_x$	$V_{OL} + 0.3 \text{ V}$	$V_{OL} + 0.15 \text{ V}$	$V_{OL} + 0.15 \text{ V}$
$V_y$	$V_{OH} - 0.3 \text{ V}$	$V_{OH} - 0.15 \text{ V}$	$V_{OH} - 0.15 \text{ V}$

**IBIS Characteristics (typ.)**



**Figure 6 I/V Characteristics-Pullup**

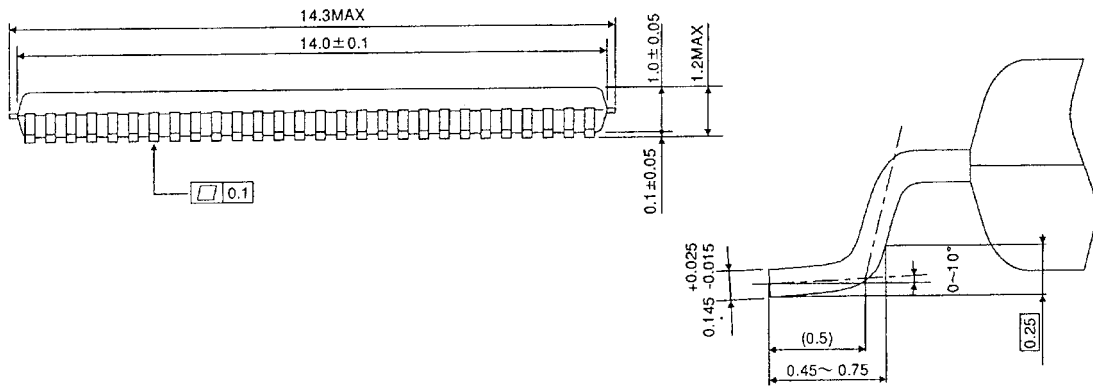
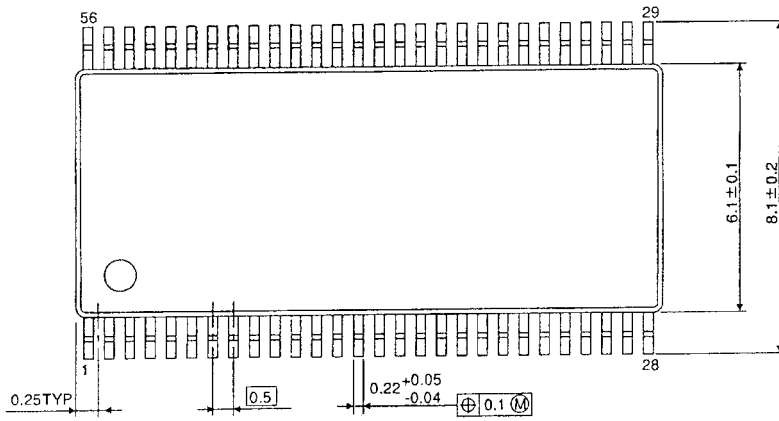


**Figure 7 I/V Characteristics-Pulldown**

**Package Dimensions**

TSSOP56-P-0061-0.50

Unit : mm



Weight: 0.25 g (typ.)

**RESTRICTIONS ON PRODUCT USE**

000707EBA

- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.  
In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc..
- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer's own risk.
- The products described in this document are subject to the foreign exchange and foreign trade laws.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA CORPORATION for any infringements of intellectual property or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any intellectual property or other rights of TOSHIBA CORPORATION or others.
- The information contained herein is subject to change without notice.