

# 74VHC4051AFT, 74VHC4052AFT, 74VHC4053AFT

## 1. Functional Description

74VHC4051AFT: 8-Channel Analog Multiplexer/Demultiplexer

74VHC4052AFT: Dual 4-Channel Analog Multiplexer/Demultiplexer

74VHC4053AFT: Triple 2-Channel Analog Multiplexer/Demultiplexer

## 2. General

The 74VHC4051AFT, 74VHC4052AFT and 74VHC4053AFT are high-speed, low-voltage drive analog multiplexer/demultiplexers using silicon gate CMOS technology. In 3 V and 5 V systems these can achieve high-speed operation with the low power dissipation that is a feature of CMOS.

The 74VHC4051AFT, 74VHC4052AFT and 74VHC4053AFT offer analog/digital signal selection as well as mixed signals. The 74VHC4051AFT has an 8-channel configuration, the 74VHC4052AFT has an 4-channel  $\times 2$  configuration, and the 74VHC4053AFT has a 2-channel  $\times 3$  configuration.

The switches for each channel are turned ON by the control pin digital signals.

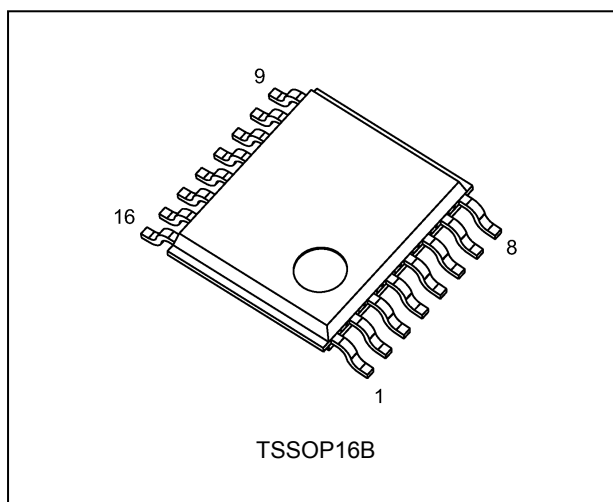
All control inputs are equipped with a newly developed input protection circuit that avoids the need for a diode on the plus side (forward side from the input to the  $V_{CC}$ ). As a result, for example, 5.5 V signals can be permitted on the inputs even when the power supply voltage to the circuits is off. As a result of this input power protection, the 74VHC4051AFT, 74VHC4052AFT and 74VHC4053AFT can be used in a variety of applications, including in the system which has two power supplies, and in battery backup circuits.

## 3. Features

- (1) AEC-Q100 (Rev. H) (Note 1)
- (2) Wide operating temperature range:  $T_{opr} = -40$  to  $125$  °C
- (3) Low ON-resistance:  $R_{ON} = 45$   $\Omega$  (typ.) ( $V_{CC} = 3.0$  V)  
 $R_{ON} = 24$   $\Omega$  (typ.) ( $V_{CC} = 4.5$  V)
- (4) Low power dissipation:  $I_{CC} = 2.0$   $\mu$ A (max) ( $T_a = 25$ °C)
- (5) High noise immunity:  $V_{IL} = 0.8$  V (max)  $V_{CC} = 3.0$  V  
 $V_{IH} = 2.0$  V (min)  $V_{CC} = 3.0$  V
- (6) Power down protection is provided on all control inputs.

Note 1: This device is compliant with the reliability requirements of AEC-Q100. For details, contact your Toshiba sales representative.

## 4. Packaging

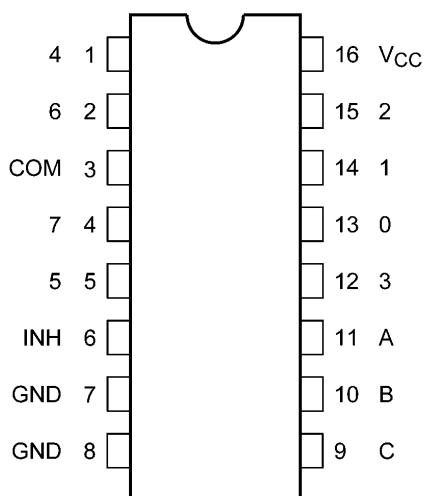


Start of commercial production

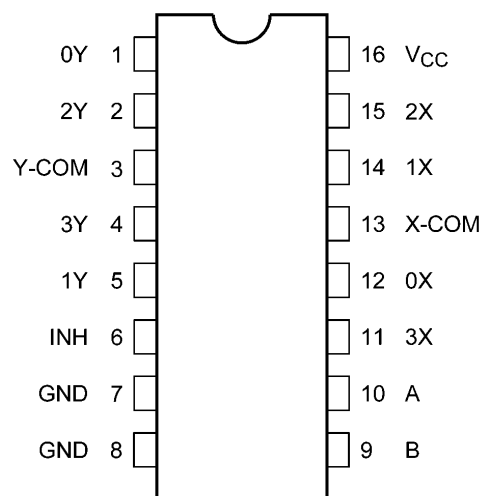
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### 5. Pin Assignment

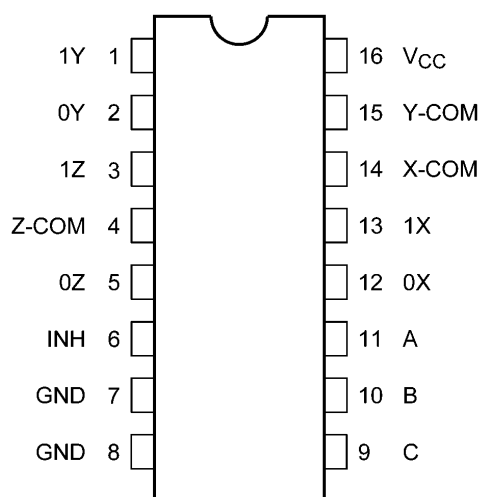
74VHC4051AFT



74VHC4052AFT



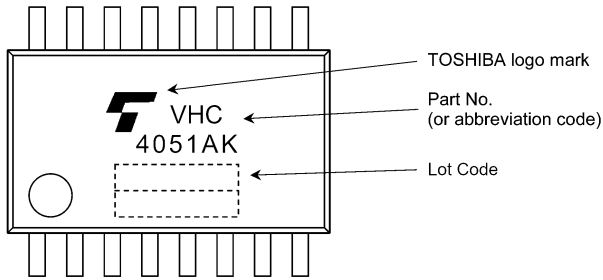
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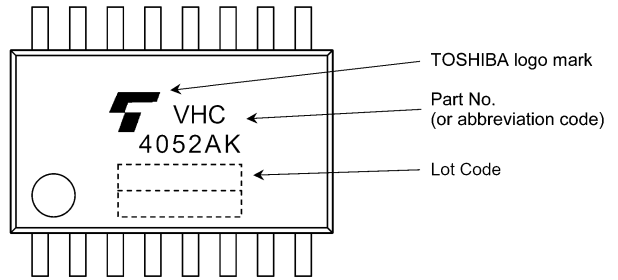
### 6. Marking

#### 6.1. Marking (Note)

74VHC4051AFT



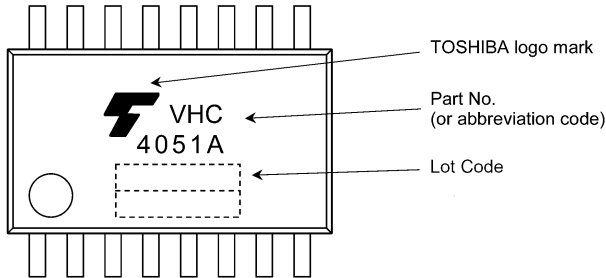
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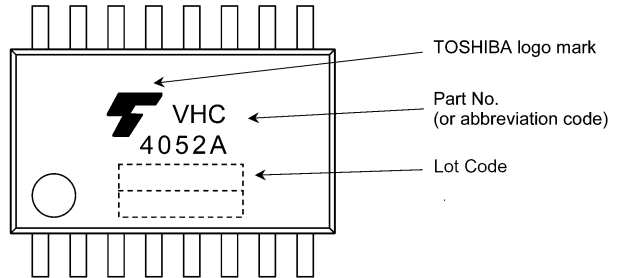
Note: For devices with the ordering part number ending in K.

#### 6.2. Marking

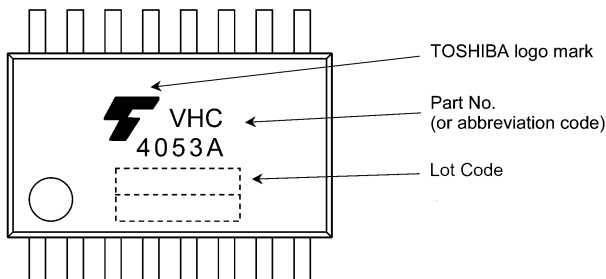
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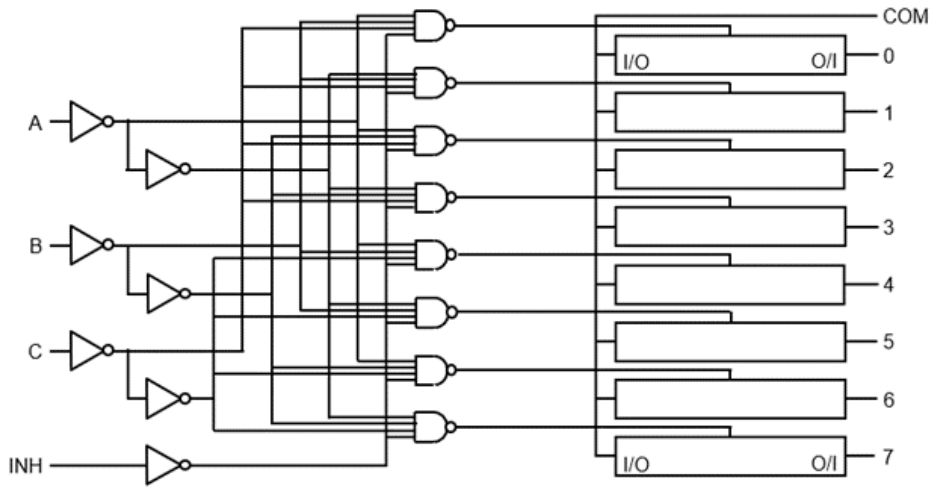


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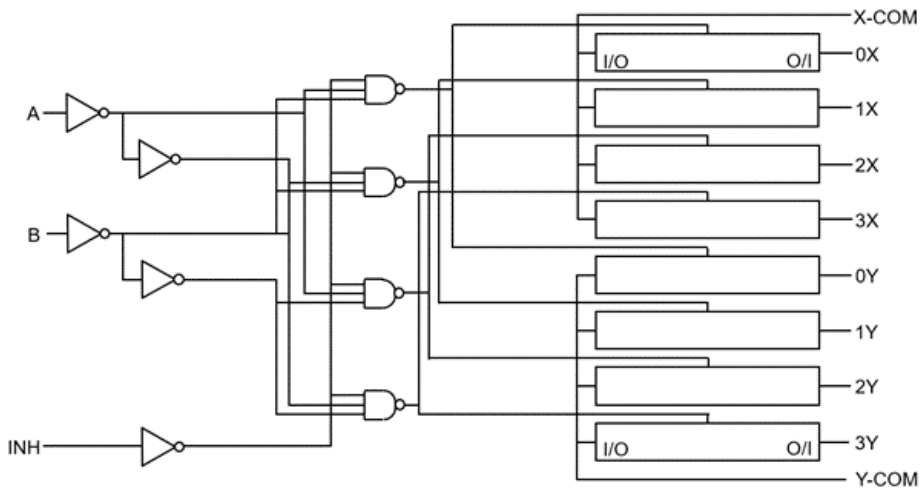


### 7. System Diagram

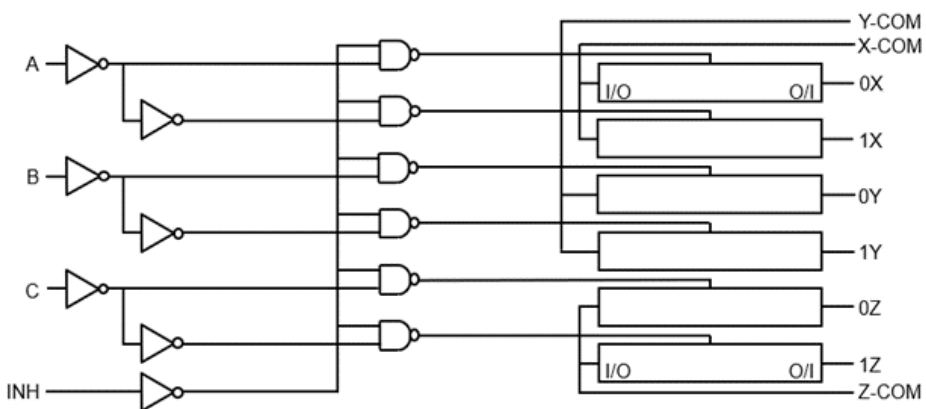
74VHC4051AFT



74VHC4052AFT



74VHC4053AFT



### 8. Truth Table

Input Inhibit	Input C*	Input B	Input A	ON Channel 74VHC4051AFT	ON Channel 74VHC4052AFT	ON Channel 74VHC4053AFT
L	L	L	L	0	0X, 0Y	0X, 0Y, 0Z
L	L	L	H	1	1X, 1Y	1X, 0Y, 0Z
L	L	H	L	2	2X, 2Y	0X, 1Y, 0Z
L	L	H	H	3	3X, 3Y	1X, 1Y, 0Z
L	H	L	L	4	—	0X, 0Y, 1Z
L	H	L	H	5	—	1X, 0Y, 1Z
L	H	H	L	6	—	0X, 1Y, 1Z
L	H	H	H	7	—	1X, 1Y, 1Z
H	X	X	X	None	None	None

X: Don't care

\*: Except 74VHC4052AFT

### 9. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	$V_{CC}$		-0.5 to 7.0	V
Input voltage	$V_{IN}$		-0.5 to 7.0	V
Switch I/O voltage	$V_{I/O}$		-0.5 to $V_{CC} + 0.5$	V
Input diode current	$I_{IK}$		-20	mA
I/O diode current	$I_{I/OK}$		$\pm 25$	mA
Switch through current	$I_T$		$\pm 25$	mA
$V_{CC}$ /ground current	$I_{CC}$		$\pm 50$	mA
Power dissipation	$P_D$	(Note 1)	180	mW
Storage temperature	$T_{stg}$		-65 to 150	°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).

Note 1: 180 mW in the range of  $T_a = -40$  to  $85$  °C. From  $T_a = 85$  to  $125$  °C a derating factor of  $-3.25$  mW/°C shall be applied until 50 mW.

### 10. Operating Ranges (Note)

Characteristics	Symbol	Test Condition	Rating	Unit
Supply voltage	$V_{CC}$	—	2.0 to 5.5	V
Input voltage	$V_{IN}$	—	0 to 5.5	V
Switch I/O voltage	$V_S$	—	0 to $V_{CC}$	V
Operating temperature	$T_{opr}$	—	-40 to 125	°C
Input rise and fall times	dt/dv	$V_{CC} = 2.5 \pm 0.2$ V	0 to 200	ns/V
		$V_{CC} = 3.3 \pm 0.3$ V	0 to 100	
		$V_{CC} = 5.0 \pm 0.5$ V	0 to 20	

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.

### 11. Electrical Characteristics

#### 11.1. DC Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Typ.	Max	Unit
High-level input voltage	$V_{IH}$	—	2.0	1.5	—	—	V
			3.0	2.0	—	—	
			4.5	3.15	—	—	
			5.5	3.85	—	—	
Low-level input voltage	$V_{IL}$	—	2.0	—	—	0.5	V
			3.0	—	—	0.8	
			4.5	—	—	1.35	
			5.5	—	—	1.65	
ON-resistance	$R_{ON}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{I/O} = V_{CC}$ to GND $I_{I/O} = 2\text{ mA}$	2.3	—	200	—	$\Omega$
			3.0	—	45	86	
			4.5	—	24	37	
		$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{I/O} = V_{CC}$ or GND $I_{I/O} = 2\text{ mA}$	2.3	—	28	73	
			3.0	—	22	38	
			4.5	—	17	27	
Difference of ON-resistance between switches	$\Delta R_{ON}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{I/O} = V_{CC}$ to GND $I_{I/O} = 2\text{ mA}$	2.3	—	10	25	$\Omega$
			3.0	—	5	15	
			4.5	—	5	13	
Input/Output leakage current (Switch OFF)	$I_{OFF}$	$V_{OS} = V_{CC}$ or GND $V_{IS} = \text{GND}$ to $V_{CC}$ $V_{IN} = V_{IH}$ or $V_{IL}$	5.5	—	—	$\pm 0.1$	$\mu\text{A}$
Input/Output leakage current (Switch ON, Output OPEN)	$I_{I/O}$	$V_{OS} = V_{CC}$ or GND $V_{IN} = V_{IH}$ or $V_{IL}$	5.5	—	—	$\pm 0.1$	$\mu\text{A}$
Control input leakage current	$I_{IN}$	$V_{IN} = V_{CC}$ or GND	5.5	—	—	$\pm 0.1$	$\mu\text{A}$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	5.5	—	—	2.0	$\mu\text{A}$

### 11.2. DC Characteristics (Unless otherwise specified, $T_a = -40$ to $85$ °C)

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Max	Unit
High-level input voltage	$V_{IH}$	—	2.0	1.5	—	V
			3.0	2.0	—	
			4.5	3.15	—	
			5.5	3.85	—	
Low-level input voltage	$V_{IL}$	—	2.0	—	0.50	V
			3.0	—	0.8	
			4.5	—	1.35	
			5.5	—	1.65	
ON-resistance	$R_{ON}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{I/O} = V_{CC}$ to GND $I_{I/O} = 2$ mA	2.3	—	—	$\Omega$
			3.0	—	108	
			4.5	—	46	
		$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{I/O} = V_{CC}$ or GND $I_{I/O} = 2$ mA	2.3	—	84	
			3.0	—	44	
			4.5	—	31	
Difference of ON-resistance between switches	$\Delta R_{ON}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{I/O} = V_{CC}$ to GND $I_{I/O} = 2$ mA	2.3	—	35	$\Omega$
			3.0	—	20	
			4.5	—	18	
Input/Output leakage current (Switch OFF)	$I_{OFF}$	$V_{OS} = V_{CC}$ or GND $V_{IS} = GND$ to $V_{CC}$ $V_{IN} = V_{IH}$ or $V_{IL}$	5.5	—	$\pm 1.0$	$\mu A$
Input/Output leakage current (Switch ON, Output OPEN)	$I_{I/O}$	$V_{OS} = V_{CC}$ or GND $V_{IN} = V_{IH}$ or $V_{IL}$	5.5	—	$\pm 1.0$	$\mu A$
Control input leakage current	$I_{IN}$	$V_{IN} = V_{CC}$ or GND	5.5	—	$\pm 1.0$	$\mu A$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	5.5	—	20.0	$\mu A$

### 11.3. DC Characteristics (Unless otherwise specified, $T_a = -40$ to $125$ °C)

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Max	Unit
High-level input voltage	$V_{IH}$	—	2.0	1.5	—	V
			3.0	2.0	—	
			4.5	3.15	—	
			5.5	3.85	—	
Low-level input voltage	$V_{IL}$	—	2.0	—	0.5	V
			3.0	—	0.8	
			4.5	—	1.35	
			5.5	—	1.65	
ON-resistance	$R_{ON}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{I/O} = V_{CC}$ to GND $I_{I/O} = 2$ mA	2.3	—	—	$\Omega$
			3.0	—	125	
			4.5	—	54	
		$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{I/O} = V_{CC}$ or GND $I_{I/O} = 2$ mA	2.3	—	105	
			3.0	—	55	
			4.5	—	39	
Difference of ON-resistance between switches	$\Delta R_{ON}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{I/O} = V_{CC}$ to GND $I_{I/O} = 2$ mA	2.3	—	45	$\Omega$
			3.0	—	25	
			4.5	—	23	
Input/Output leakage current (Switch OFF)	$I_{OFF}$	$V_{OS} = V_{CC}$ or GND $V_{IS} =$ GND to $V_{CC}$ $V_{IN} = V_{IH}$ or $V_{IL}$	5.5	—	$\pm 4.0$	$\mu A$
Input/Output leakage current (Switch ON, Output OPEN)	$I_{I/O}$	$V_{OS} = V_{CC}$ or GND $V_{IN} = V_{IH}$ or $V_{IL}$	5.5	—	$\pm 4.0$	$\mu A$
Control input leakage current	$I_{IN}$	$V_{IN} = V_{CC}$ or GND	5.5	—	$\pm 2.0$	$\mu A$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	5.5	—	40.0	$\mu A$

### 11.4. AC Characteristics (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ , Input: $t_r = t_f = 3\text{ ns}$ )

Characteristics	Part Number	Symbol	Test Condition	$V_{CC}$ (V)	$C_L$ (pF)	Min	Typ.	Max	Unit	
Phase difference between input to output		$\varphi_{I/O}$		$2.5 \pm 0.2$	15	—	1.2	10	ns	
					50	—	2.6	12		
				$3.3 \pm 0.3$	15	—	0.8	6		
					50	—	1.5	9		
				$5.0 \pm 0.5$	15	—	0.3	4		
					50	—	0.6	6		
Output enable time		$t_{PZL}, t_{PZH}$	$R_L = 1\text{ k}\Omega$ Figure 1	$2.5 \pm 0.2$	15	—	3.3	15	ns	
					50	—	4.2	25		
				$3.3 \pm 0.3$	15	—	2.3	11		
					50	—	3.0	18		
				$5.0 \pm 0.5$	15	—	1.6	7		
					50	—	2.1	12		
Output disable time		$t_{PLZ}, t_{PHZ}$	$R_L = 1\text{ k}\Omega$ Figure 1	$2.5 \pm 0.2$	15	—	6	15	ns	
					50	—	9.6	25		
				$3.3 \pm 0.3$	15	—	4.5	11		
					50	—	7.2	18		
				$5.0 \pm 0.5$	15	—	3.2	7		
					50	—	5.1	12		
Control input capacitance		$C_{IN}$	All types	—	—	—	2	—	pF	
Common terminal capacitance	74VHC4051AFT	$C_{IS}$	Figure 2	—	—	—	23.4	—	pF	
	74VHC4052AFT						—	13.1		—
	74VHC4053AFT						—	8.2		—
Switch terminal capacitance	74VHC4051AFT	$C_{OS}$	Figure 2	—	—	—	5.7	—	pF	
	74VHC4052AFT						—	5.6		—
	74VHC4053AFT						—	5.6		—
Feedthrough capacitance	74VHC4051AFT	$C_{IOS}$	Figure 2	—	—	—	0.5	—	pF	
	74VHC4052AFT						—	0.5		—
	74VHC4053AFT						—	0.5		—
Power dissipation capacitance	74VHC4051AFT	$C_{PD}$	Figure 2 (Note 1)	—	—	—	15	—	pF	
	74VHC4052AFT						—	24		—
	74VHC4053AFT						—	12		—

Note 1:  $C_{PD}$  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.

$$I_{CC(opr)} = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}$$

### 11.5. AC Characteristics

(Unless otherwise specified,  $T_a = -40$  to  $85$  °C, Input:  $t_r = t_f = 3$  ns)

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	$C_L$ (pF)	Min	Max	Unit
Phase difference between input to output	$\phi_{I/O}$		$2.5 \pm 0.2$	15	—	16	ns
				50	—	18	
			$3.3 \pm 0.3$	15	—	10	
				50	—	12	
			$5.0 \pm 0.5$	15	—	7	
				50	—	8	
Output enable time	$t_{PZL}, t_{PZH}$	$R_L = 1$ k $\Omega$ Figure 1	$2.5 \pm 0.2$	15	—	20	ns
				50	—	32	
			$3.3 \pm 0.3$	15	—	15	
				50	—	22	
			$5.0 \pm 0.5$	15	—	10	
				50	—	16	
Output disable time	$t_{PLZ}, t_{PHZ}$	$R_L = 1$ k $\Omega$ Figure 1	$2.5 \pm 0.2$	15	—	23	ns
				50	—	32	
			$3.3 \pm 0.3$	15	—	15	
				50	—	22	
			$5.0 \pm 0.5$	15	—	10	
				50	—	16	
Control input capacitance	$C_{IN}$	—	—	—	—	10	pF

### 11.6. AC Characteristics

(Unless otherwise specified,  $T_a = -40$  to  $125$  °C, Input:  $t_r = t_f = 3$  ns)

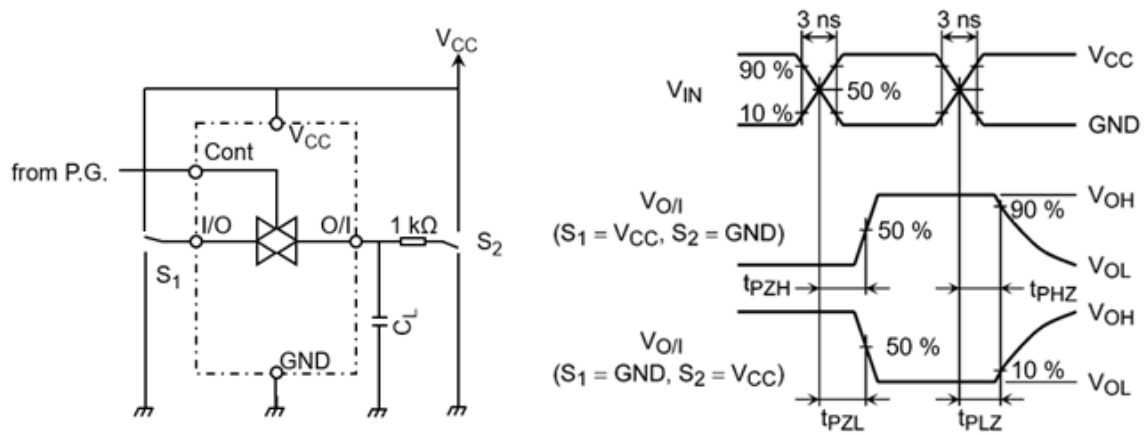
Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	$C_L$ (pF)	Min	Max	Unit
Phase difference between input to output	$\phi_{I/O}$		$2.5 \pm 0.2$	15	—	20	ns
				50	—	22	
			$3.3 \pm 0.3$	15	—	13	
				50	—	14	
			$5.0 \pm 0.5$	15	—	9	
				50	—	9.5	
Output enable time	$t_{PZL}, t_{PZH}$	$R_L = 1$ k $\Omega$ Figure 1	$2.5 \pm 0.2$	15	—	23.5	ns
				50	—	37	
			$3.3 \pm 0.3$	15	—	18	
				50	—	25	
			$5.0 \pm 0.5$	15	—	12	
				50	—	19	
Output disable time	$t_{PLZ}, t_{PHZ}$	$R_L = 1$ k $\Omega$ Figure 1	$2.5 \pm 0.2$	15	—	28.5	ns
				50	—	37	
			$3.3 \pm 0.3$	15	—	18	
				50	—	25	
			$5.0 \pm 0.5$	15	—	12	
				50	—	19	
Control input capacitance	$C_{IN}$	—	—	—	—	10	pF

### 11.7. Analog Switch Characteristics (T<sub>a</sub> = 25 °C) (Note)

Characteristics	Part Number	Symbol	Test Condition	V <sub>CC</sub> (V)	Typ.	Unit	
Sine Wave Distortion		THD	R <sub>L</sub> = 10 kΩ, C <sub>L</sub> = 50 pF f <sub>IN</sub> = 1 kHz	V <sub>IN</sub> = 2.0 V <sub>p-p</sub>	3.0	0.1	%
				V <sub>IN</sub> = 4.0 V <sub>p-p</sub>	4.5	0.03	
Maximum frequency response	74VHC4051AFT	f <sub>MAX(I/O)</sub>	V <sub>IN</sub> is centered at (V <sub>CC</sub> /2). Adjust input for 0 dBm. Increase f <sub>IN</sub> frequency until dB meter reads -3 dB. R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 10 pF, sine wave Figure 3	3.0	150	MHz	
	74VHC4052AFT				200		
	74VHC4053AFT				240		
	74VHC4051AFT			4.5	180		
	74VHC4052AFT				230		
	74VHC4053AFT				280		
Feed through attenuation (switch OFF)		FTH	V <sub>IN</sub> is centered at (V <sub>CC</sub> /2). Adjust input for 0 dBm. R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 50 pF, f <sub>IN</sub> = 1 MHz, sine wave Figure 4	3.0	-45	dB	
					4.5		-45
				3.0	-65		
					4.5		-65
Crosstalk (control input to signal output)		X <sub>talk</sub>	R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 50 pF, f <sub>IN</sub> = 1 MHz, square wave (t <sub>r</sub> = t <sub>f</sub> = 6 ns) Figure 5	3.0	60	mV	
					4.5		100
Crosstalk (between any switches)		X <sub>talk</sub>	V <sub>IN</sub> is centered at (V <sub>CC</sub> /2). Adjust input for 0 dBm. R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 50 pF, f <sub>IN</sub> = 1 MHz, sine wave Figure 6	3.0	-45	dB	
					4.5		-45

Note: These characteristics are determined by design of devices.

### 12. AC Test Circuit



Cont: Control Inputs A or B or C or INH (C: Except VHC4052A)

P.G.: Pulse generator

Figure 1 t<sub>PZH</sub>, t<sub>PHZ</sub>, t<sub>PLZ</sub>, t<sub>PLH</sub>

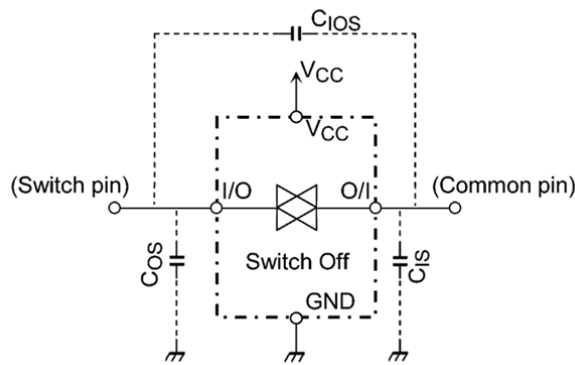


Figure 2 C<sub>ios</sub>, C<sub>is</sub>, C<sub>os</sub>

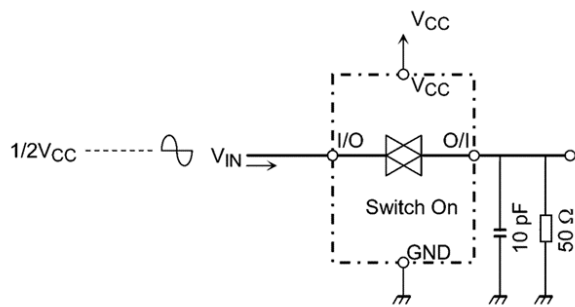
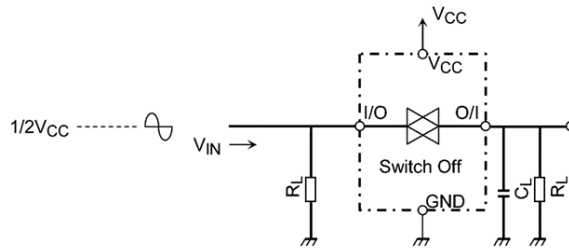
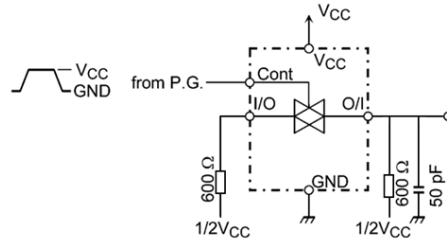


Figure 3 Frequency Response



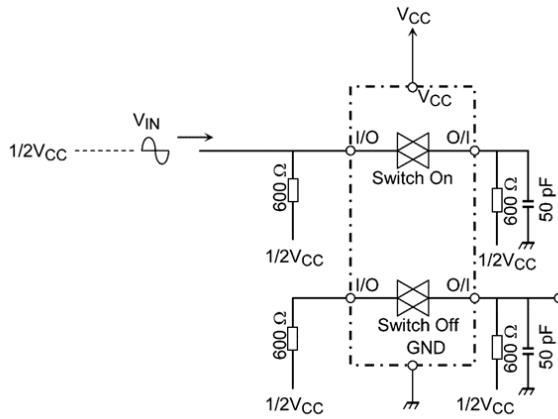
**Figure 4 Feedthrough Attenuation**



Cont: Control Inputs A or B or C or INH (C: Except VHC4052A)

P.G. : Pulse generator

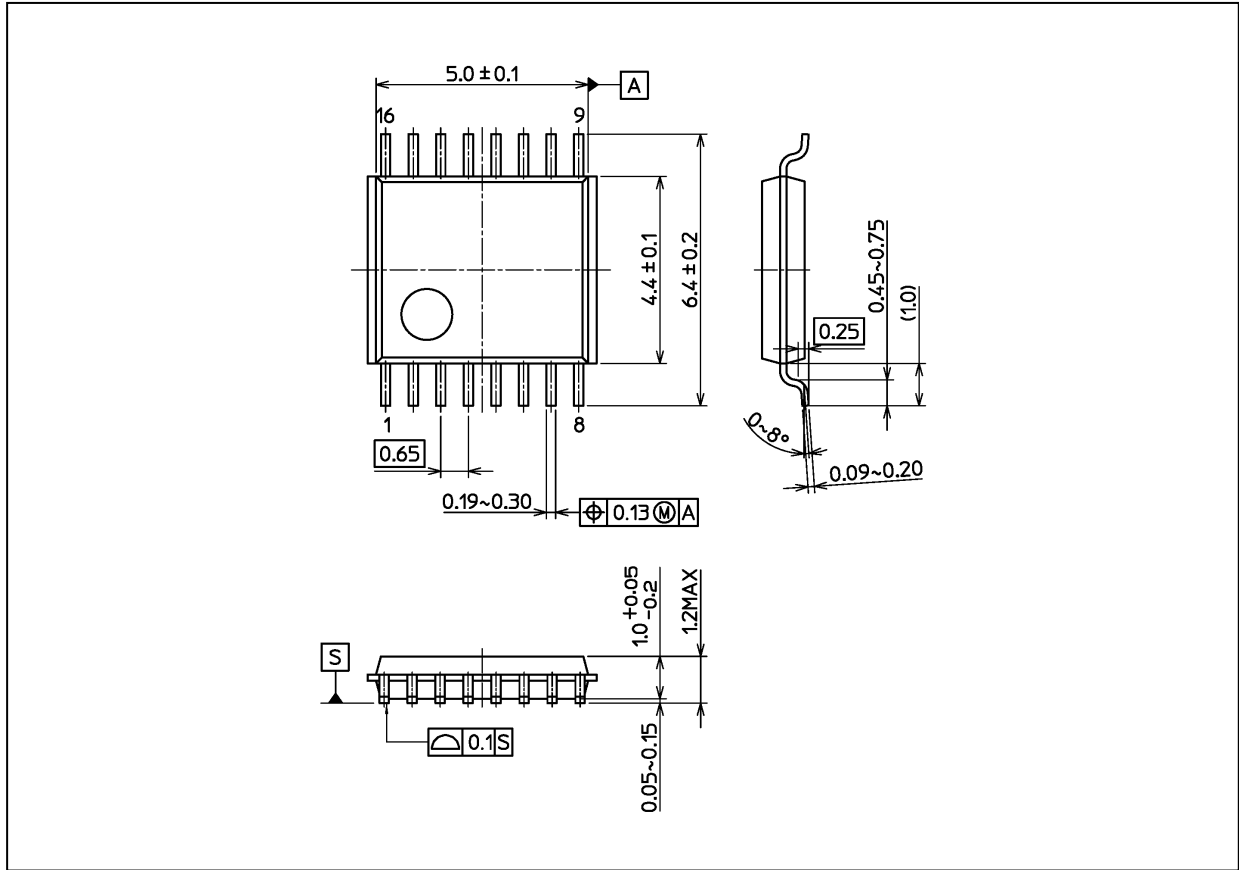
**Figure 5 Cross Talk (control input to output signal)**



**Figure 6 Cross Talk (between any two switches)**

## Package Dimensions

Unit: mm



Weight: 0.055 g (typ.)

Package Name(s)
Nickname: TSSOP16B

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