

TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

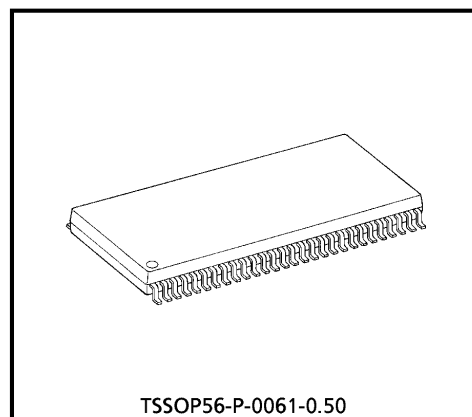
**TC74VCX16835FT****LOW-VOLTAGE 18-BIT UNIVERSAL BUS DRIVER  
WITH 3.6 V TOLERANT INPUTS AND OUTPUTS**

The TC74VCX16835FT is a high performance CMOS 18-bit UNIVERSAL BUS DRIVER. Designed for use in 1.8, 2.5 or 3.3 Volt systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

It is also designed with over voltage 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 (CLK) 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 CLK. When  $\overline{OE}$  is high, the outputs are in the high-impedance state.

All inputs are equipped with protection circuits against static discharge.



TSSOP56-P-0061-0.50

Weight : 0.25 g (Typ.)

**FEATURES**

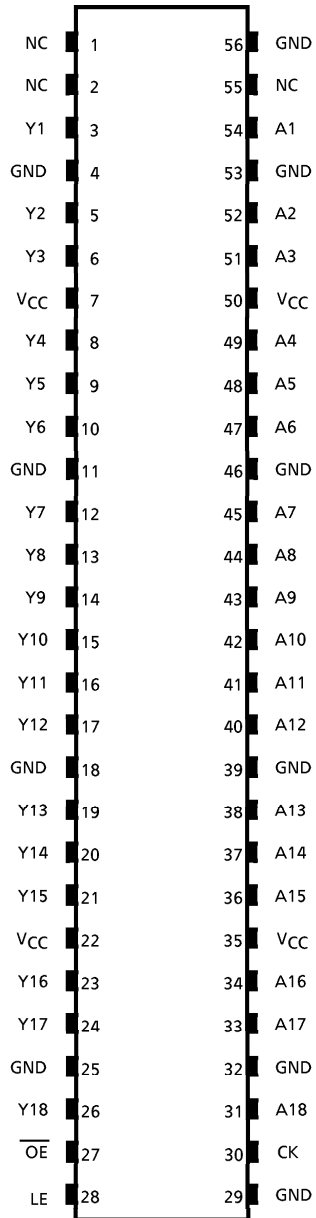
- Low Voltage Operation :  $V_{CC} = 1.8 \sim 3.6 V$
- High Speed Operation :  $t_{pd} = 3.3 \text{ ns (max.) at } V_{CC} = 3.0 \sim 3.6 V$   
:  $t_{pd} = 4.2 \text{ ns (max.) at } V_{CC} = 2.3 \sim 2.7 V$   
:  $t_{pd} = 8.4 \text{ ns (max.) at } V_{CC} = 1.8 V$
- 3.6 V Tolerant inputs and outputs.
- Output Current :  $I_{OH} / I_{OL} = \pm 24 \text{ mA (min.) at } V_{CC} = 3.0 V$   
:  $I_{OH} / I_{OL} = \pm 18 \text{ mA (min.) at } V_{CC} = 2.3 V$   
:  $I_{OH} / I_{OL} = \pm 6 \text{ mA (min.) at } V_{CC} = 1.8 V$
- Latch-up Performance :  $\pm 300 \text{ mA}$
- ESD Performance : Human Body Model  $> \pm 2000 V$   
: Machine Model  $> \pm 200 V$
- Package : TSSOP  
(Thin Shrink Small Outline Package)
- Power Down Protection is provided on all inputs and outputs.
- Supports live insertion / withdrawal (Note 1)

(Note 1) : To ensure the high-impedance state during power up or power down,  $\overline{OE}$  should be tied to  $V_{CC}$  through a pullup resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

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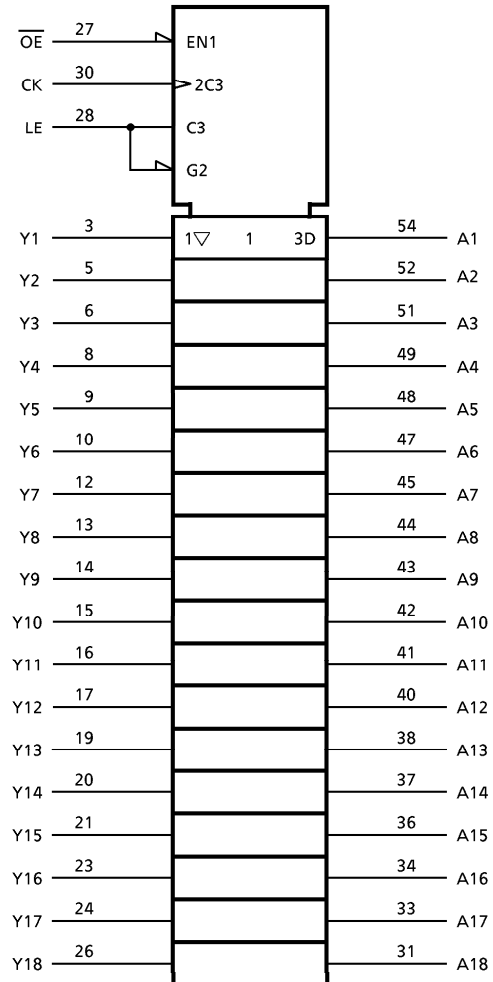
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**PIN ASSIGNMENT**



(TOP VIEW)

**SYMBOL**

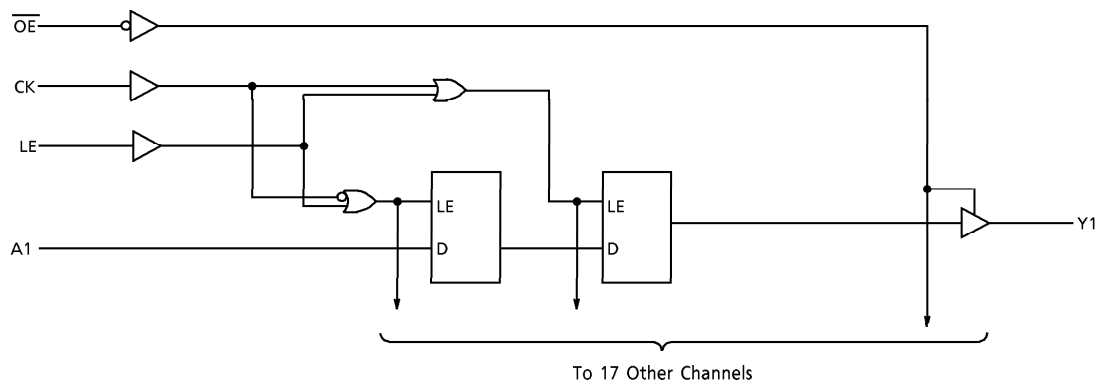


**TRUTH TABLE**

INPUTS				OUTPUTS
$\overline{OE}$	LE	CK	A	Y
H	X	X	X	Z
L	H	X	L	L
L	H	X	H	H
L	L	$\uparrow$	L	L
L	L	$\downarrow$	H	H
L	L	H	X	Y0 *
L	L	L	X	Y0 *

(\*) : 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

PARAMETER	SYMBOL	RATING	UNIT
Power Supply Voltage	$V_{CC}$	-0.5~4.6	V
DC Input Voltage	$V_{IN}$	-0.5~4.6	V
DC Output Voltage	$V_{OUT}$	-0.5~4.6 (Note 2)	V
		-0.5~ $V_{CC}$ + 0.5 (Note 3)	
Input Diode Current	$I_{IK}$	-50	mA
Output Diode Current	$I_{OK}$	±50 (Note 4)	mA
DC Output Current	$I_{OUT}$	±50	mA
Power Dissipation	$P_D$	400	mW
DC $V_{CC}$ /Ground Current Per Supply Pin	$I_{CC}/I_{GND}$	±100	mA
Storage Temperature	$T_{stg}$	-65~150	°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

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	$V_{CC}$	1.8~3.6	V
		1.2~3.6 (Note 5)	
Input Voltage	$V_{IN}$	-0.3~3.6	V
Output Voltage	$V_{I/O}$	0~3.6 (Note 6)	V
		0~ $V_{CC}$ (Note 7)	
Output Current	$I_{OH}/I_{OL}$	±24 (Note 8)	mA
		±18 (Note 9)	
		±6 (Note 10)	
Operating Temperature	$T_{opr}$	-40~85	°C
Input Rise And Fall Time	$dt/dv$	0~10 (Note 11)	ns/V

(Note 5) : Data Retention Only

(Note 6) : Off-State

(Note 7) : High or Low State

(Note 8) :  $V_{CC} = 3.0\sim 3.6\text{ V}$

(Note 9) :  $V_{CC} = 2.3\sim 2.7\text{ V}$

(Note 10) :  $V_{CC} = 1.8\text{ V}$

(Note 11) :  $V_{IN} = 0.8\sim 2.0\text{ V}$ ,  $V_{CC} = 3.0\text{ V}$

**ELECTRICAL CHARACTERISTICS**

DC characteristics (Ta = -40~85°C, 2.7 V < VCC ≤ 3.6 V)

PARAMETER		SYMBOL	TEST CONDITION	VCC (V)	MIN.	MAX.	UNIT	
Input Voltage	"H" Level			V <sub>IH</sub>				
	"L" Level	V <sub>IL</sub>		2.7~3.6	—	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	2.7~3.6	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	2.7~3.6	—	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> = 0~3.6 V	2.7~3.6	—	± 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> = 0~3.6 V	2.7~3.6	—	± 10.0	μA	
Power Off Leakage Current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V	0	—	10.0	μA	
Quiescent Supply Current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND	2.7~3.6	—	20.0	μA	
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V	2.7~3.6	—	± 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	2.7~3.6	—	750	μA	

**ELECTRICAL CHARACTERISTICS**

DC characteristics (Ta = -40~85°C, 2.3 V ≤ VCC ≤ 2.7 V)

PARAMETER		SYMBOL	TEST CONDITION	VCC (V)	MIN.	MAX.	UNIT	
Input Voltage	"H" Level			V <sub>IH</sub>				
	"L" Level	V <sub>IL</sub>		2.3~2.7	—	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	2.3~2.7	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	2.3~2.7	—	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> = 0~3.6 V	2.3~2.7	—	± 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> = 0~3.6 V	2.3~2.7	—	± 10.0	μA	
Power Off Leakage Current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V	0	—	10.0	μA	
Quiescent Supply Current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND	2.3~2.7	—	20.0	μA	
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V	2.3~2.7	—	± 20.0		

**ELECTRICAL CHARACTERISTICS**

DC characteristics (Ta = -40~85°C, 1.8 V ≤ VCC < 2.3 V)

PARAMETER		SYMBOL	TEST CONDITION		VCC (V)	MIN.	MAX.	UNIT
					1.8~2.3			
Input Voltage	"H" Level	V <sub>IH</sub>			1.8~2.3	0.7 × V <sub>CC</sub>	—	V
	"L" Level	V <sub>IL</sub>			1.8~2.3	—	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> = 0~3.6 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> = 0~3.6 V		1.8	—	± 10.0	μA
Power Off Leakage Current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 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 = -40~85°C, Input tr = tf = 2.0 ns, CL = 30 pF, RL = 500 Ω)

PARAMETER	SYMBOL	TEST CONDITION	VCC (V)	MIN.	MAX.	UNIT
Maximum Clock Frequency	fMAX	(Fig.1, 2)	1.8	100	—	MHz
			2.5 ± 0.2	200	—	
			3.3 ± 0.3	250	—	
Propagation Delay Time (An-Yn)	tpLH tpHL	(Fig.1, 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)	tpLH tpHL	(Fig.1, 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)	tpLH tpHL	(Fig.1, 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	tpZL tpZH	(Fig.1, 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	tpLZ tpHZ	(Fig.1, 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	tw (H) tw (L)	(Fig.1, 3, 4)	1.8	4.0	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum Set-up Time (An-CK, An-LE)	ts	(Fig.1, 3, 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)	th	(Fig.1, 3, 4)	1.8	1.0	—	ns
			2.5 ± 0.2	0.7	—	
			3.3 ± 0.3	0.7	—	
Output to Output Skew	tosLH tosHL	(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.

$$(tosLH = |tpLHm - tpLHn|, tosHL = |tpHLm - tpHLn|)$$

AC characteristics (Ta = 0~85°C, Input  $t_r = t_f = 2.0$  ns,  $C_L = 0$  pF,  $R_L = 500 \Omega$ )

PARAMETER	SYMBOL	TEST CONDITION	V <sub>CC</sub> (V)	MIN.	MAX.	UNIT
Propagation Delay Time (An-Yn) (Note 13)	$t_{pLH}$ $t_{pHL}$	(Fig.1, 2)	$3.3 \pm 0.15$	0.9	2.0	ns
Propagation Delay Time (CK-Yn) (Note 13)	$t_{pLH}$ $t_{pHL}$	(Fig.1, 3)	$3.3 \pm 0.15$	1.5	2.9	ns
Propagation Delay Time (LE-Yn) (Note 13)	$t_{pLH}$ $t_{pHL}$	(Fig.1, 4)	$3.3 \pm 0.15$	0.7	2.6	ns
Output Enable Time (Note 13)	$t_{pZL}$ $t_{pZH}$	(Fig.1, 5)	$3.3 \pm 0.15$	0.7	2.6	ns
Output Disable Time (Note 13)	$t_{pLZ}$ $t_{pHZ}$	(Fig.1, 5)	$3.3 \pm 0.15$	0.7	2.7	ns
Minimum Set-up Time (An-CK, An-LE) (Note 13)	$t_s$	(Fig.1, 3, 4)	$3.3 \pm 0.15$	1.5	—	ns
Minimum Hold Time (An-CK, An-LE) (Note 13)	$t_h$	(Fig.1, 3, 4)	$3.3 \pm 0.15$	0.7	—	ns

(Note 13) : TOSHIBA SPICE simulation data.

AC characteristics (Ta = 0~85°C, Input  $t_r = t_f = 2.0$  ns,  $C_L = 50$  pF,  $R_L = 500 \Omega$ )

PARAMETER	SYMBOL	TEST CONDITION	V <sub>CC</sub> (V)	MIN.	MAX.	UNIT
Propagation Delay Time (An-Yn)	$t_{pLH}$ $t_{pHL}$	(Fig.1, 2)	$3.3 \pm 0.15$	1.0	3.6	ns
Propagation Delay Time (CK-Yn)	$t_{pLH}$ $t_{pHL}$	(Fig.1, 3)	$3.3 \pm 0.15$	1.7	4.5	ns
Propagation Delay Time (LE-Yn)	$t_{pLH}$ $t_{pHL}$	(Fig.1, 4)	$3.3 \pm 0.15$	1.0	4.1	ns
Output Enable Time	$t_{pZL}$ $t_{pZH}$	(Fig.1, 5)	$3.3 \pm 0.15$	1.0	4.1	ns
Output Disable Time	$t_{pLZ}$ $t_{pHZ}$	(Fig.1, 5)	$3.3 \pm 0.15$	1.0	4.2	ns
Minimum Set-up Time (An-CK, An-LE)	$t_s$	(Fig.1, 3, 4)	$3.3 \pm 0.15$	1.5	—	ns
Minimum Hold Time (An-CK, An-LE)	$t_h$	(Fig.1, 3, 4)	$3.3 \pm 0.15$	0.7	—	ns



Dynamic switching characteristics (Ta = 25°C, Input tr = tf = 2.0 ns, CL = 30 pF)

PARAMETER	SYMBOL	TEST CONDITION	VCC (V)	TYP.	UNIT
Quiet Output Maximum Dynamic VOL	VOLP	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 VOL	VOLV	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 VOH	VOHV	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 (Ta = 25°C)

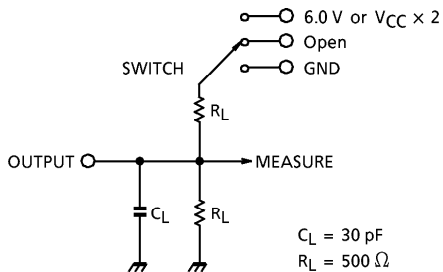
PARAMETER	SYMBOL	TEST CONDITION	VCC (V)	TYP.	UNIT
Input Capacitance	C <sub>IN</sub>		1.8, 2.5, 3.3	6	pF
Output Capacitance	C <sub>OUT</sub>		1.8, 2.5, 3.3	7	pF
Power Dissipation Capacitance	C <sub>PD</sub>	f <sub>IN</sub> = 10 MHz (Note 15)	1.8, 2.5, 3.3	20	pF

(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 :

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

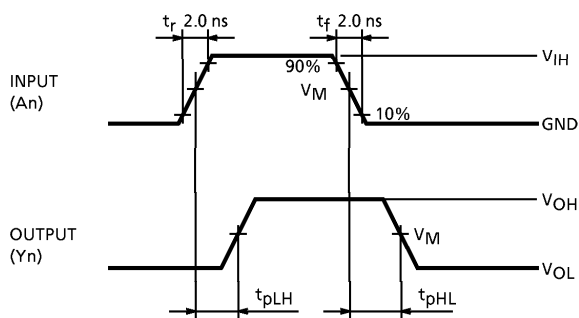
Fig.1 Test circuit



PARAMETER	SWITCH
$t_{pLH}, t_{pHL}$	Open
$t_{pLZ}, t_{pZL}$	6.0 V @ $V_{CC} = 3.3 \pm 0.3 \text{ V}$ $V_{CC} \times 2$ @ $V_{CC} = 2.5 \pm 0.2 \text{ V}$ @ $V_{CC} = 1.8 \text{ V}$
$t_{pHZ}, t_{pZH}$	GND

**AC WAVEFORM**

Fig.2  $t_{pLH}, t_{pHL}$



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 V	$V_{CC}$	$V_{CC}$
$V_M$	1.5 V	$V_{CC} / 2$	$V_{CC} / 2$
$V_X$	$V_{OL} + 0.3 \text{ V}$	$V_{OL} + 0.15 \text{ V}$	$V_{OL} + 0.15 \text{ V}$
$V_Y$	$V_{OH} - 0.3 \text{ V}$	$V_{OH} - 0.15 \text{ V}$	$V_{OH} - 0.15 \text{ V}$

Fig.3  $t_{pLH}, t_{pHL}, t_w, t_s, t_h$

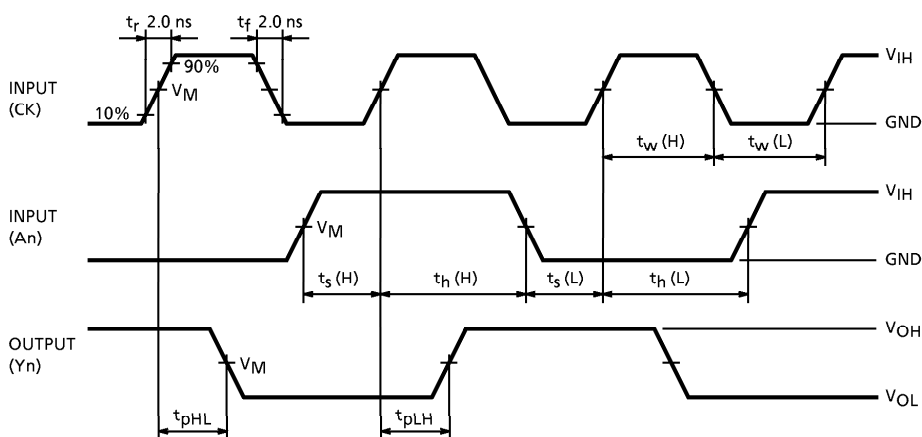


Fig.4  $t_{pLH}$ ,  $t_{pHL}$ ,  $t_w$ ,  $t_s$ ,  $t_h$

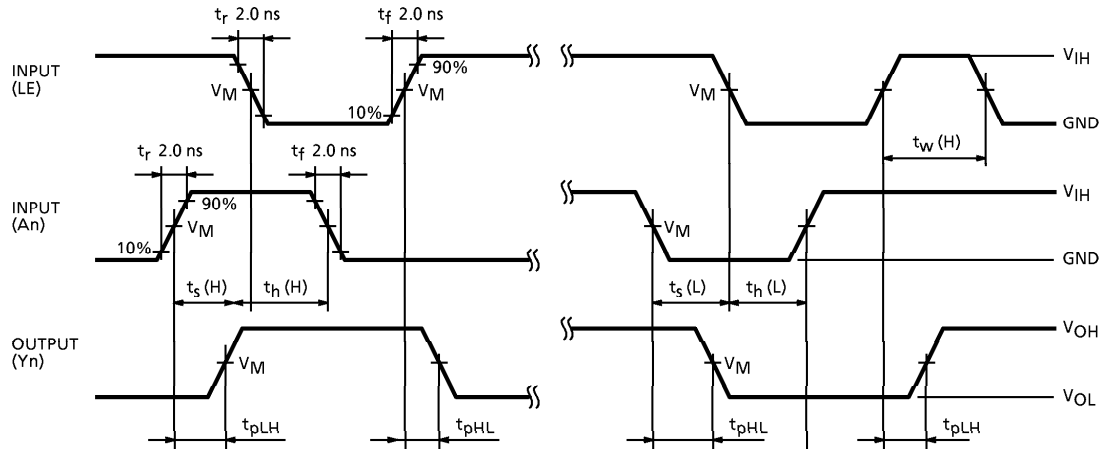
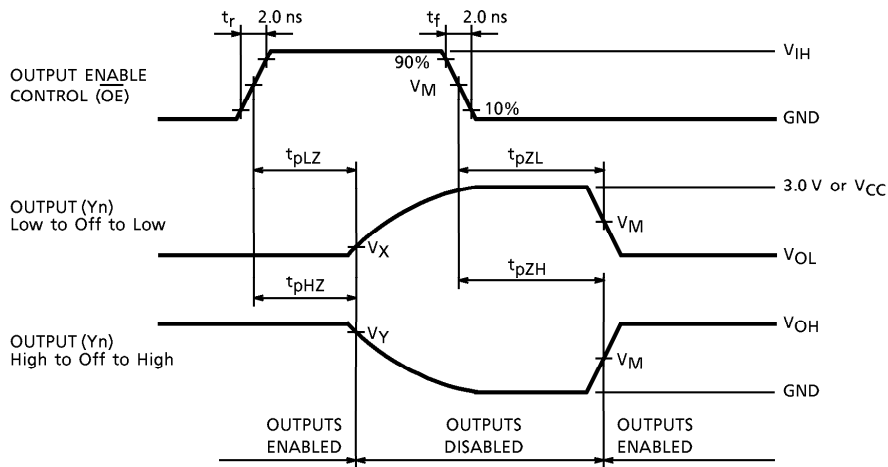


Fig.5  $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$



IBIS CHARACTERISTICS (Typ.)

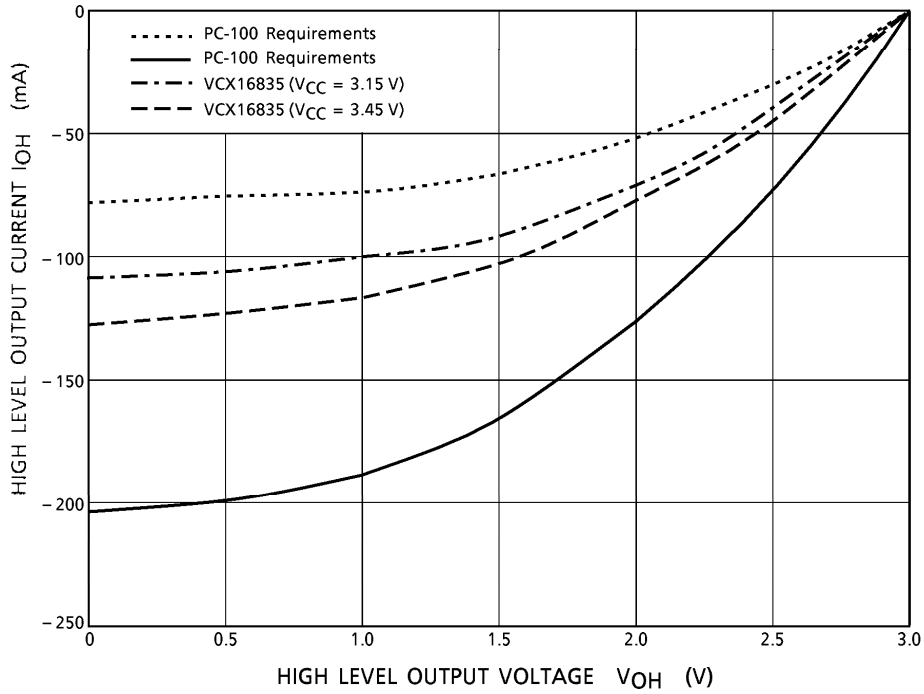


Fig.6 I/V Characteristics-Pullup

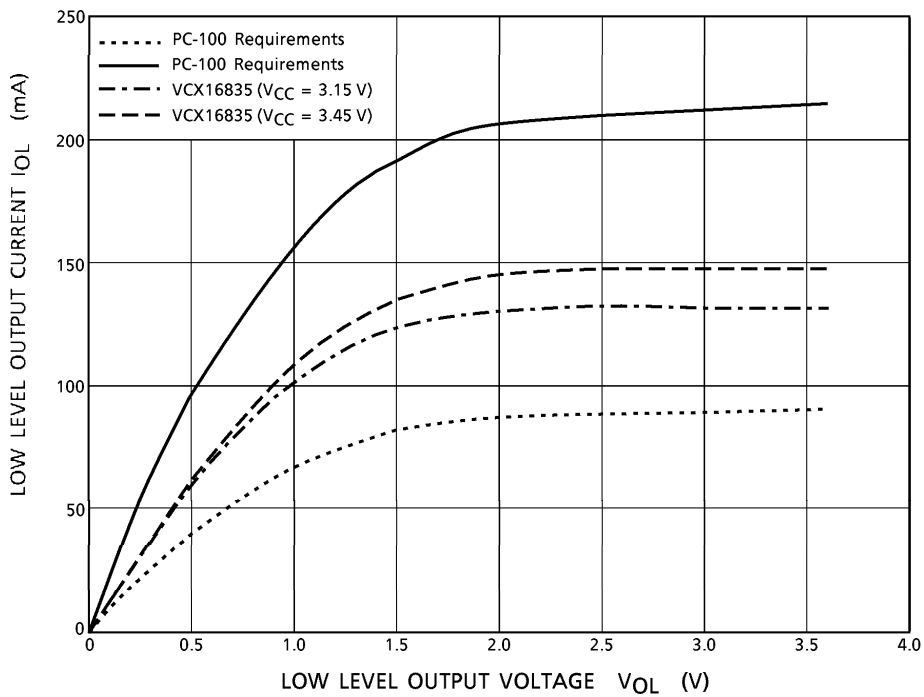
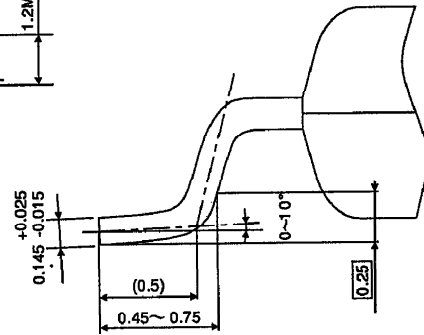
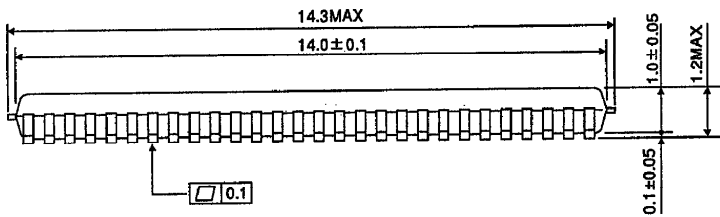
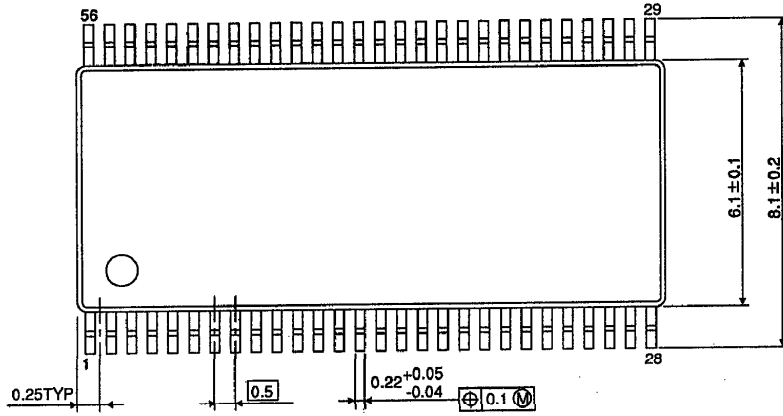


Fig.7 I/V Characteristics-Pulldown

OUTLINE DRAWING  
TSSOP56-P-0061-0.50

Unit : mm



Weight : 0.25 g (Typ.)