

# 74HC4053D

## 1. Functional Description

- Triple 2-Channel Analog Multiplexer/Demultiplexer

## 2. General

The 74HC4053D are high speed CMOS ANALOG MULTIPLEXER/DEMULTIPLEXER fabricated with silicon gate C<sup>2</sup>MOS technology. They achieve the high speed operation similar to equivalent LSTTL while maintaining the CMOS low power dissipation.

The 74HC4053D has a 2 channel × 3 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.

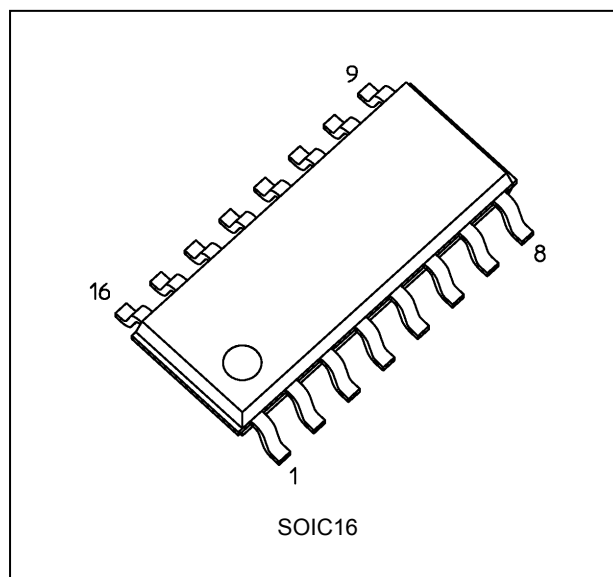
For example, in the case of  $V_{CC} = 5\text{ V}$ ,  $GND = 0\text{ V}$ ,  $V_{EE} = -5\text{ V}$ , signals between  $-5\text{ V}$  and  $+5\text{ V}$  can be switched from the logical circuit with a single power supply of  $5\text{ V}$ . As the ON-resistance of each switch is low, they can be connected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

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

## 3. Features

- (1) Low power dissipation:  $I_{CC} = 4.0\ \mu\text{A}$  (max) ( $V_{CC} = 6.0\text{ V}$ ,  $V_{EE} = GND$ ,  $T_a = 25\text{ }^\circ\text{C}$ )
- (2) High noise immunity:  $V_{NIH} = V_{NIL} = 28\% V_{CC}$  (min)
- (3) Low ON-resistance:  $R_{ON} = 50\ \Omega$  (typ.) at  $V_{CC} - V_{EE} = 9\text{ V}$
- (4) High noise immunity: THD = 0.020 % (typ.) at  $V_{CC} - V_{EE} = 9\text{ V}$
- (5) Pin and function compatible with 4053B

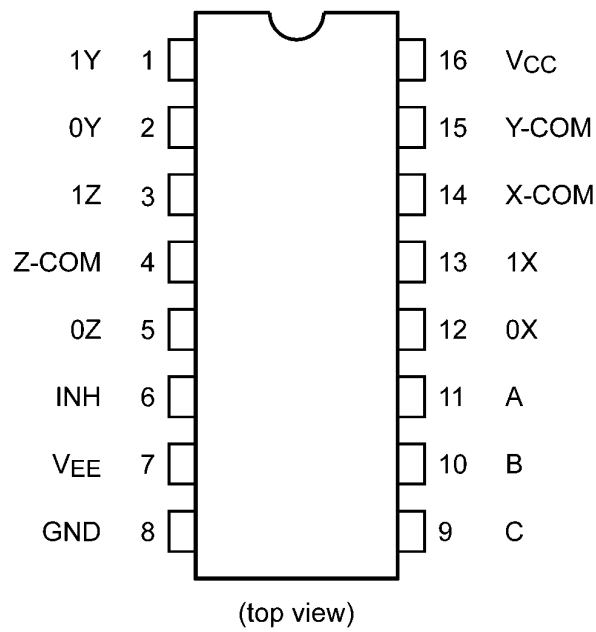
## 4. Packaging



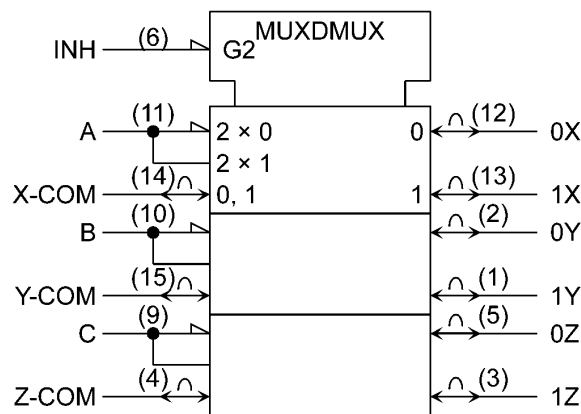
Start of commercial production

2016-08

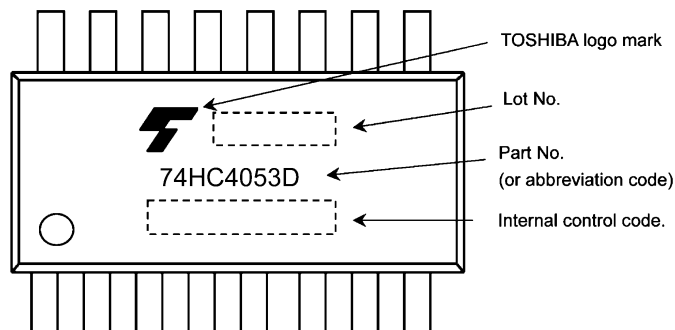
**5. Pin Assignment**



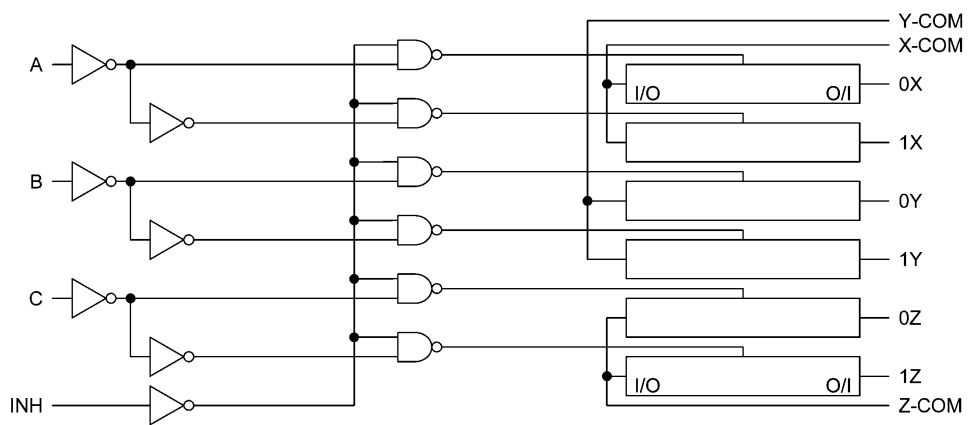
**6. IEC Logic Symbol**



**7. Marking**



8. System Diagram



**9. Truth Table**

| Input Inhibit | Input C | Input B | Input A | ON Channel |
|---------------|---------|---------|---------|------------|
| L             | L       | L       | L       | 0X, 0Y, 0Z |
| L             | L       | L       | H       | 1X, 0Y, 0Z |
| L             | L       | H       | L       | 0X, 1Y, 0Z |
| L             | L       | H       | H       | 1X, 1Y, 0Z |
| L             | H       | L       | L       | 0X, 0Y, 1Z |
| L             | H       | L       | H       | 1X, 0Y, 1Z |
| L             | H       | H       | L       | 0X, 1Y, 1Z |
| L             | H       | H       | H       | 1X, 1Y, 1Z |
| H             | X       | X       | X       | None       |

X: Don't care

**10. Absolute Maximum Ratings (Note)**

| Characteristics          | Symbol          | Rating                           | Unit |
|--------------------------|-----------------|----------------------------------|------|
| Supply voltage           | $V_{CC}$        | -0.5 to 7.0                      | V    |
|                          | $V_{EE}$        | -7.0 to 0                        |      |
|                          | $V_{CC}-V_{EE}$ | -0.5 to 13.0                     |      |
| 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        | $P_D$           | 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).

**11. Operating Ranges (Note)**

| Characteristics           | Symbol          | Rating               | Unit |
|---------------------------|-----------------|----------------------|------|
| Supply voltage            | $V_{CC}$        | 2.0 to 6.0           | V    |
|                           | $V_{EE}$        | -6.0 to 0            |      |
|                           | $V_{CC}-V_{EE}$ | 2.0 to 12.0          |      |
| Input voltage             | $V_{IN}$        | 0 to $V_{CC}$        | V    |
| Switch I/O voltage        | $V_{I/O}$       | $V_{EE}$ to $V_{CC}$ | V    |
| Operating temperature     | $T_{opr}$       | -40 to 85            | °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.

**12. Electrical Characteristics**

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

| 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 $V_{IL}$<br>$V_{IO} = V_{CC}$ to $V_{EE}$<br>$I_{IO} \leq 2\text{ mA}$    | GND          | 4.5          | —    | 85   | 180        | $\Omega$      |
|  |                 |  | -4.5         | 4.5          | —    | 55   | 120        |               |
|  |                 |  | -6.0         | 6.0          | —    | 50   | 100        |               |
|  |                 | $V_{IN} = V_{IH}$ or $V_{IL}$<br>$V_{IO} = V_{CC}$ or $V_{EE}$<br>$I_{IO} \leq 2\text{ mA}$    | GND          | 2.0          | —    | 150  | —          |               |
|  |                 |  | GND          | 4.5          | —    | 70   | 150        |               |
|  |                 |  | -4.5         | 4.5          | —    | 50   | 100        |               |
| Difference of ON-resistance between switches | $\Delta R_{ON}$ | $V_{IN} = V_{IH}$ or $V_{IL}$<br>$V_{IO} = V_{CC}$ to $V_{EE}$<br>$I_{IO} \leq 2\text{ mA}$    | GND          | 4.5          | —    | 10   | 30         | $\Omega$      |
|  |                 |  | -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<br>$V_{IS} = \text{GND}$ or $V_{CC}$<br>$V_{IN} = V_{IH}$ or $V_{IL}$ | GND          | 6.0          | —    | —    | $\pm 0.06$ | $\mu\text{A}$ |
|  |                 |  | -6.0         | 6.0          | —    | —    | $\pm 0.1$  |               |
| Input/Output leakage current (Switch ON)     | $I_{IO}$        | $V_{OS} = V_{CC}$ or GND<br>$V_{IN} = V_{IH}$ or $V_{IL}$                                      | GND          | 6.0          | —    | —    | $\pm 0.06$ | $\mu\text{A}$ |
|  |                 |  | -6.0         | 6.0          | —    | —    | $\pm 0.1$  |               |
| Control input leakage current                | $I_{IN}$        | $V_{IN} = V_{CC}$ or GND   | GND          | 6.0          | —    | —    | $\pm 0.1$  | $\mu\text{A}$ |
| Quiescent supply current                     | $I_{CC}$        | $V_{IN} = V_{CC}$ or GND   | GND          | 6.0          | —    | —    | 4.0        | $\mu\text{A}$ |
|  |                 |  | -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 $V_{IL}$<br>$V_{I/O} = V_{CC}$ to $V_{EE}$<br>$I_{I/O} \leq 2$ mA  | GND          | 4.5          | —    | 225       | $\Omega$ |
|  |                 |   | -4.5         | 4.5          | —    | 150       |          |
|  |                 |   | -6.0         | 6.0          | —    | 125       |          |
|  |                 |   | GND          | 2.0          | —    | —         |          |
|  |                 |   | GND          | 4.5          | —    | 190       |          |
|  |                 |   | -4.5         | 4.5          | —    | 125       |          |
| Difference of ON-resistance between switches | $\Delta R_{ON}$ | $V_{IN} = V_{IH}$ or $V_{IL}$<br>$V_{I/O} = V_{CC}$ to $V_{EE}$<br>$I_{I/O} \leq 2$ mA  | GND          | 4.5          | —    | 35        | $\Omega$ |
|  |                 |   | -4.5         | 4.5          | —    | 15        |          |
|  |                 |   | -6.0         | 6.0          | —    | 12        |          |
| Input/Output leakage current (Switch OFF)    | $I_{OFF}$       | $V_{OS} = V_{CC}$ or GND<br>$V_{IS} =$ GND or $V_{CC}$<br>$V_{IN} = V_{IH}$ or $V_{IL}$ | GND          | 6.0          | —    | $\pm 0.6$ | $\mu A$  |
|  |                 |   | -6.0         | 6.0          | —    | $\pm 1.0$ |          |
| Input/Output leakage current (Switch ON)     | $I_{I/O}$       | $V_{OS} = V_{CC}$ or GND<br>$V_{IN} = V_{IH}$ or $V_{IL}$                               | GND          | 6.0          | —    | $\pm 0.6$ | $\mu A$  |
|  |                 |   | -6.0         | 6.0          | —    | $\pm 1.0$ |          |
| Control input leakage current                | $I_{IN}$        | $V_{IN} = V_{CC}$ or GND  | GND          | 6.0          | —    | $\pm 1.0$ | $\mu A$  |
| Quiescent supply current                     | $I_{CC}$        | $V_{IN} = V_{CC}$ or GND  | GND          | 6.0          | —    | 40.0      | $\mu A$  |
|  |                 |   | -6.0         | 6.0          | —    | 80.0      |          |

**12.3. AC Characteristics**

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

| Characteristics                          | Symbol             | Test Condition                   | $V_{EE}$ (V) | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|--|--------------------|----------------------------------|--------------|--------------|-----|------|-----|------|
| Phase difference between input to output | $\phi_{I/O}$       | —                                | GND          | 2.0          | —   | 25   | 60  | ns   |
|  |                    |                                  | GND          | 4.5          | —   | 6    | 12  |      |
|  |                    |                                  | GND          | 6.0          | —   | 5    | 10  |      |
|  |                    |                                  | -4.5         | 4.5          | —   | 4    | —   |      |
| Output enable time                       | $t_{PZL}, t_{PZH}$ | $R_L = 1$ k $\Omega$<br>Figure 1 | GND          | 2.0          | —   | 50   | 225 | ns   |
|  |                    |                                  | GND          | 4.5          | —   | 14   | 45  |      |
|  |                    |                                  | GND          | 6.0          | —   | 12   | 38  |      |
|  |                    |                                  | -4.5         | 4.5          | —   | 14   | —   |      |
| Output disable time                      | $t_{PLZ}, t_{PHZ}$ | $R_L = 1$ k $\Omega$<br>Figure 1 | GND          | 2.0          | —   | 95   | 225 | ns   |
|  |                    |                                  | GND          | 4.5          | —   | 30   | 45  |      |
|  |                    |                                  | GND          | 6.0          | —   | 26   | 38  |      |
|  |                    |                                  | -4.5         | 4.5          | —   | 26   | —   |      |
| Control input capacitance                | $C_{IN}$           | —                                | —            | —            | —   | 5    | 10  | pF   |
| Common terminal capacitance              | $C_{IS}$           | Figure 2                         | -5.0         | 5.0          | —   | 11   | 20  | pF   |
| Switch terminal capacitance              | $C_{OS}$           | Figure 2                         | -5.0         | 5.0          | —   | 7    | 15  | pF   |
| Feedthrough capacitance                  | $C_{IOS}$          | Figure 2                         | -5.0         | 5.0          | —   | 0.75 | 2   | pF   |
| Power dissipation capacitance            | $C_{PD}$           | Figure 2<br>(Note 1)             | GND          | 5.0          | —   | 10   | —   | pF   |

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.

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

**12.4. AC Characteristics (Unless otherwise specified,  $C_L = 50 \text{ pF}$ ,  $T_a = -40 \text{ to } 85 \text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 6 \text{ ns}$ )**

| Characteristics                          | Symbol             | Test Condition                        | $V_{EE}$ (V) | $V_{CC}$ (V) | Min | Max | Unit |
|--|--------------------|---------------------------------------|--------------|--------------|-----|-----|------|
| Phase difference between input to output | $\phi_{I/O}$       | —                                     | GND          | 2.0          | —   | 75  | ns   |
|  |                    |                                       | GND          | 4.5          | —   | 15  |      |
|  |                    |                                       | GND          | 6.0          | —   | 13  |      |
|  |                    |                                       | -4.5         | 4.5          | —   | —   |      |
| Output enable time                       | $t_{PZL}, t_{PZH}$ | $R_L = 1 \text{ k}\Omega$<br>Figure 1 | GND          | 2.0          | —   | 280 | ns   |
|  |                    |                                       | GND          | 4.5          | —   | 56  |      |
|  |                    |                                       | GND          | 6.0          | —   | 48  |      |
|  |                    |                                       | -4.5         | 4.5          | —   | —   |      |
| Output disable time                      | $t_{PLZ}, t_{PHZ}$ | $R_L = 1 \text{ k}\Omega$<br>Figure 1 | GND          | 2.0          | —   | 280 | ns   |
|  |                    |                                       | GND          | 4.5          | —   | 56  |      |
|  |                    |                                       | GND          | 6.0          | —   | 48  |      |
|  |                    |                                       | -4.5         | 4.5          | —   | —   |      |
| Control input capacitance                | $C_{IN}$           | —                                     | —            | —            | —   | 10  | pF   |
| Common terminal capacitance              | $C_{IS}$           | Figure 2                              | -5.0         | 5.0          | —   | 20  | pF   |
| Switch terminal capacitance              | $C_{OS}$           | Figure 2                              | -5.0         | 5.0          | —   | 15  | pF   |
| Feedthrough capacitance                  | $C_{IOS}$          | Figure 2                              | -5.0         | 5.0          | —   | 2   | pF   |

**12.5. Analog Switch Characteristics ( $T_a = 25 \text{ }^\circ\text{C}$ ) (Note)**

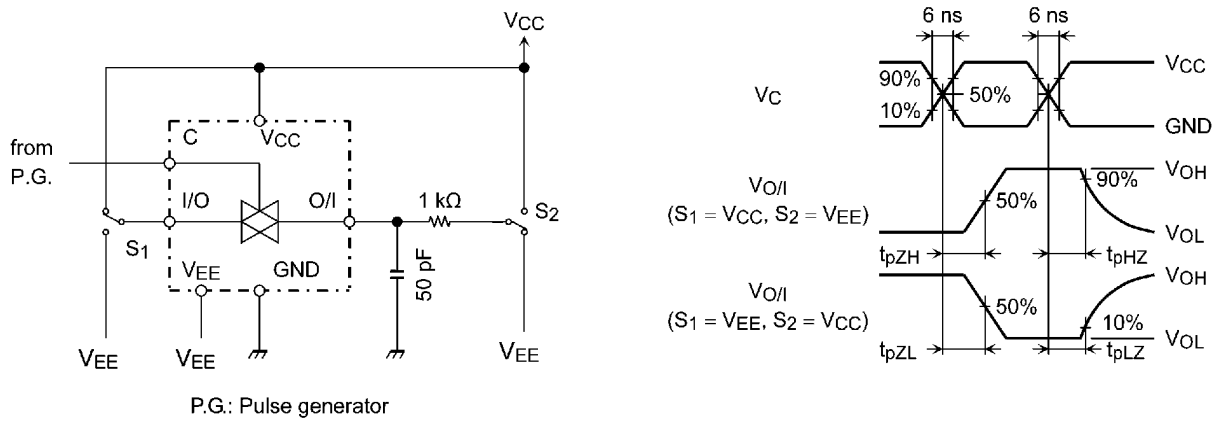
| Characteristics                            | Symbol         | Test Condition   | $V_{EE}$ (V)                    | $V_{CC}$ (V) | Typ. | Unit  |     |
|--|----------------|--|---------------------------------|--------------|------|-------|-----|
| Sine Wave Distortion                       | THD            | $R_L = 10 \text{ k}\Omega$ , $C_L = 50 \text{ pF}$<br>$f_{IN} = 1 \text{ kHz}$   | $V_{IN} = 4.0 \text{ V}_{p-p}$  | -2.25        | 2.25 | 0.025 | %   |
|  |                |  | $V_{IN} = 8.0 \text{ V}_{p-p}$  | -4.5         | 4.5  | 0.020 |     |
|  |                |  | $V_{IN} = 11.0 \text{ V}_{p-p}$ | -6.0         | 6.0  | 0.018 |     |
| Maximum frequency response                 | $f_{MAX(I/O)}$ | Adjust $f_{IN}$ voltage to obtain 0 dBm at $V_{OS}$<br>Increase $f_{IN}$ frequency until dB meter reads -3 dB<br>$R_L = 50 \text{ }\Omega$ , $C_L = 10 \text{ pF}$<br>$f_{IN} = 1 \text{ MHz}$ , sine wave<br>Figure 3 | (Note 1)                        | -2.25        | 2.25 | 120   | MHz |
|  |                |  | (Note 2)                        | —            | —    | 95    |     |
|  |                |  | (Note 1)                        | -4.5         | 4.5  | 190   |     |
|  |                |  | (Note 2)                        | —            | —    | 150   |     |
|  |                |  | (Note 1)                        | -6.0         | 6.0  | 200   |     |
|  |                |  | (Note 2)                        | —            | —    | 190   |     |
| Feed through attenuation (switch OFF)      | FTH            | $V_{IN}$ is centered at $(V_{CC} - V_{EE})/2$<br>Adjust input for 0 dBm.<br>$R_L = 600 \text{ }\Omega$ , $C_L = 50 \text{ pF}$ ,<br>$f_{IN} = 1 \text{ MHz}$ , sine wave<br>Figure 4                                   | -2.25                           | 2.25         | -50  | dB    |     |
|  |                |  | -4.5                            | 4.5          | -50  |       |     |
|  |                |  | -6.0                            | 6.0          | -50  |       |     |
| Crosstalk (control input to signal output) | $X_{talk}$     | $R_L = 600 \text{ }\Omega$ , $C_L = 50 \text{ pF}$ ,<br>$f_{IN} = 1 \text{ MHz}$ ,<br>square wave ( $t_r = t_f = 6 \text{ ns}$ )<br>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.<br>$R_L = 600 \text{ }\Omega$ , $C_L = 50 \text{ pF}$ ,<br>$f_{IN} = 1 \text{ MHz}$ , sine wave<br>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.

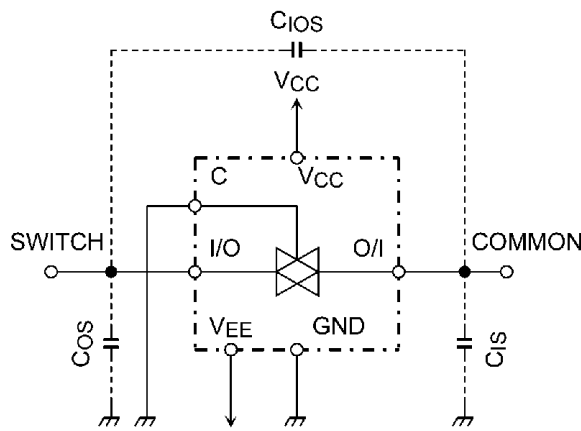
Note 1: Input COMMON terminal, and measured at SWITCH terminal.

Note 2: Input SWITCH terminal, and measured at COMMON terminal.

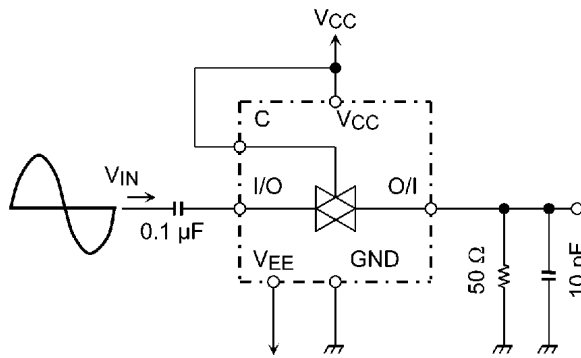
**13. AC Test Circuit**



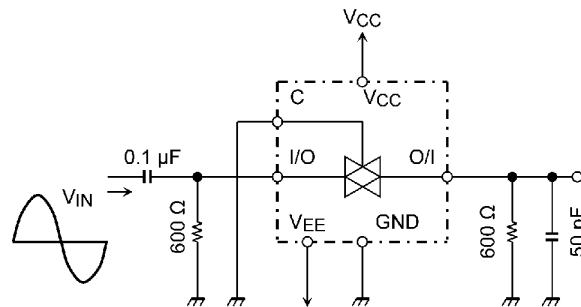
**Figure 1**  $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$



**Figure 2**  $C_{10S}$ ,  $C_{1S}$ ,  $C_{0S}$

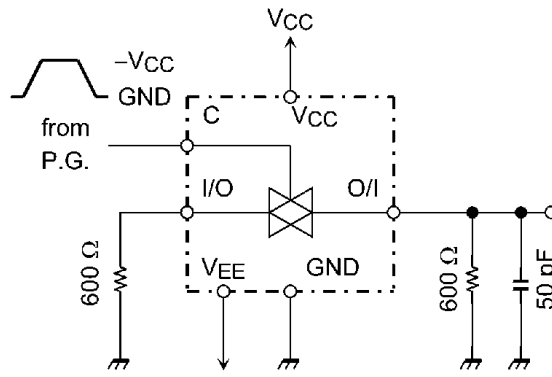


**Figure 3** Frequency Response



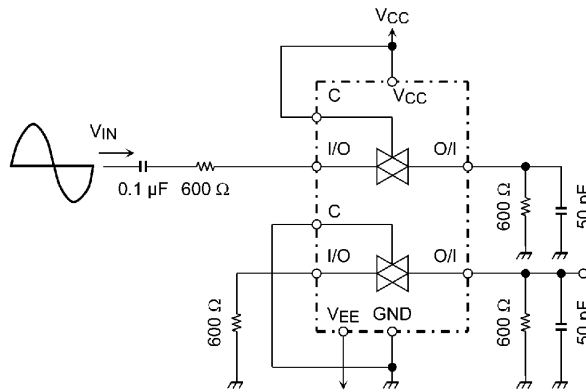
**Figure 4** Feedthrough Attenuation





P.G.: Pulse generator

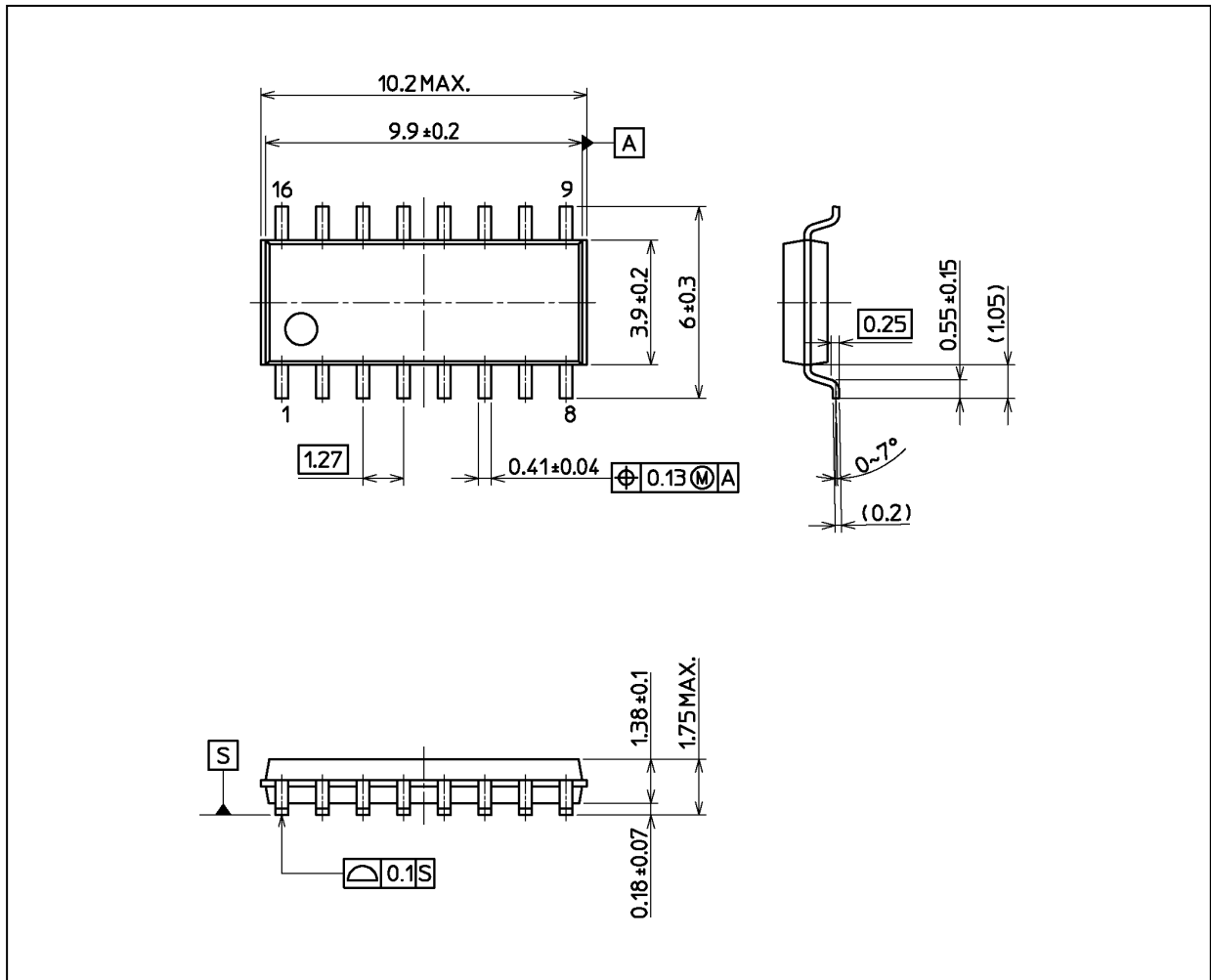
**Figure 5 Cross Talk (control input to output signal)**



**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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