

# CD74HC4051-Q1 ANALOG MULTIPLEXER/DEMUTIPLEXER

SCLS552A – DECEMBER 2003 – REVISED APRIL 2008

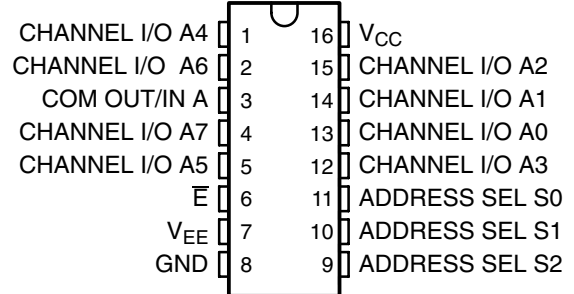
- **Qualified for Automotive Applications**
- **Wide Analog Input Voltage Range of  $\pm 5$  V Max**
- **Low ON Resistance**
  - 70  $\Omega$  Typical ( $V_{CC} - V_{EE} = 4.5$  V)
  - 40  $\Omega$  Typical ( $V_{CC} - V_{EE} = 9$  V)
- **Low Crosstalk Between Switches**
- **Fast Switching and Propagation Speeds**
- **Break-Before-Make Switching**
- **Operation Control Voltage = 2 V to 6 V**
- **Switch Voltage = 0 V to 10 V**
- **High Noise Immunity  $N_{IL} = 30\%$ ,  $N_{IH} = 30\%$  of  $V_{CC}$ ,  $V_{CC} = 5$  V**

## description/ordering information

This device is a digitally controlled analog switch that utilizes silicon-gate CMOS technology to achieve operating speeds similar to LSTTL, with the low power consumption of standard CMOS integrated circuits.

This analog multiplexer/demultiplexer controls analog voltages that may vary across the voltage supply range (i.e.,  $V_{CC}$  to  $V_{EE}$ ). These bidirectional switches allow any analog input to be used as an output and vice versa. The switches have low ON resistance and low OFF leakages. In addition, the device has an enable control ( $\bar{E}$ ) that, when high, disables all switches to their OFF state.

M OR PW PACKAGE  
(TOP VIEW)



## ORDERING INFORMATION†

$T_A$	PACKAGE‡		ORDERABLE PART NUMBER	TOP-SIDE MARKING
	SOIC – M	Tape and reel		
–40°C to 125°C	SOIC – M	Tape and reel	CD74HC4051QM96Q1	HC4051Q
	TSSOP – PW	Tape and reel	CD74HC4051QPWRQ1	HJ4051Q

† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at <http://www.ti.com>.

‡ Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS  
INSTRUMENTS**

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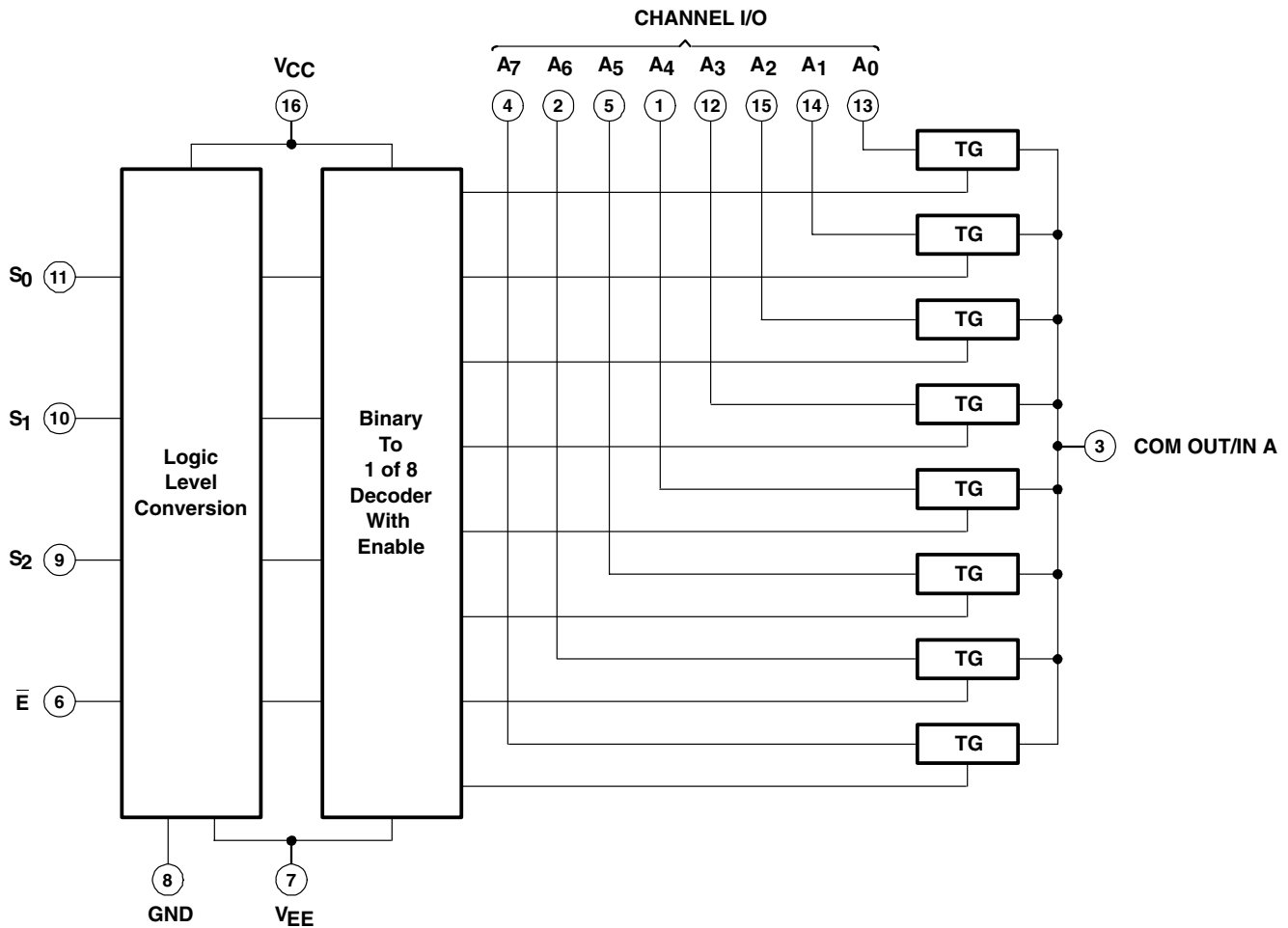
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FUNCTION TABLE

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

X = Don't care

## logic diagram (positive logic)



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## absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, $V_{CC} - V_{EE}$ (see Note 1)	–0.5 V to 10.5 V
Supply voltage range, $V_{CC}$	–0.5 V to 7 V
Supply voltage range, $V_{EE}$	+0.5 V to –7 V
Input clamp current, $I_{IK}$ ( $V_I < -0.5$ V or $V_I > V_{CC} + 0.5$ V)	±20 mA
Output clamp current, $I_{OK}$ ( $V_O < V_{EE} - 0.5$ V or $V_O > V_{CC} + 0.5$ V)	±20 mA
Switch current ( $V_I > V_{EE} - 0.5$ V or $V_I < V_{CC} + 0.5$ V)	±25 mA
Continuous current through $V_{CC}$ or GND	±50 mA
$V_{EE}$ current, $I_{EE}$	–20 mA
Package thermal impedance, $\theta_{JA}$ (see Note 2): M package	73°C/W
PW package	108°C/W
Maximum junction temperature, $T_J$	150°C
Lead temperature (during soldering):	
At distance $1/16 \pm 1/32$ inch ( $1,59 \pm 0,79$ mm) from case for 10 s max	300°C
Storage temperature range, $T_{stg}$	–65°C to 150°C

† 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.

- NOTES: 1. All voltages referenced to GND unless otherwise specified.  
2. The package thermal impedance is calculated in accordance with JESD 51-7.

## recommended operating conditions (see Note 3)

		MIN	MAX	UNIT	
$V_{CC}$	Supply voltage (see Note 4)	2	6	V	
	Supply voltage, $V_{CC} - V_{EE}$ (see Figure 1)	2	10	V	
$V_{EE}$	Supply voltage, (see Note 4 and Figure 2)	0	–6	V	
$V_{IH}$	High-level input voltage	$V_{CC} = 2$ V	1.5	V	
		$V_{CC} = 4.5$ V	3.15		
		$V_{CC} = 6$ V	4.2		
$V_{IL}$	Low-level input voltage	$V_{CC} = 2$ V	0.5	V	
		$V_{CC} = 4.5$ V	1.35		
		$V_{CC} = 6$ V	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	$V_{CC} = 2$ V	0	1000	ns
		$V_{CC} = 4.5$ V	0	500	
		$V_{CC} = 6$ V	0	400	
$T_A$	Operating free-air temperature	–40	125	°C	

- NOTES: 3. All unused inputs of the device must be held at  $V_{CC}$  or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.  
4. 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 0.6 V (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.

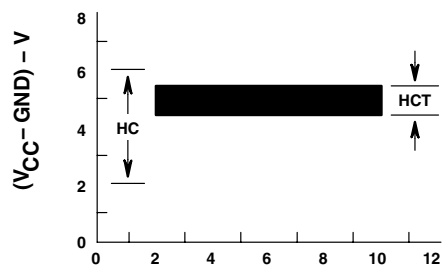


# CD74HC4051-Q1

## ANALOG MULTIPLEXER/DEMULTIPLEXER

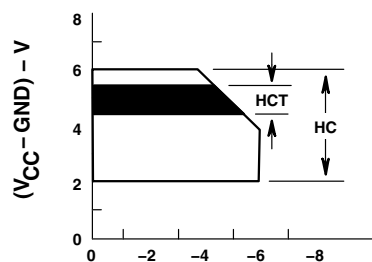
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### recommended operating area as a function of supply voltages



(V<sub>CC</sub> - V<sub>EE</sub>) - V

Figure 1



(V<sub>EE</sub> - GND) - V

Figure 2

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

PARAMETER	TEST CONDITIONS	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		
r <sub>on</sub>	I <sub>O</sub> = 1 mA, V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , See Figure 8	V <sub>IS</sub> = V <sub>CC</sub> or V <sub>EE</sub>	0 V	4.5 V	70	160	240		Ω	
			0 V	6 V	60	140	210			
			-4.5 V	4.5 V	40	120	180			
		V <sub>IS</sub> = V <sub>CC</sub> to V <sub>EE</sub>	0 V	4.5 V	90	180	270			
			0 V	6 V	80	160	240			
			-4.5 V	4.5 V	45	130	195			
Δr <sub>on</sub>	Between any two channels	0 V	4.5 V	10					Ω	
		0 V	6 V	8.5						
		-4.5 V	4.5 V	5						
I <sub>IZ</sub>	For switch OFF: When V <sub>IS</sub> = V <sub>CC</sub> , V <sub>OS</sub> = V <sub>EE</sub> ; When V <sub>IS</sub> = V <sub>EE</sub> , V <sub>OS</sub> = V <sub>CC</sub> For switch ON: All applicable combinations of V <sub>IS</sub> and V <sub>OS</sub> voltage levels, V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>	0 V	6 V	±0.2			±2		μA	
		-5 V	5 V	±0.4			±4			
I <sub>IL</sub>	V <sub>I</sub> = V <sub>CC</sub> or GND	0 V	6 V	±0.1			±1		μA	
I <sub>CC</sub>	I <sub>O</sub> = 0, V <sub>I</sub> = V <sub>CC</sub> or GND	When V <sub>IS</sub> = V <sub>EE</sub> , V <sub>OS</sub> = V <sub>CC</sub>	0 V	6 V	8			160		μA
		When V <sub>IS</sub> = V <sub>CC</sub> , V <sub>OS</sub> = V <sub>EE</sub>	-5 V	5 V	16			320		

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**switching characteristics over recommended operating free-air temperature range (unless otherwise noted) (see Figure 7)**

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> = 15 pF		5 V	4					ns
			C <sub>L</sub> = 50 pF	0 V	2 V	60			90		ns
					4.5 V	12			18		
					6 V	10			15		
-4.5 V	4.5 V			8		12					
t <sub>en</sub>	ADDRESS SEL or $\bar{E}$	OUT	C <sub>L</sub> = 15 pF		5 V	19					ns
			C <sub>L</sub> = 50 pF	0 V	2 V	225			340		
					4.5 V	45			68		
					6 V	38			57		
-4.5 V	4.5 V			32		48					
t <sub>dis</sub>	ADDRESS SEL or $\bar{E}$	OUT	C <sub>L</sub> = 15 pF		5 V	19					ns
			C <sub>L</sub> = 50 pF	0 V	2 V	225			340		
					4.5 V	45			68		
					6 V	38			57		
-4.5 V	4.5 V			32		48					
C <sub>I</sub>	Control		C <sub>L</sub> = 50 pF					10	10	pF	

**operating characteristics, V<sub>CC</sub> = 5 V, 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 Note 5)	50	pF

NOTE 5: 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

# CD74HC4051-Q1

## ANALOG MULTIPLEXER/DEMULTIPLEXER

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### analog channel characteristics, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	$V_{EE}$	$V_{CC}$	MIN	TYP	MAX	UNIT
$C_I$	Switch input capacitance				5		pF
$C_{COM}$	Common output capacitance				25		pF
$f_{max}$	Minimum switch frequency response at -3 dB	See Figure 3 and Figure 9, and Notes 6 and 7	-2.25 V	2.25 V	145		MHz
			-4.5 V	4.5 V	180		
Sine-wave distortion	See Figure 4		-2.25 V	2.25 V	0.035		%
			-4.5 V	4.5 V	0.018		
$\bar{E}$ or ADDRESS SEL to switch feed-through noise	See Figure 5, and Notes 7 and 8		-2.25 V	2.25 V	(TBD)		mV
			-4.5 V	4.5 V	(TBD)		
Switch OFF signal feed through	See Figure 6 and Figure 10, and Notes 7 and 8		-2.25 V	2.25 V	-73		dB
			-4.5 V	4.5 V	-75		

- NOTES: 6. Adjust input voltage to obtain 0 dBm at  $V_{OS}$  for  $f_{IN} = 1$  MHz.  
 7.  $V_{IS}$  is centered at  $(V_{CC} - V_{EE})/2$ .  
 8. Adjust input for 0 dBm.

### PARAMETER MEASUREMENT INFORMATION

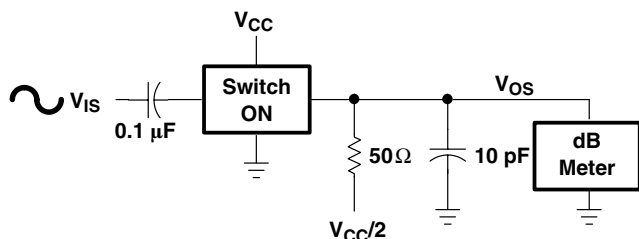


Figure 3. Frequency-Response Test Circuit

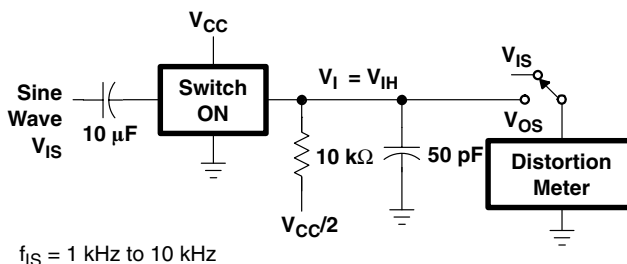


Figure 4. Sine-Wave Distortion Test Circuit

PARAMETER MEASUREMENT INFORMATION

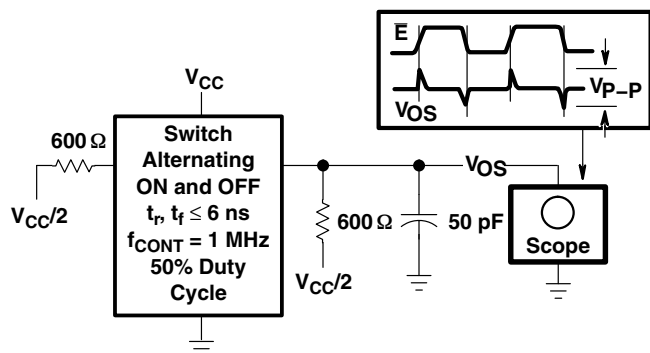


Figure 5. Control to Switch Feedthrough Noise Test Circuit

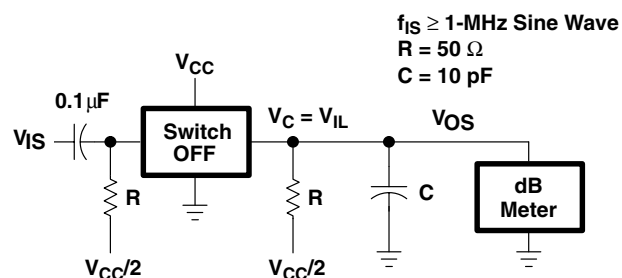
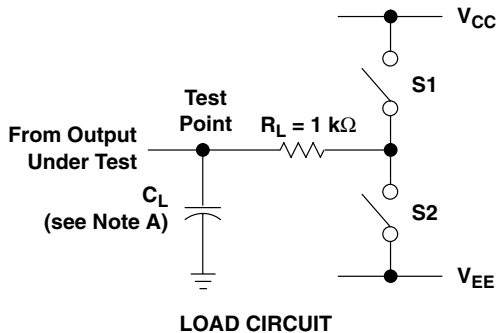


Figure 6. Switch OFF Signal Feedthrough Test Circuit

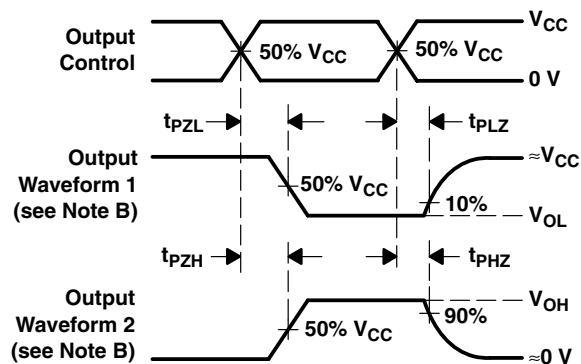
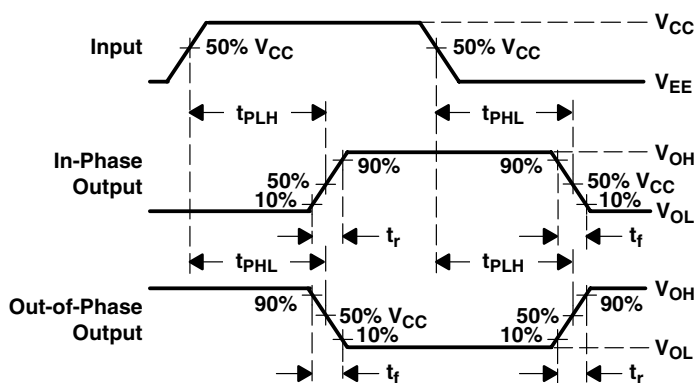
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## PARAMETER MEASUREMENT INFORMATION



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



- NOTES: 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:  $PRR \leq 1$  MHz,  $Z_O = 50 \Omega$ ,  $t_r = 6$  ns,  $t_f = 6$  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  $t_{pd}$ .

**Figure 7. Load Circuit and Voltage Waveforms**



TYPICAL CHARACTERISTICS

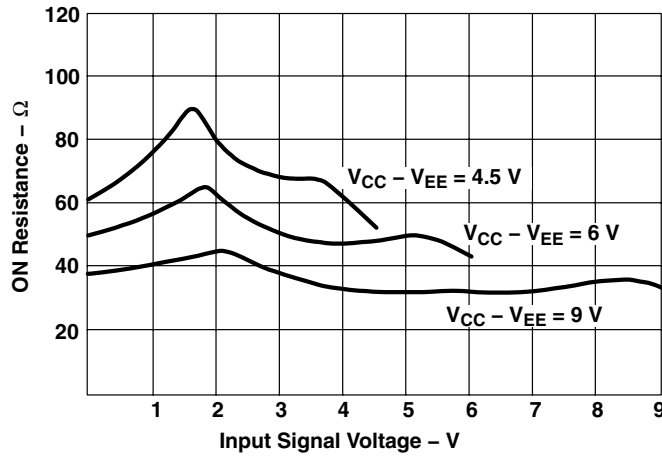


Figure 8. Typical ON Resistance vs Input Signal Voltage

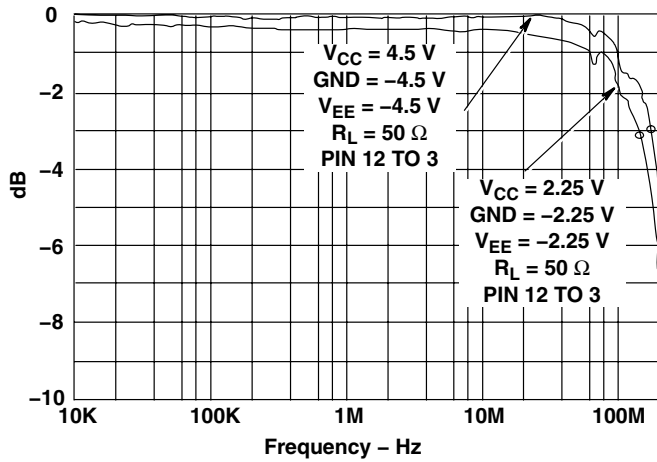


Figure 9. Channel ON Bandwidth

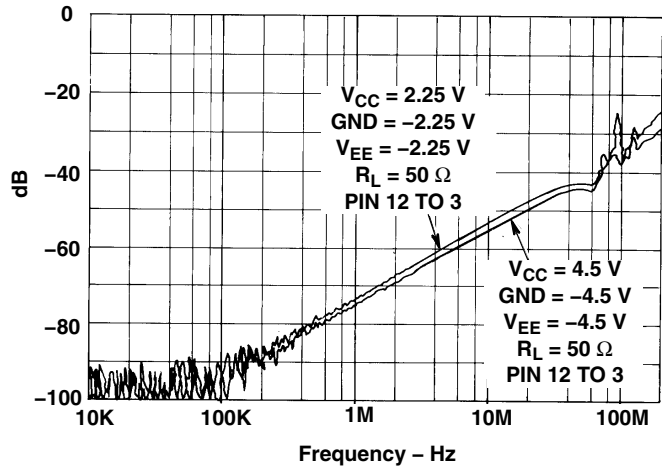


Figure 10. Channel OFF Feedthrough

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
CD74HC4051QM96G4Q1	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
CD74HC4051QM96Q1	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
CD74HC4051QPWRG4Q1	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
CD74HC4051QPWRQ1	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	

<sup>(1)</sup> 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.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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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

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.

D (R-PDSO-G16)

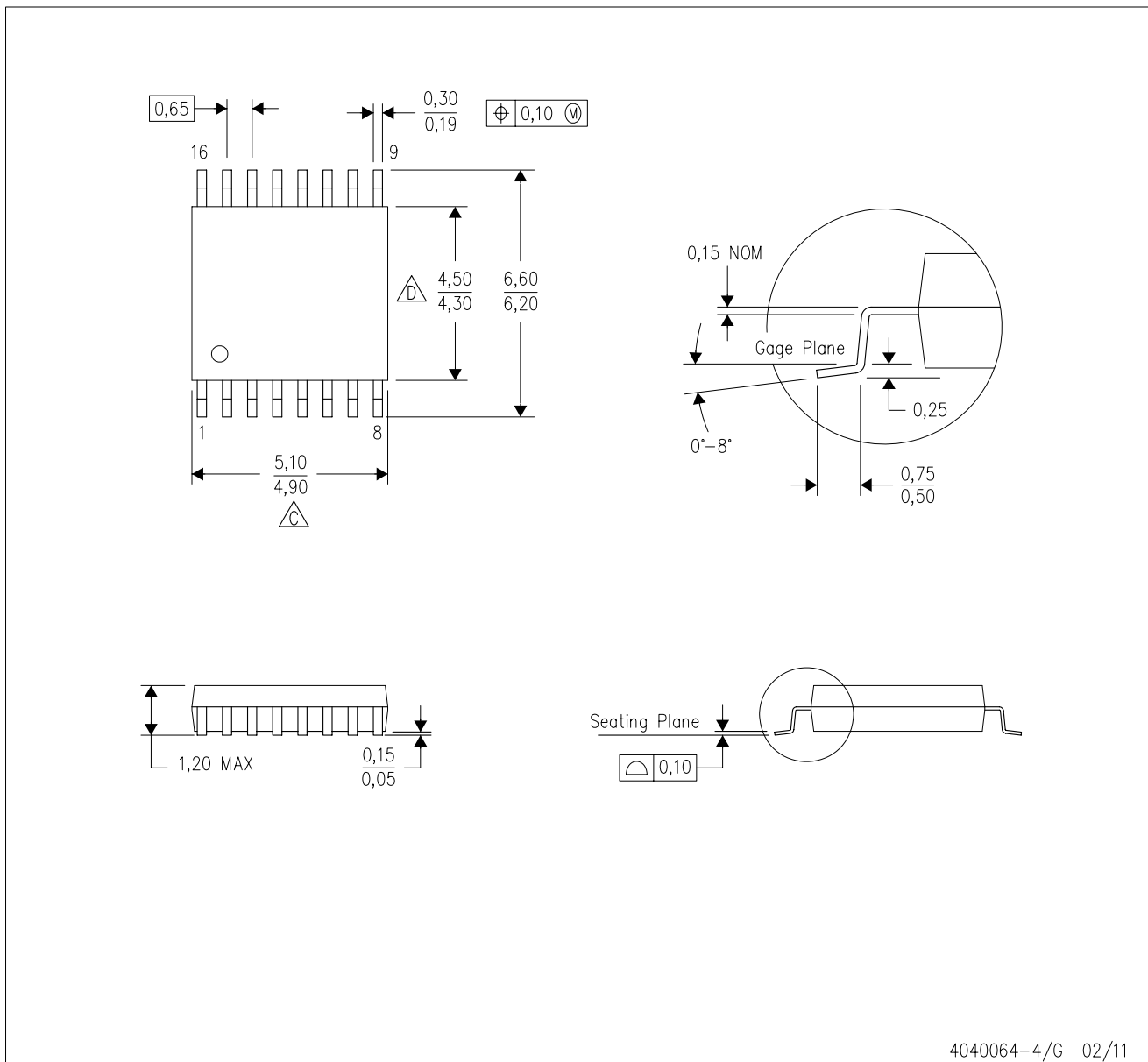
PLASTIC SMALL OUTLINE





- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - 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 0,15 each side.
  -  D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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