CMOS Digital Integrated Circuits Silicon Monolithic

74HC4051D,74HC4052D

1. Functional Description

74HC4051D:8-Channel Analog Multiplexer/Demultiplexer
74HC4052D:Dual 4-Channel Analog Multiplexer/Demultiplexer

2. General

The 74HC4051D, 74HC4052D are high speed CMOS ANALOG MULTIPLEXER/DEMULTIPLEXER fabricated with silicon gate C^{2}MOS technology. They achieve the high speed operation similar to equivalent LSTTL while maintaining the CMOS low power dissipation.

The 74HC4051D has an 8 channel configuration and the 74HC4052D has a 4 channel × 2 configuration.

The digital signal to the control terminal turns "ON" the corresponding switch of each channel a large amplitude signal (V_{CC} - V_{EE}) can then be switched by the small logical amplitude (V_{CC} - GND) control signal.

For example, in the case of V_{CC} = 5 V, GND = 0 V, V_{EE} = -5 V, signals between -5 V and +5 V can be switched from the logical circuit with a single power supply of 5 V. As the ON-resistance of each switch is low, they can be connected to circuits with low input impedance.

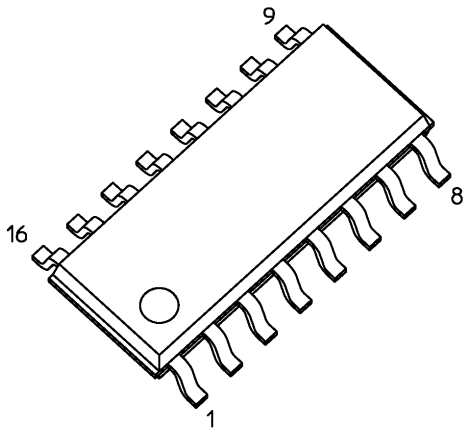
All inputs are equipped with protection circuits against static discharge or transient excess voltage.

3. Features

(1) Wide operating temperature range: T_{opr} = -40 to 125 °C (Note 1)
(2) Low power dissipation: I_{CC} = 4.0 μA (max) (V_{CC} = 6.0 V, V_{EE} = GND, T_a = 25 °C)
(3) Low ON-resistance: R_{ON} = 50 Ω (typ.) at V_{CC} - V_{EE} = 9 V
(4) High degree of linearity: THD = 0.02 % (typ.) at V_{CC} - V_{EE} = 9 V

Note 1: Operating Range spec of T_{opr} = -40 °C to 125 °C is applicable only for the products which manufactured after July 2020.

4. Packaging

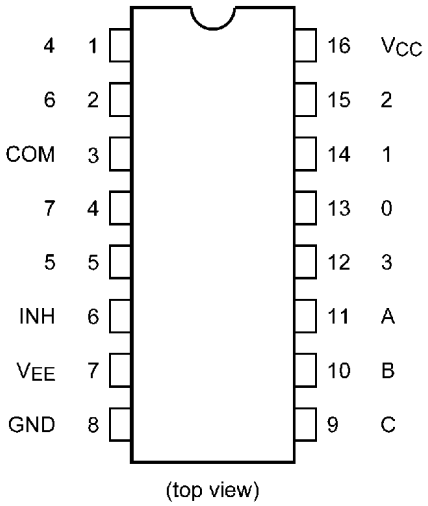


SOIC16

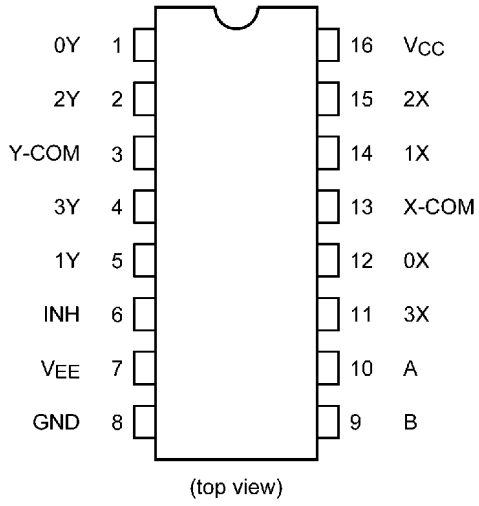
Start of commercial production
2016-04

5. Pin Assignment

74HC4051D

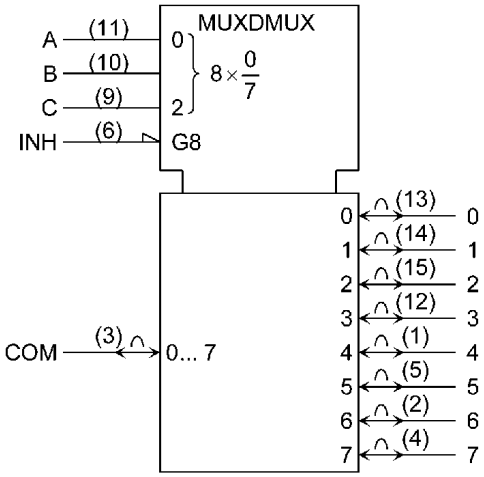


74HC4052D

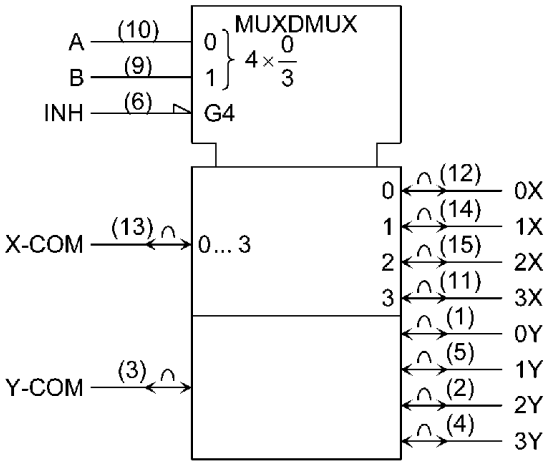


6. IEC Logic Symbol

74HC4051D

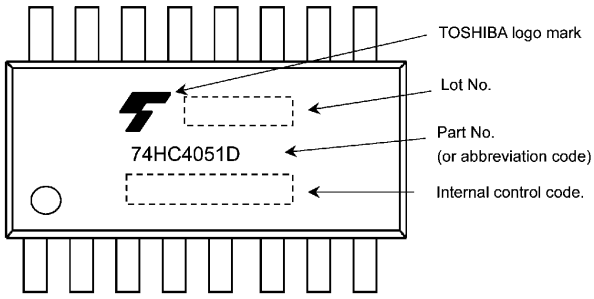


74HC4052D

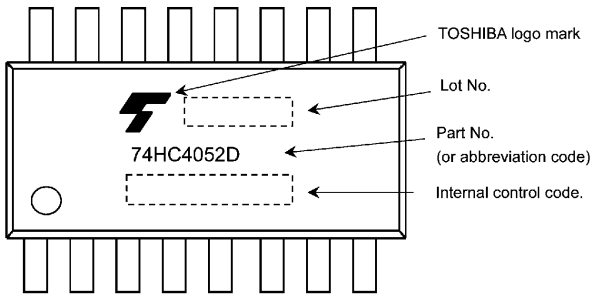


7. Marking

74HC4051D

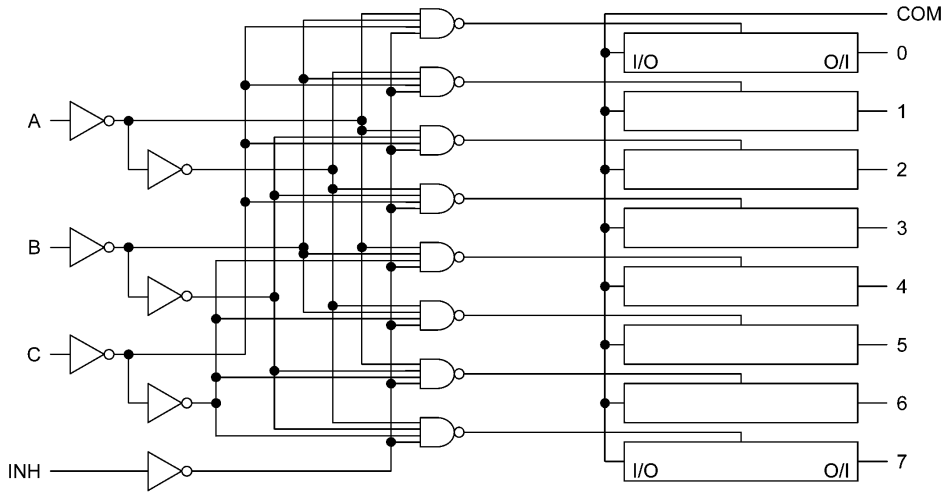


74HC4052D

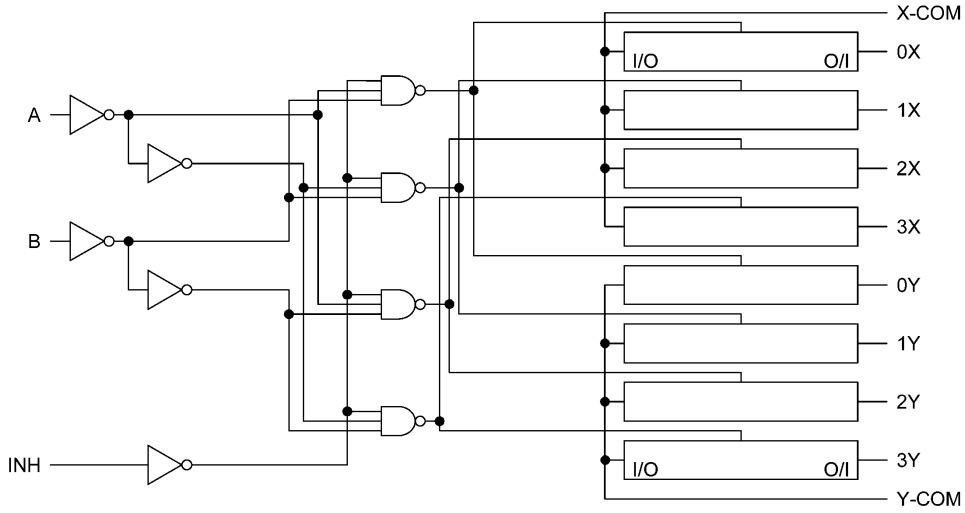


8. System Diagram

74HC4051D



74HC4052D



9. Truth Table

Input Inhibit	Input C*	Input B	Input A	ON Channel 74HC4051D	ON Channel 74HC4052D
L	L	L	L	0	0X, 0Y
L	L	L	H	1	1X, 1Y
L	L	H	L	2	2X, 2Y
L	L	H	H	3	3X, 3Y
L	H	L	L	4	—
L	H	L	H	5	—
L	H	H	L	6	—
L	H	H	H	7	—
H	X	X	X	None	None

X: Don't care
*: Except 74HC4052D

10. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		-0.5 to 7.0	V
Supply voltage	V_{EE}		-7.0 to 0	V
Supply voltage	V_{CC}-V_{EE}		-0.5 to 13.0	V
Input voltage	V_{IN}		-0.5 to V_{CC} + 0.5	V
Switch I/O voltage	$V_{I/O}$		V_{EE} - 0.5 to V_{CC} + 0.5	V
Input diode current	I_{IK}		±20	mA
I/O diode current	$I_{I/OK}$		±20	mA
Switch through current	I_T		±25	mA
V_{CC}/ground current	I_{CC}		±50	mA
Power dissipation	P_D	(Note 1)	500	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: P_D derates linearly with -8 mW/°C above 85 °C.

11. Operating Ranges (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		2.0 to 6.0	V
Supply voltage	V_{EE}		-6.0 to 0	V
Supply voltage	V_{CC}-V_{EE}		2.0 to 12.0	V
Input voltage	V_{IN}		0 to V_{CC}	V
Switch I/O voltage	$V_{I/O}$		V_{EE} to V_{CC}	V
Operating temperature	T_{opr}	(Note 1)	-40 to 125	°C
Input rise and fall times	t_r,t_f		0 to 50	μs

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.

Note 1: Operating Range spec of T_{opr} = -40 °C to 125 °C is applicable only for the products which manufactured after July 2020.

12. Electrical Characteristics

12.1. DC Characteristics (Unless otherwise specified, T_a = 25 °C)

Characteristics	Symbol	Test Condition	V_{EE} (V)	V_{CC} (V)	Min	Typ.	Max	Unit
High-level input voltage	V_{IH}	—		2.0	1.50	—	—	V
				4.5	3.15	—	—	
				6.0	4.20	—	—	
Low-level input voltage	V_{IL}	—		2.0	—	—	0.50	V
				4.5	—	—	1.35	
				6.0	—	—	1.80	
ON-resistance	R_{ON}	V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{CC} to V_{EE} $I_{I/O}$ ≤ 2 mA	GND	4.5	—	180	240	Ω
			-4.5	4.5	—	140	190	
			-6.0	6.0	—	135	180	
		V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{EE} $I_{I/O}$ ≤ 2 mA	GND	2.0	—	210	—	
			GND	4.5	—	150	200	
			-4.5	4.5	—	130	170	
			-6.0	6.0	—	125	170	
		V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{CC} $I_{I/O}$ ≤ 2 mA	GND	2.0	—	220	—	
			GND	4.5	—	95	130	
			-4.5	4.5	—	75	100	
			-6.0	6.0	—	70	100	
Difference of ON-resistance between switches	ΔR_{ON}	V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{CC} to V_{EE} $I_{I/O}$ ≤ 2 mA	GND	4.5	—	10	30	Ω
			-4.5	4.5	—	5	12	
			-6.0	6.0	—	5	10	
Input/Output leakage current (Switch OFF)	I_{OFF}	V_{OS} = V_{CC} or GND V_{IS} = GND or V_{CC} V_{IN} = V_{IH} or V_{IL}	GND	6.0	—	—	±0.06	μA
			-6.0	6.0	—	—	±0.1	
Input/Output leakage current (Switch ON)	$I_{I/O}$	V_{OS} = V_{CC} or GND V_{IN} = V_{IH} or V_{IL}	GND	6.0	—	—	±0.06	μA
			-6.0	6.0	—	—	±0.1	
Control input leakage current	I_{IN}	V_{IN} = V_{CC} or GND	GND	6.0	—	—	±0.1	μA
Quiescent supply current	I_{CC}	V_{IN} = V_{CC} or GND	GND	6.0	—	—	4.0	μA
			-6.0	6.0	—	—	8.0	

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

Characteristics	Symbol	Test Condition	V_{EE} (V)	V_{CC} (V)	Min	Max	Unit
High-level input voltage	V_{IH}	—		2.0	1.50	—	V
				4.5	3.15	—	
				6.0	4.20	—	
Low-level input voltage	V_{IL}	—		2.0	—	0.50	V
				4.5	—	1.35	
				6.0	—	1.80	
ON-resistance	R_{ON}	V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{CC} to V_{EE} $I_{I/O} \leq$ 2 mA	GND	4.5	—	300	Ω
			-4.5	4.5	—	240	
			-6.0	6.0	—	225	
		V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{EE} $I_{I/O} \leq$ 2 mA	GND	4.5	—	250	
			-4.5	4.5	—	215	
			-6.0	6.0	—	215	
		V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{CC} $I_{I/O} \leq$ 2 mA	GND	4.5	—	165	
			-4.5	4.5	—	125	
			-6.0	6.0	—	125	
Difference of ON-resistance between switches	ΔR_{ON}	V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{CC} to V_{EE} $I_{I/O} \leq$ 2 mA	GND	4.5	—	35	Ω
			-4.5	4.5	—	15	
			-6.0	6.0	—	12	
Input/Output leakage current (Switch OFF)	I_{OFF}	V_{OS} = V_{CC} or GND V_{IS} = GND or V_{CC} V_{IN} = V_{IH} or V_{IL}	GND	6.0	—	±0.6	μA
			-6.0	6.0	—	±1.0	
Input/Output leakage current (Switch ON)	$I_{I/O}$	V_{OS} = V_{CC} or GND V_{IN} = V_{IH} or V_{IL}	GND	6.0	—	±0.6	μA
			-6.0	6.0	—	±1.0	μA
Control input leakage current	I_{IN}	V_{IN} = V_{CC} or GND	GND	6.0	—	±1.0	μA
Quiescent supply current	I_{CC}	V_{IN} = V_{CC} or GND	GND	6.0	—	40.0	μA
			-6.0	6.0	—	80.0	

12.3. DC Characteristics (Note) (Unless otherwise specified, T_a = -40 to 125 °C)

Characteristics	Symbol	Test Condition	V_{EE} (V)	V_{CC} (V)	Min	Max	Unit
High-level input voltage	V_{IH}	—		2.0	1.50	—	V
				4.5	3.15	—	
				6.0	4.20	—	
Low-level input voltage	V_{IL}	—		2.0	—	0.50	V
				4.5	—	1.35	
				6.0	—	1.80	
ON-resistance	R_{ON}	V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{CC} to V_{EE} $I_{I/O} \leq$ 2 mA	GND	4.5	—	340	Ω
			-4.5	4.5	—	275	
			-6.0	6.0	—	255	
		V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{EE} $I_{I/O} \leq$ 2 mA	GND	4.5	—	285	
			-4.5	4.5	—	245	
			-6.0	6.0	—	245	
		V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{CC} $I_{I/O} \leq$ 2 mA	GND	4.5	—	190	
			-4.5	4.5	—	145	
			-6.0	6.0	—	145	
Difference of ON-resistance between switches	ΔR_{ON}	V_{IN} = V_{IH} or V_{IL} $V_{I/O}$ = V_{CC} to V_{EE} $I_{I/O} \leq$ 2 mA	GND	4.5	—	35	Ω
			-4.5	4.5	—	15	
			-6.0	6.0	—	12	
Input/Output leakage current (Switch OFF)	I_{OFF}	V_{OS} = V_{CC} or GND V_{IS} = GND or V_{CC} V_{IN} = V_{IL}	GND	6.0	—	±3.0	μA
			-6.0	6.0	—	±5.0	
Input/Output leakage current (Switch ON)	$I_{I/O}$	V_{OS} = V_{CC} or GND V_{IN} = V_{IH} or V_{IL}	GND	6.0	—	±3.0	μA
			-6.0	6.0	—	±5.0	
Control input leakage current	I_{IN}	V_{IN} = V_{CC} or GND	GND	6.0	—	±1.0	μA
Quiescent supply current	I_{CC}	V_{IN} = V_{CC} or GND	GND	6.0	—	80.0	μA
			-6.0	6.0	—	160.0	

Note: Operating Range spec of T_{opr} = -40 °C to 125 °C is applicable only for the products which manufactured after July 2020.

12.4. AC Characteristics
(Unless otherwise specified, C_L = 50 pF, T_a = 25 °C, Input: $t_r = t_f$ = 6 ns)

Characteristics	Part Number	Symbol	Test Condition	V_{EE} (V)	V_{CC} (V)	Min	Typ.	Max	Unit
Phase difference between input to output		$\varphi_{I/O}$	—	GND	2.0	—	18	25	ns
				GND	4.5	—	7	12	
				GND	6.0	—	6	10	
				-4.5	4.5	—	5	8	
Output enable time	74HC4051D	t_{PZL},t_{PZH}	R_L = 1 kΩ Figure 1	GND	2.0	—	90	145	ns
				GND	4.5	—	30	45	
				GND	6.0	—	25	35	
				-4.5	4.5	—	24	34	
	74HC4052D		R_L = 1 kΩ Figure 1	GND	2.0	—	90	145	
				GND	4.5	—	30	45	
				GND	6.0	—	25	35	
				-4.5	4.5	—	24	34	
Output disable time	74HC4051D	t_{PLZ},t_{PHZ}	R_L = 1 kΩ Figure 1	GND	2.0	—	56	85	ns
				GND	4.5	—	26	35	
				GND	6.0	—	25	33	
				-4.5	4.5	—	24	32	
	74HC4052D		R_L = 1 kΩ Figure 1	GND	2.0	—	56	85	
				GND	4.5	—	26	35	
				GND	6.0	—	25	33	
				-4.5	4.5	—	24	32	
Control input capacitance		C_{IN}	—	—	—	—	5	10	pF
Common terminal capacitance	74HC4051D	C_{IS}	Figure 2	-5.0	5.0	—	36	70	pF
	74HC4052D					—	19	40	
Switch terminal capacitance	74HC4051D	C_{OS}	Figure 2	-5.0	5.0	—	7	15	pF
	74HC4052D					—	7	15	
Feedthrough capacitance	74HC4051D	C_{IOS}	Figure 2	-5.0	5.0	—	0.95	2	pF
	74HC4052D					—	0.85	2	
Power dissipation capacitance	74HC4051D	C_{PD}	Figure 2 (Note 1)	-5.0	5.0	—	11	—	pF
	74HC4052D					—	19	—	

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.

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

12.5. AC Characteristics (Unless otherwise specified, C_L = 50 pF, T_a = -40 to 85 °C, Input: $t_r = t_f$ = 6 ns)

Characteristics	Part Number	Symbol	Test Condition	V_{EE} (V)	V_{CC} (V)	Min	Max	Unit
Phase difference between input to output		$\varphi_{I/O}$	—	GND	2.0	—	30	ns
				GND	4.5	—	15	
				GND	6.0	—	13	
				-4.5	4.5	—	10	
Output enable time	74HC4051D	t_{PZL},t_{PZH}	R_L = 1 kΩ Figure 1	GND	2.0	—	150	ns
				GND	4.5	—	55	
				GND	6.0	—	42	
				-4.5	4.5	—	41	
	74HC4052D		R_L = 1 kΩ Figure 1	GND	2.0	—	150	
				GND	4.5	—	55	
				GND	6.0	—	42	
				-4.5	4.5	—	41	
Output disable time	74HC4051D	t_{PLZ},t_{PHZ}	R_L = 1 kΩ Figure 1	GND	2.0	—	90	ns
				GND	4.5	—	45	
				GND	6.0	—	40	
				-4.5	4.5	—	39	
	74HC4052D		R_L = 1 kΩ Figure 1	GND	2.0	—	90	
				GND	4.5	—	45	
				GND	6.0	—	40	
				-4.5	4.5	—	39	
Control input capacitance		C_{IN}	—	—	—	—	10	pF
Common terminal capacitance	74HC4051D	C_{IS}	Figure 2	-5.0	5.0	—	70	pF
	74HC4052D					—	40	
Switch terminal capacitance	74HC4051D	C_{OS}	Figure 2	-5.0	5.0	—	15	pF
	74HC4052D					—	15	
Feedthrough capacitance	74HC4051D	C_{IOS}	Figure 2	-5.0	5.0	—	2	pF
	74HC4052D					—	2	

12.6. AC Characteristics (Note)
(Unless otherwise specified, C_L = 50 pF, T_a = -40 to 125 °C, Input: $t_r = t_f$ = 6 ns)

Characteristics	Part Number	Symbol	Test Condition	V_{EE} (V)	V_{CC} (V)	Min	Max	Unit
Phase difference between input to output		$\varphi_{I/O}$	—	GND	2.0	—	35	ns
				GND	4.5	—	17	
				GND	6.0	—	15	
				-4.5	4.5	—	12	
Output enable time	74HC4051D	t_{PZL},t_{PZH}	R_L = 1 kΩ Figure 1	GND	2.0	—	155	ns
				GND	4.5	—	62	
				GND	6.0	—	47	
				-4.5	4.5	—	46	
	74HC4052D		R_L = 1 kΩ Figure 1	GND	2.0	—	155	
				GND	4.5	—	62	
				GND	6.0	—	47	
				-4.5	4.5	—	46	
Output disable time	74HC4051D	t_{PLZ},t_{PHZ}	R_L = 1 kΩ Figure 1	GND	2.0	—	95	ns
				GND	4.5	—	52	
				GND	6.0	—	45	
				-4.5	4.5	—	44	
	74HC4052D		R_L = 1 kΩ Figure 1	GND	2.0	—	95	
				GND	4.5	—	52	
				GND	6.0	—	45	
				-4.5	4.5	—	44	
Control input capacitance		C_{IN}	—	—	—	—	10	pF
Common terminal capacitance	74HC4051D	C_{IS}	Figure 2	-5.0	5.0	—	70	pF
	74HC4052D			-5.0	5.0	—	40	
Switch terminal capacitance	74HC4051D	C_{OS}	Figure 2	-5.0	5.0	—	15	pF
	74HC4052D	C_{OS}		-5.0	5.0	—	15	
Feedthrough capacitance	74HC4051D	C_{IOS}	Figure 2	-5.0	5.0	—	2	pF
	74HC4052D			-5.0	5.0	—	2	

Note: Operating Range spec of T_{opr} = -40 °C to 125 °C is applicable only for the products which manufactured after July 2020.

12.7. Analog Switch Characteristics (T_a = 25 °C) (Note)

Characteristics	Part Number	Symbol	Test Condition		V_{EE} (V)	V_{CC} (V)	Typ.	Unit
Sine Wave Distortion		THD	R_L = 10 kΩ, C_L = 50 pF f_{IN} = 1 kHz	V_{IN} = 4.0 V_{p-p}	-2.25	2.25	0.025	%
				V_{IN} = 8.0 V_{p-p}	-4.5	4.5	0.020	
				V_{IN} = 11.0 V_{p-p}	-6.0	6.0	0.018	
Maximum frequency response		$f_{MAX(I/O)}$	Adjust f_{IN} voltage to obtain 0 dBm at V_{OS} Increase f_{IN} frequency until dB meter reads -3 dB R_L = 50 Ω, C_L = 10 pF f_{IN} = 1 MHz, sine wave Figure 3	(Note 1)	-2.25	2.25	120	MHz
	74HC4051D			(Note 2)			45	
	74HC4052D						70	
				(Note 1)	-4.5	4.5	190	
	74HC4051D			(Note 2)			70	
	74HC4052D						110	
				(Note 1)	-6.0	6.0	200	
	74HC4051D			(Note 2)			85	
	74HC4052D						140	
Feed through attenuation (switch OFF)		FTH	V_{IN} is centered at (V_{CC}/2). Adjust input for 0 dBm. R_L = 600 Ω, C_L = 50 pF, f_{IN} = 1 MHz, sine wave Figure 4		-2.25	2.25	-50	dB
					-4.5	4.5	-50	
					-6.0	6.0	-50	
Crosstalk (control input to signal output)		X_{talk}	R_L = 600 Ω, C_L = 50 pF, f_{IN} = 1 MHz, square wave (t_r = t_f = 6 ns) Figure 5		-2.25	2.25	60	mV
					-4.5	4.5	140	
					-6.0	6.0	200	
Crosstalk (between any switches)		X_{talk}	Adjust V_{IN} to obtain 0 dBm at input. R_L = 600 Ω, C_L = 50 pF, f_{IN} = 1 MHz, sine wave Figure 6		-2.25	2.25	-50	dB
					-4.5	4.5	-50	
					-6.0	6.0	-50	

Note: These characteristics are determined by design of devices.
Note 1: Input COMMON terminal, and measured at SWITCH terminal.
Note 2: Input SWITCH terminal, and measured at COMMON terminal.

13. AC Test Circuit

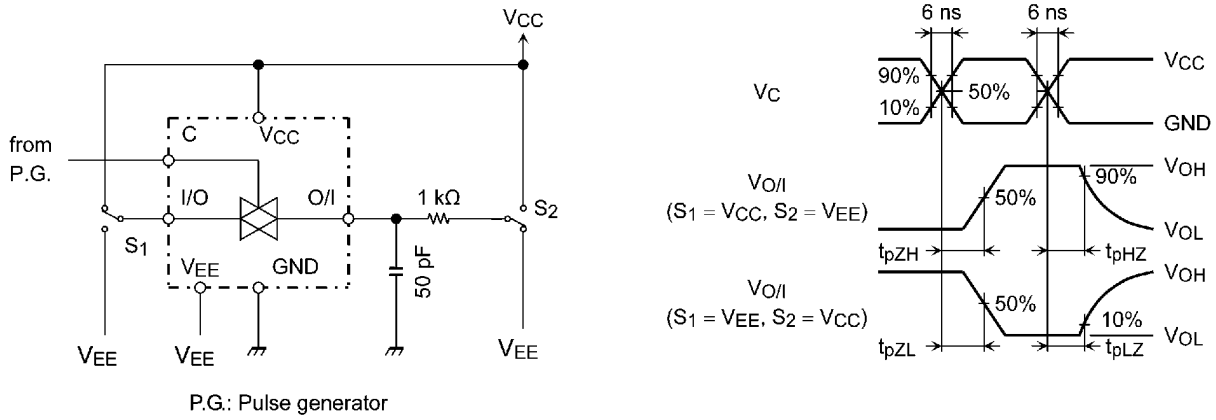


Figure 1 t_{PLZ}, t_{PHZ}, t_{PZL}, t_{PZH}

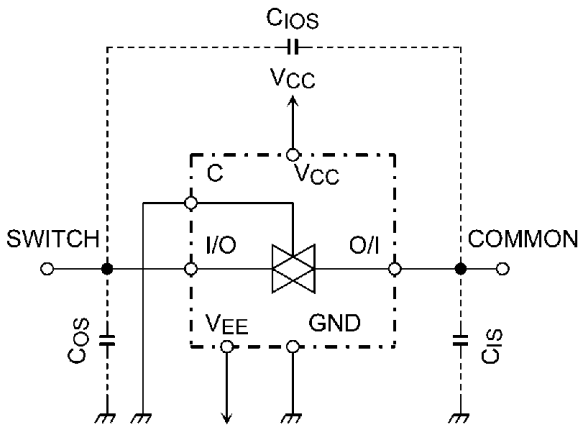


Figure 2 C_{IOS}, C_{IS}, C_{OS}

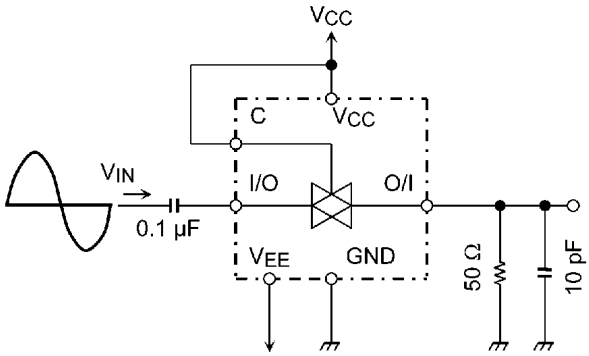


Figure 3 Frequency Response

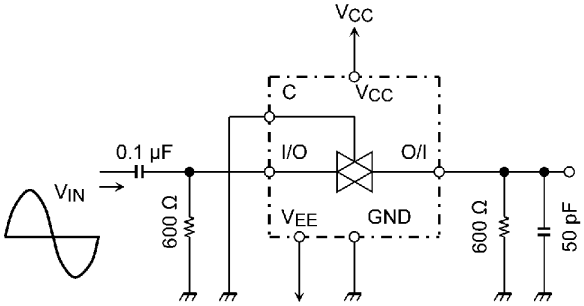
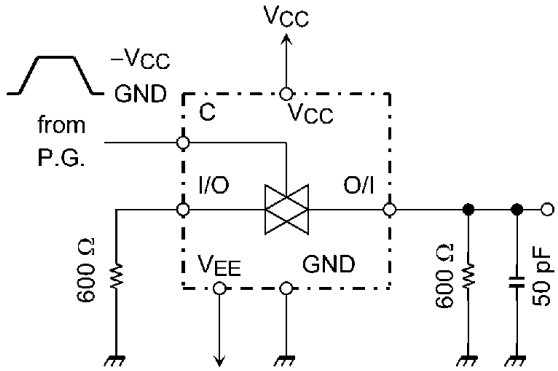


Figure 4 Feedthrough Attenuation



P.G.: Pulse generator

Figure 5 Cross Talk (control input to output signal)

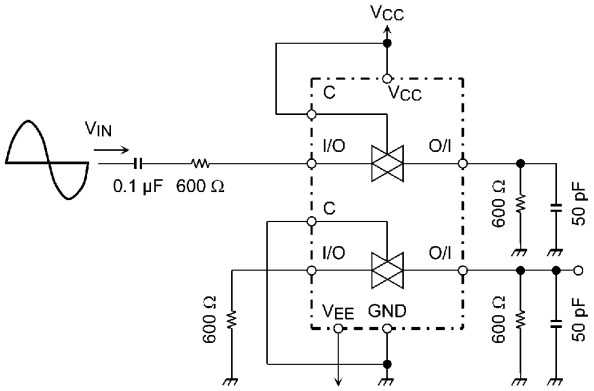
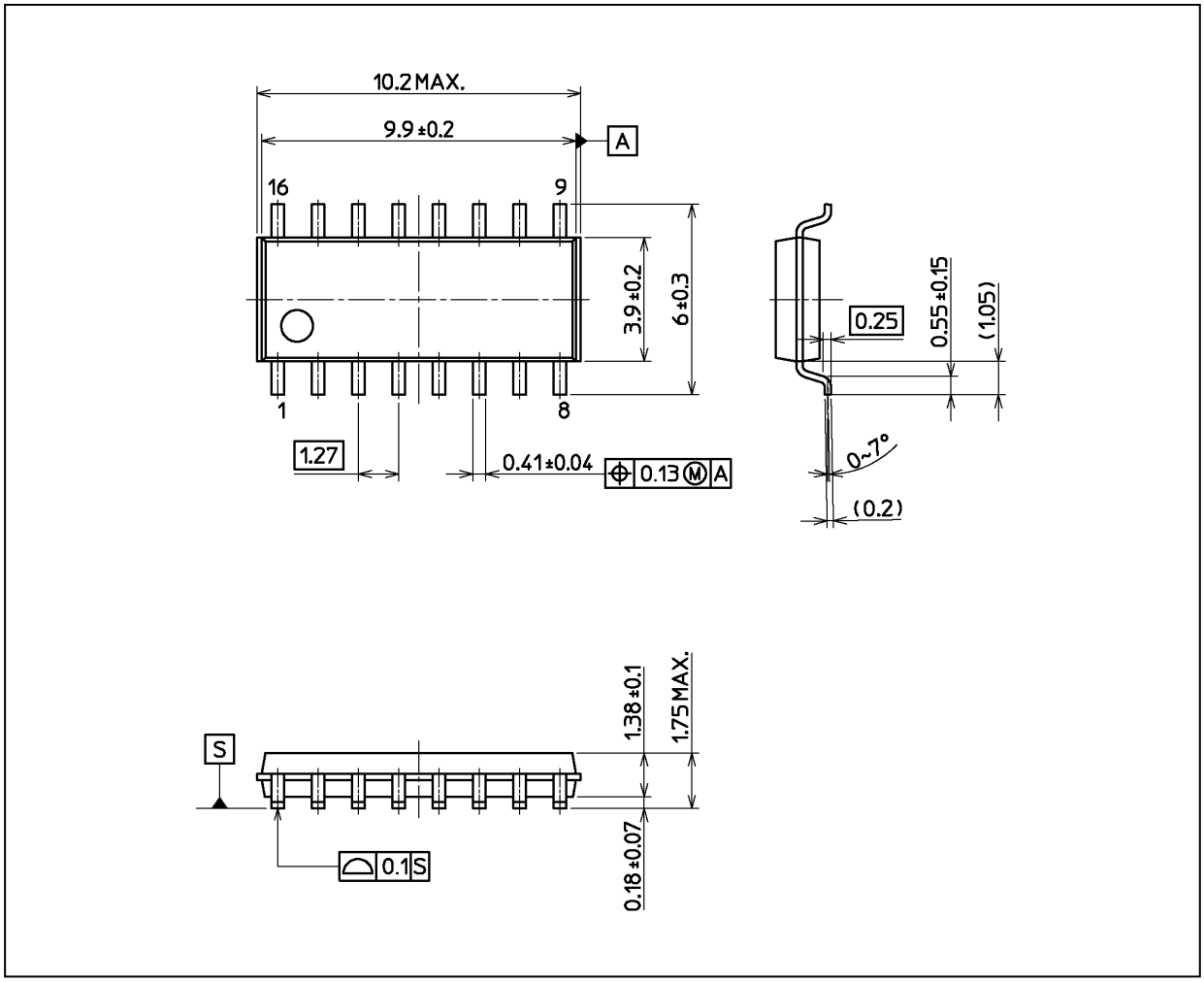


Figure 6 Cross Talk (between any two switches)

Package Dimensions

Unit: mm



Weight: 0.15 g (typ.)

Package Name(s)
Nickname: SOIC16

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