

## CD74HC4051-Q1 汽车级模拟多路复用器或多路信号分离器

### 1 特性

- 符合汽车应用要求
- 宽模拟输入电压范围： $\pm 5V$  (最大值)
- 低导通电阻：
  - 70  $\Omega$  典型值 ( $V_{CC} - V_{EE} = 4.5V$ )
  - 40  $\Omega$  典型值 ( $V_{CC} - V_{EE} = 9V$ )
- 低开关间串扰
- 快速开关和传播速度
- 先断后合开关
- 工作控制电压 = 2V 至 6V
- 开关电压 = 0V 至 10V
- 高抗噪性， $N_{IL}$  和  $N_{IH} = V_{CC}$  的 30%， $V_{CC} = 5V$

### 2 应用

- 数字射频
- 信号门控
- 工厂自动化
- 电视
- 电器
- 可编程逻辑电路
- 传感器

### 3 说明

此器件是数字控制的模拟开关，其使用硅栅 CMOS 技术并借助标准 CMOS 集成电路的低功耗特性来实现与 LSTTL 接近的运行速度。

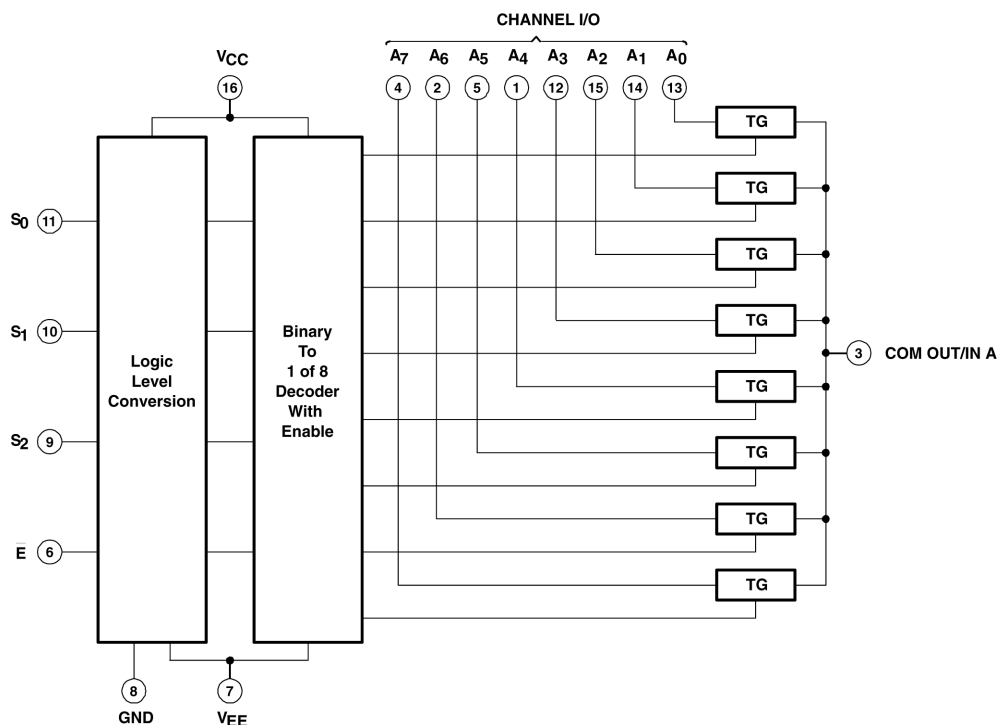
此模拟多路复用器/多路信号分离器可控制模拟电压，该电压可能会在整个电源电压范围内变化（例如， $V_{CC}$  变为  $V_{EE}$ ）。这些双向开关可将任何模拟输入用作输出，反之亦然。这些开关具有低导通电阻和低关断泄漏。此外，此器件具有使能控制 ( $\bar{E}$ )，当处于高电平时将禁用所有开关，将所有开关置于关断状态。

#### 封装信息

器件型号	封装 <sup>(1)</sup>	封装尺寸 <sup>(2)</sup>
CD74HC4051-Q1	PW (TSSOP, 16)	5mm × 6.4mm
	D (SOIC, 16)	9.9mm × 3.9mm

(1) 有关更多信息，请参阅节 10。

(2) 封装尺寸 (长 × 宽) 为标称值，并包括引脚 (如适用)。



逻辑图 (正逻辑)



## Table of Contents

<b>1 特性</b> .....	<b>1</b>	<b>6 Parameter Measurement Information</b> .....	<b>7</b>
<b>2 应用</b> .....	<b>1</b>	<b>7 Detailed Description</b> .....	<b>9</b>
<b>3 说明</b> .....	<b>1</b>	7.1 Functional Block Diagram.....	<b>9</b>
<b>4 Pin Configuration and Functions</b> .....	<b>2</b>	7.2 Device Functional Modes.....	<b>9</b>
<b>5 Specifications</b> .....	<b>3</b>	<b>8 Device and Documentation Support</b> .....	<b>10</b>
5.1 Absolute Maximum Ratings.....	<b>3</b>	8.1 接收文档更新通知.....	<b>10</b>
5.2 Recommended Operating Conditions.....	<b>3</b>	8.2 支持资源.....	<b>10</b>
5.3 Recommended Operating Area as a Function of Supply Voltages.....	<b>4</b>	8.3 Trademarks.....	<b>10</b>
5.4 Electrical Characteristics.....	<b>4</b>	8.4 静电放电警告.....	<b>10</b>
5.5 Switching Characteristics.....	<b>5</b>	8.5 术语表.....	<b>10</b>
5.6 Operating Characteristics.....	<b>5</b>	<b>9 Revision History</b> .....	<b>10</b>
5.7 Analog Channel Characteristics.....	<b>5</b>	<b>10 Mechanical, Packaging, and Orderable     Information</b> .....	<b>11</b>
5.8 Typical Characteristics.....	<b>6</b>		

## 4 Pin Configuration and Functions

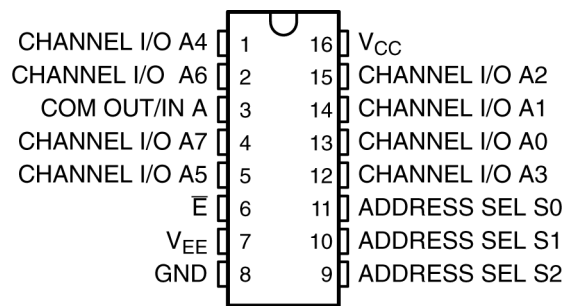


图 4-1. PW, D Package, 16-Pin TSSOP, SOIC (Top View)

表 4-1. Function Table

INPUTS				ON CHANNEL(S)
E	S <sub>2</sub>	S <sub>1</sub>	S <sub>0</sub>	
L	L	L	L	A0
L	L	L	H	A1
L	L	H	L	A2
L	L	H	H	A3
L	H	L	L	A4
L	H	L	H	A5
L	H	H	L	A6
L	H	H	H	A7
H	X	X	X	None

## 5 Specifications

### 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

			MIN	MAX	UNIT
$V_{CC} - V_{EE}$ (see <sup>(2)</sup> )	Supply voltage range		-0.5	10.5	V
$V_{CC}$	Supply voltage range		-0.5	7	V
$V_{EE}$	Supply voltage range		+0.5	-7	V
$I_{IK}$ ( $V_I < -0.5V$ or $V_I > V_{CC} + 0.5V$ )	Input clamp current			±20	mA
$I_{OK}$ ( $V_O < V_{EE} - 0.5V$ or $V_O > V_{CC} + 0.5V$ )	Output clamp current			±20	mA
( $V_I > V_{EE} - 0.5V$ or $V_I < V_{CC} + 0.5V$ )	Switch current			±25	mA
	Continuous current through $V_{CC}$ or GND			±50	mA
$I_{EE}$	$V_{EE}$ current			-20	mA
$R_{\theta JA}$	Package thermal impedance	D package		91.6	°C/W
		PW package		116.5	°C/W
$T_J$	Maximum junction temperature			150	°C
Lead temperature (during soldering):		At distance 1/16 ± 1/32 inch (1,59 ± 0,79 mm) from case for 10 s max		300	°C
$T_{stg}$	Storage temperature range		-65	150	°C

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages referenced to GND unless otherwise specified.

### 5.2 Recommended Operating Conditions

(see <sup>(1)</sup>)

			MIN	MAX	UNIT
$V_{CC}$	Supply voltage (see <sup>(2)</sup> )		2	6	V
	Supply voltage, $V_{CC} - V_{EE}$ (see 图 5-1)		2	10	V
$V_{EE}$	Supply voltage, (see <sup>(2)</sup> and 图 5-2)		0	-6	V
$V_{IH}$	High-level input voltage	$V_{CC} = 2V$	1.5		V
		$V_{CC} = 4.5V$	3.15		
		$V_{CC} = 6V$	4.2		
$V_{IL}$	Low-level input voltage	$V_{CC} = 2V$		0.5	V
		$V_{CC} = 4.5V$		1.35	
		$V_{CC} = 6V$		1.8	
$V_I$	Input control voltage		0	$V_{CC}$	V
$V_{IS}$	Analog switch I/O voltage		$V_{EE}$	$V_{CC}$	V
$t_t$	Input transition (rise and fall) time	$V_{CC} = 2V$	0	1000	ns
		$V_{CC} = 4.5V$	0	500	
		$V_{CC} = 6V$	0	400	
$T_A$	Operating free-air temperature		-40	125	°C

- (1) All unused inputs of the device must be held at  $V_{CC}$  or GND for proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

- (2) In certain applications, the external load resistor current may include both  $V_{CC}$  and signal-line components. To avoid drawing  $V_{CC}$  current when switch current flows into the transmission gate inputs, the voltage drop across the bidirectional switch must not exceed 0.6V (calculated from  $r_{on}$  values shown in electrical characteristics table). No  $V_{CC}$  current flows through  $R_L$  if the switch current flows into the COM OUT/IN A terminal.

### 5.3 Recommended Operating Area as a Function of Supply Voltages

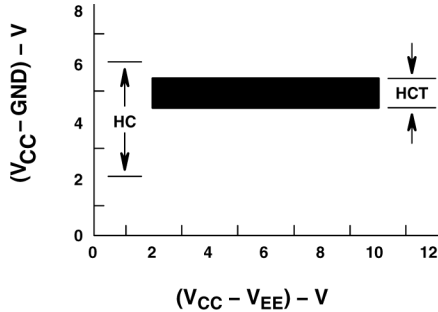


图 5-1.  $(V_{CC} - V_{EE}) - V$

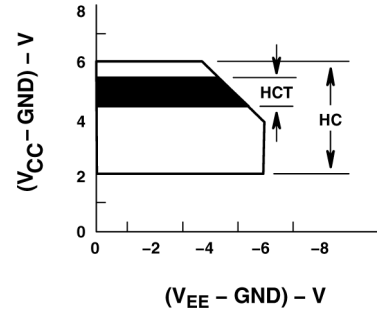


图 5-2.  $(V_{EE} - GND) - V$

### 5.4 Electrical Characteristics

over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$V_{EE}$	$V_{CC}$	$T_A = 25^\circ\text{C}$			$T_A = -40^\circ\text{C TO } 125^\circ\text{C}$		UNIT
				MIN	TYP	MAX	MIN	MAX	
$r_{on}$	$I_O = 1\text{ mA}, V_I = V_{IH}$ or $V_{IL}$ , See 图 5-3	$V_{IS} = V_{CC}$ or $V_{EE}$	0V	4.5V	70	160	240	$\Omega$	
			0V	6V	60	140	210		
			-4.5V	4.5V	40	120	180		
		$V_{IS} = V_{CC}$ to $V_{EE}$	0V	4.5V	90	180	270		
			0V	6V	80	160	240		
			-4.5V	4.5V	45	130	195		
$\Delta r_{on}$	Between any two channels	0V	4.5V	10			$\Omega$		
		0V	6V	8.5					
		-4.5V	4.5V	5					
$I_{IZ}$	For switch OFF: When $V_{IS} = V_{CC}, V_{OS} = V_{EE}$ ; When $V_{IS} = V_{EE}, V_{OS} = V_{CC}$ For switch ON: All applicable combinations of $V_{IS}$ and $V_{OS}$ voltage levels, $V_I = V_{IH}$ or $V_{IL}$	0V	6V		$\pm 0.2$	$\pm 2$	$\mu\text{A}$		
		-5V	5V		$\pm 0.4$	$\pm 4$			
$I_{IL}$	$V_I = V_{CC}$ or GND	0V	6V		$\pm 0.1$	$\pm 1$	$\mu\text{A}$		
$I_{CC}$	$I_O = 0, V_I = V_{CC}$ or GND	When $V_{IS} =$ $V_{EE}, V_{OS} = V_{CC}$	0V	6V		12	160	$\mu\text{A}$	
		When $V_{IS} =$ $V_{CC}, V_{OS} = V_{EE}$	-5V	5V		32	320		

## 5.5 Switching Characteristics

over recommended operating free-air temperature range (unless otherwise noted) (see 图 6-5)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAPACITANCE	V <sub>EE</sub>	V <sub>CC</sub>	T <sub>A</sub> = 25°C			T <sub>A</sub> = -40 °C TO 125°C		UNIT	
						MIN	TYP	MAX	MIN	MAX		
t <sub>pd</sub>	IN	OUT	C <sub>L</sub> = 15pF		5V			4			ns	
			C <sub>L</sub> = 50pF	0V	2V				60		90	ns
					4.5V				12		18	
					6V				10		15	
-4.5V	4.5V			8		12						
t <sub>en</sub>	ADDRESS SEL or $\bar{E}$	OUT	C <sub>L</sub> = 15pF		5V			19			ns	
			C <sub>L</sub> = 50pF	0V	2V				325			490
					4.5V				45			68
					6V				38			57
-4.5V	4.5V			32		48						
t <sub>dis</sub>	ADDRESS SEL or $\bar{E}$	OUT	C <sub>L</sub> = 15pF		5V			27			ns	
			C <sub>L</sub> = 50pF	0V	2V				250			400
					4.5V				50			68
					6V				44			57
-4.5V	4.5V			44		55						
C <sub>I</sub>	Control		C <sub>L</sub> = 50pF						10	10	pF	

## 5.6 Operating Characteristics

V<sub>CC</sub> = 5V, T<sub>A</sub> = 25°C, Input t<sub>r</sub>, t<sub>f</sub> = 6 ns

PARAMETER		TYP	UNIT
C <sub>pd</sub>	Power dissipation capacitance (see (1))	50	pF

(1) C<sub>pd</sub> is used to determine the dynamic power consumption, per package.

- $P_D = C_{pd} V_{CC}^2 f_I + \sum (C_L + C_S) V_{CC}^2 f_O$
- f<sub>O</sub> = output frequency
- f<sub>I</sub> = input frequency
- C<sub>L</sub> = output load capacitance
- C<sub>S</sub> = switch capacitance
- V<sub>CC</sub> = supply voltage

## 5.7 Analog Channel Characteristics

T<sub>A</sub> = 25°C

PARAMETER	TEST CONDITIONS	V <sub>EE</sub>	V <sub>CC</sub>	MIN	TYP	MAX	UNIT
C <sub>I</sub>	Switch input capacitance				5		pF
C <sub>COM</sub>	Common output capacitance				25		pF
f <sub>max</sub>	Minimum switch frequency response at -3 dB	-2.25V	2.25V		145		MHz
		-4.5V	4.5V		180		

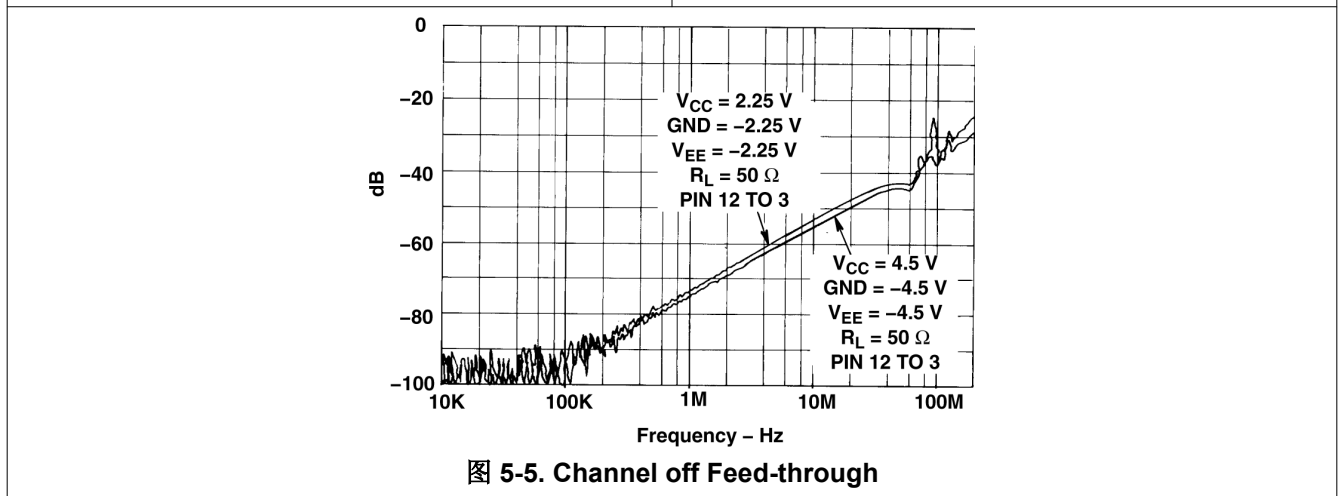
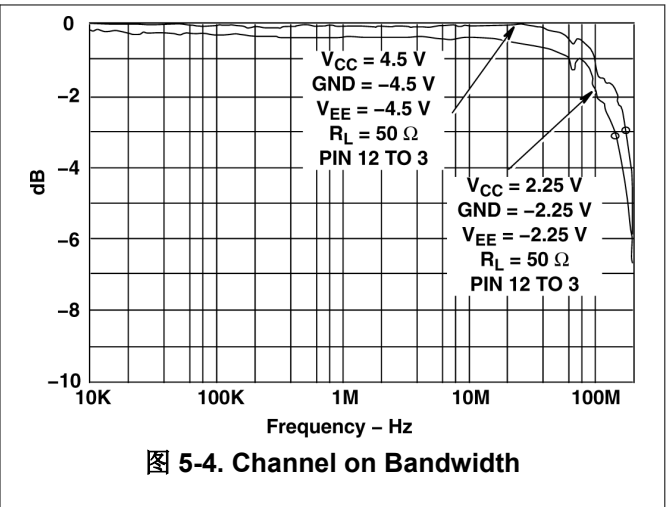
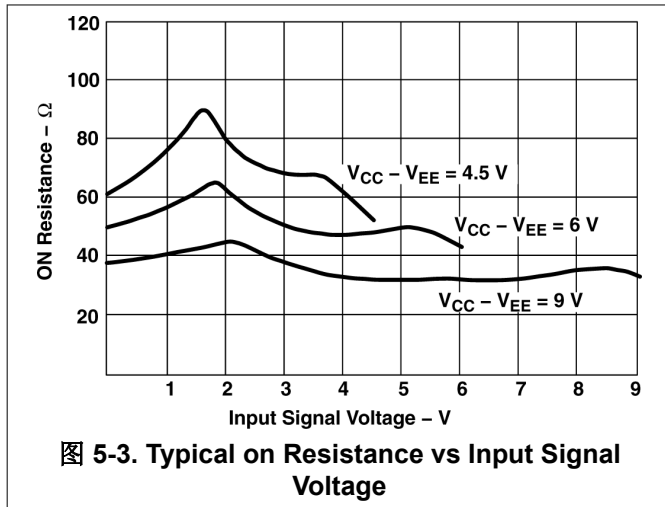
### 5.7 Analog Channel Characteristics (续)

T<sub>A</sub> = 25°C

PARAMETER		TEST CONDITIONS	V <sub>EE</sub>	V <sub>CC</sub>	MIN	TYP	MAX	UNIT
THD	Sine-wave distortion	See 图 6-2	-2.25V	2.25V	0.03	5		%
			-4.5V	4.5V	0.01	8		
O <sub>ISO</sub>	Switch OFF signal feed through	See 图 6-4 and 图 5-5, and (2) and (3)	-2.25V	2.25V	-73			dB
			-4.5V	4.5V	-75			

- (1) Adjust input voltage to obtain 0 dBm at V<sub>OS</sub> for f<sub>IN</sub> = 1MHz.
- (2) V<sub>IS</sub> is centered at (V<sub>CC</sub> - V<sub>EE</sub>)/2.
- (3) Adjust input for 0 dBm.

### 5.8 Typical Characteristics



## 6 Parameter Measurement Information

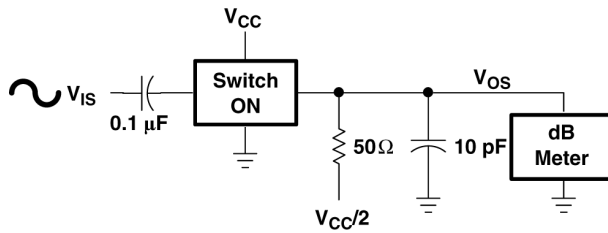


图 6-1. Frequency-Response Test Circuit

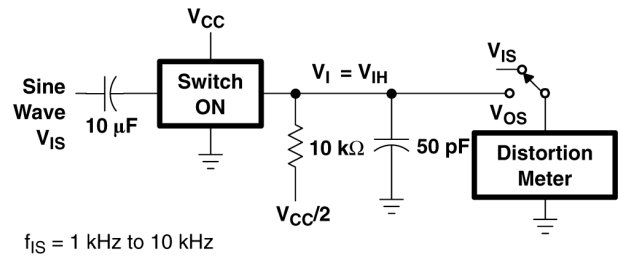


图 6-2. Sine-Wave Distortion Test Circuit

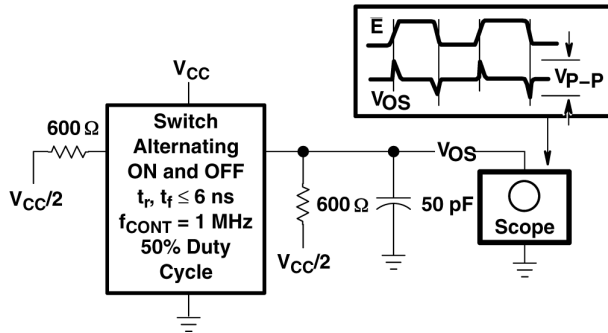


图 6-3. Control to Switch Feed-through Noise Test Circuit

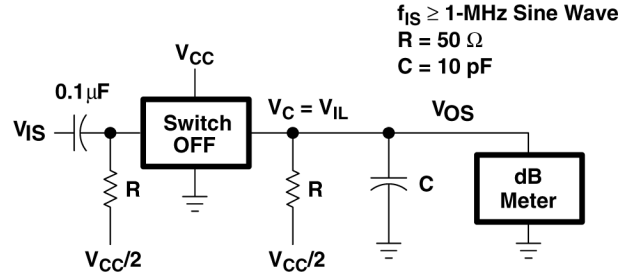
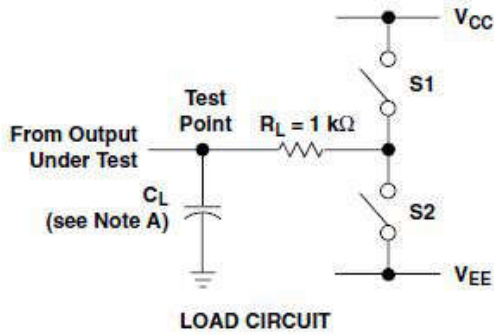
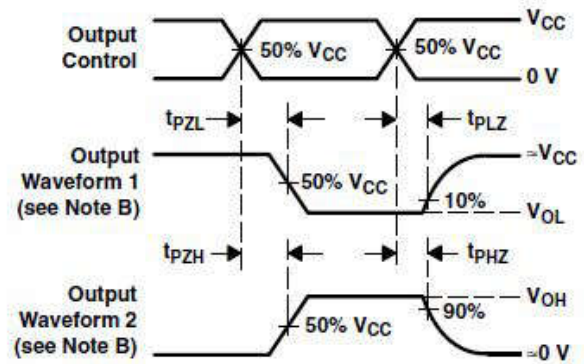
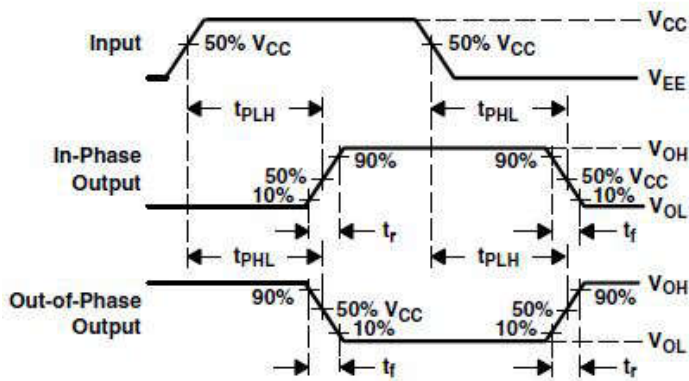


图 6-4. Switch off Signal Feed-through Test Circuit



PARAMETER	S1	S2	
$t_{en}$	$t_{pZH}$	Open	Closed
	$t_{pZL}$	Closed	Open
$t_{dis}$	$t_{pHZ}$	Open	Closed
	$t_{pLZ}$	Closed	Open
$t_{pd}$	Open	Open	



- A.  $C_L$  includes probe and test-fixture capacitance.
- B. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.
- C. Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1\text{MHz}$ ,  $Z_O = 50\ \Omega$ ,  $t_r = 6\text{ ns}$ ,  $t_f = 6\text{ ns}$ .
- D. For clock inputs,  $f_{max}$  is measured with the input duty cycle at 50%.
- E. The outputs are measured one at a time with one input transition per measurement.
- F.  $t_{pLZ}$  and  $t_{pHZ}$  are the same as  $t_{dis}$ .
- G.  $t_{pZL}$  and  $t_{pZH}$  are the same as  $t_{en}$ .
- H.  $t_{pLH}$  and  $t_{pHL}$  are the same as  $t_{pd}$ .

**图 6-5. Load Circuit and Voltage Waveforms**



## 7 Detailed Description

### 7.1 Functional Block Diagram

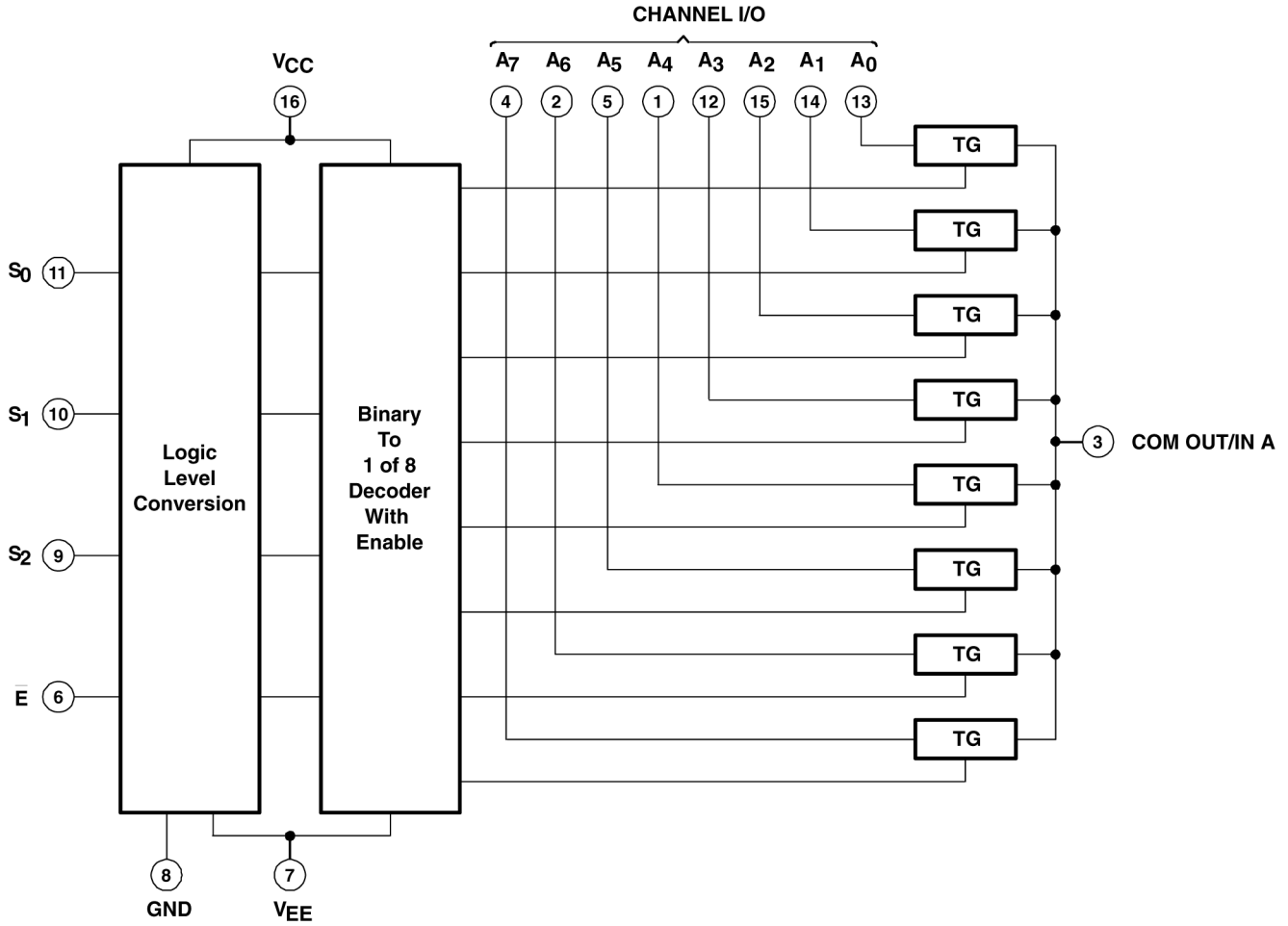


图 7-1. Logic Diagram (Positive Logic)

### 7.2 Device Functional Modes

表 7-1. Function Table

INPUTS				ON CHANNEL(S)
E	S <sub>2</sub>	S <sub>1</sub>	S <sub>0</sub>	
L	L	L	L	A0
L	L	L	H	A1
L	L	H	L	A2
L	L	H	H	A3
L	H	L	L	A4
L	H	L	H	A5
L	H	H	L	A6
L	H	H	H	A7
H	X	X	X	None

## 8 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

### 8.1 接收文档更新通知

要接收文档更新通知，请导航至 [ti.com](http://ti.com) 上的器件产品文件夹。点击 [通知](#) 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

### 8.2 支持资源

TI E2E™ 中文支持论坛是工程师的重要参考资料，可直接从专家处获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题，获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的 [使用条款](#)。

### 8.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.

所有商标均为其各自所有者的财产。

### 8.4 静电放电警告



静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

### 8.5 术语表

TI 术语表 本术语表列出并解释了术语、首字母缩略词和定义。

## 9 Revision History

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision A (April 2008) to Revision B (April 2024)	Page
• 更新了整个文档中的表格、图和交叉参考的编号格式.....	1
• 将 M ( SOIC , 16 ) 更改为 D ( SOIC , 16 ) ，以准确反映封装图.....	1
• Changed the package thermal impedance for the D package from: 73°C/W to: 91.6°C/W .....	3
• Changed the package thermal impedance for the PW package from: 108°C/W to: 116.5°C/W .....	3
• Changed I <sub>CC</sub> MAX from: 8 μA to: 12 μA when V <sub>IS</sub> = V <sub>EE</sub> , V <sub>OS</sub> = V <sub>CC</sub> at a TA = 25°C .....	4
• Changed I <sub>CC</sub> MAX from: 16 μA to: 32 μA when V <sub>IS</sub> = V <sub>CC</sub> , V <sub>OS</sub> = V <sub>EE</sub> at a TA = 25°C .....	4
• Changed t <sub>en</sub> MAX from: 225ns to: 325ns when C <sub>L</sub> = 50pF at a TA = 25°C and from: 340ns to: 490ns when C <sub>L</sub> = 50pF at a TA = -40°C to 125°C.....	5
• Changed t <sub>dis</sub> TYP from: 19ns to: 27ns when C <sub>L</sub> = 15pF at a TA = 25°C.....	5
• Changed t <sub>dis</sub> MAX from: 225ns to: 250ns when C <sub>L</sub> = 50pF, V <sub>EE</sub> = 0V, and V <sub>CC</sub> = 2V at a TA = 25°C, and from: 340ns to: 400ns at a TA = -40°C to 125°C.....	5
• Changed t <sub>dis</sub> MAX from: 45ns to: 50ns when C <sub>L</sub> = 50pF, V <sub>EE</sub> = 0V, and V <sub>CC</sub> = 4.5V at a TA = 25°C.....	5
• Changed t <sub>dis</sub> MAX from: 38ns to: 44ns when C <sub>L</sub> = 50pF, V <sub>EE</sub> = 0V, and V <sub>CC</sub> = 6V at a TA = 25°C.....	5
• Changed t <sub>dis</sub> MAX from: 32ns to: 44ns when C <sub>L</sub> = 50pF, V <sub>EE</sub> = -4.5V, and V <sub>CC</sub> = 4.5V at a TA = 25°C, and from: 48ns to: 55ns at a TA = -40°C to 125°C.....	5
• Removed the TBD $\bar{E}$ or ADDRESS SEL to switch feed-through noise parameter.....	5

## 10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
CD74HC4051QM96G4Q1	OBSOLETE	SOIC	D	16		TBD	Call TI	Call TI	-40 to 125	HC4051Q	
CD74HC4051QM96Q1	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	HC4051Q	Samples
CD74HC4051QPWRG4Q1	OBSOLETE	TSSOP	PW	16		TBD	Call TI	Call TI	-40 to 125	HJ4051Q	
CD74HC4051QPWRQ1	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	HJ4051Q	Samples

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) **MSL, Peak Temp.** - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) **Lead finish/Ball material** - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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**OTHER QUALIFIED VERSIONS OF CD74HC4051-Q1 :**

- Catalog : [CD74HC4051](#)
- Enhanced Product : [CD74HC4051-EP](#)
- Military : [CD54HC4051](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CD74HC4051QPWRQ1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
CD74HC4051QPWRQ1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**




\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CD74HC4051QPWRQ1	TSSOP	PW	16	2000	367.0	367.0	35.0
CD74HC4051QPWRQ1	TSSOP	PW	16	2000	353.0	353.0	32.0

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  -  C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
  -  D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
  - E. Reference JEDEC MS-012 variation AC.





4220204/A 02/2017

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

4220204/A 02/2017

NOTES: (continued)

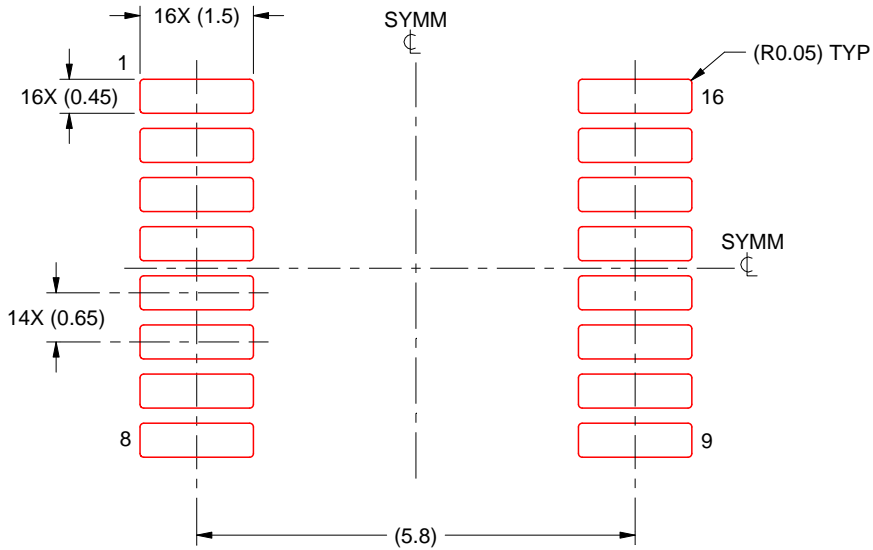
- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

4220204/A 02/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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