

# CD74HCT4051-Q1 HIGH-SPEED CMOS LOGIC ANALOG MULTIPLEXER/DEMULTIPLEXER

SCLS569B – JANUARY 2004 – REVISED APRIL 2008

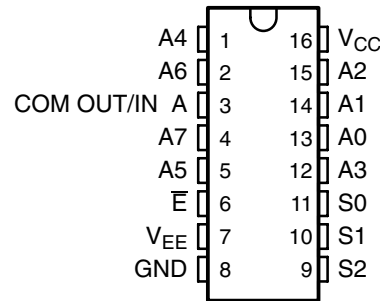
- **Qualified for Automotive Applications**
- **Wide Analog Input Voltage Range:**  
±5 V Max
- **Low ON Resistance**
  - 70 Ω Typical ( $V_{CC} - V_{EE} = 4.5\text{ V}$ )
  - 40 Ω Typical ( $V_{CC} - V_{EE} = 9\text{ V}$ )
- **Low Crosstalk Between Switches**
- **Fast Switching and Propagation Speeds**
- **Break-Before-Make Switching**
- **Wide Operating Temperature Range: –40°C to 125°C**
- **Operation Control Voltage: 4.5 V to 5.5 V**
- **Switch Voltage: 0 V to 10 V**
- **Direct LSTTL Input Logic Compatibility:**  
 $V_{IL} = 0.8\text{ V Max}$ ,  $V_{IH} = 2\text{ V Min}$
- **CMOS Input Compatibility:  $I_I \leq 1\ \mu\text{A}$  at  $V_{OL}$ ,  $V_{OH}$**

## 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  $V_{EE}$ ). It is a bidirectional switch that allows any analog input to be used as an output and vice-versa. The switch has low ON resistance and low OFF leakages. In addition, this device has an enable control that, when high, disables all switches to their OFF state.

**M PACKAGE  
(TOP VIEW)**



## ORDERING INFORMATION†

T <sub>A</sub>	PACKAGE‡	ORDERABLE PART NUMBER§	TOP-SIDE MARKING
–40°C to 125°C	SOIC – M   Reel of 2500	CD74HCT4051QM96Q1	HCT4051Q

† 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>.

§ The suffix 96 denotes tape and reel.



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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.



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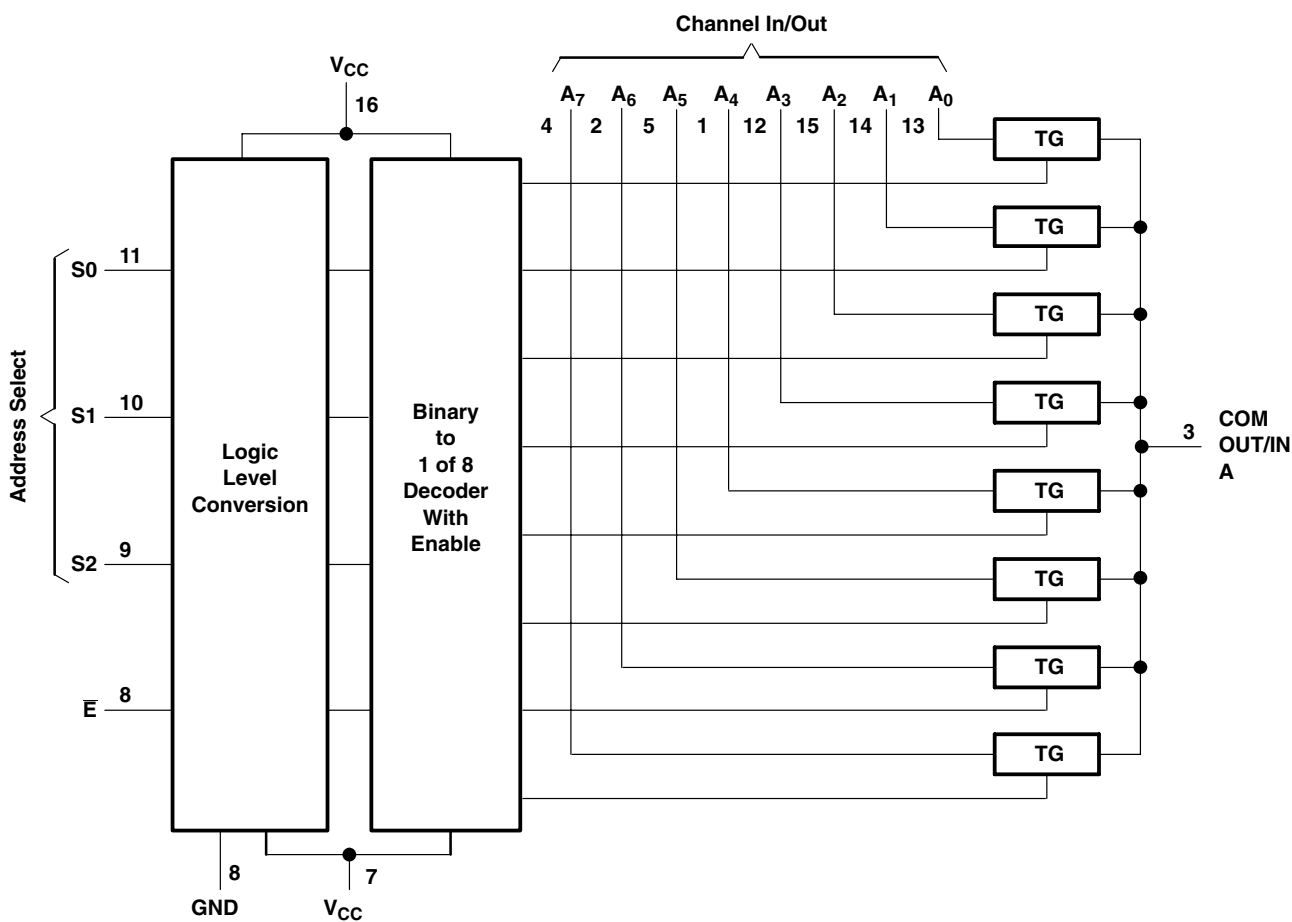
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FUNCTION TABLE

INPUTS				ON CHANNELS
ENABLE	S2	S1	S0	
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)



**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
$V_{CC}$	-0.5 V to +7 V
$V_{EE}$	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)	73°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	4.5	5.5	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	2		V
$V_{IL}$	Low-level input voltage		0.8	V
$V_I$	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		$V_{CC} = 4.5$ V	ns
$T_A$	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.

# CD74HCT4051-Q1

## HIGH-SPEED CMOS LOGIC

### ANALOG MULTIPLEXER/DEMULTIPLEXER

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

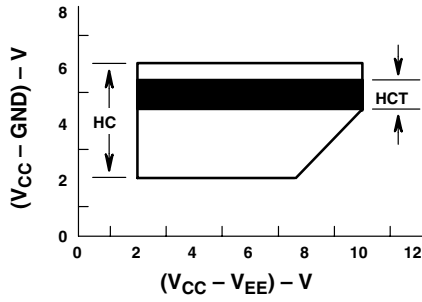


Figure 1

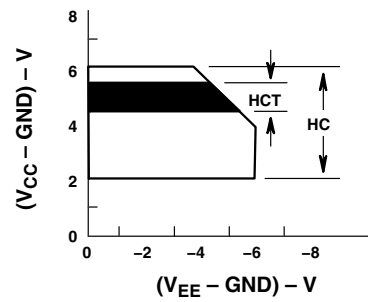


Figure 2

#### 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 9	V <sub>IS</sub> = V <sub>CC</sub> or V <sub>EE</sub>	0 V	4.5 V	70	160	240		Ω
			-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		
			-4.5 V	4.5 V	45	130	195		
Δr <sub>on</sub>	Between any two channels	0 V	4.5 V	10					Ω
		-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	Control input		5.5 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	5.5 V	8			160	μA
		When V <sub>IS</sub> = V <sub>CC</sub> , V <sub>OS</sub> = V <sub>EE</sub>	-4.5 V	5.5 V	16			320	
ΔI <sub>CC</sub>	Per input pin: 1 unit load, See Note 5, V <sub>IN</sub> = V <sub>CC</sub> - 2.1 V			4.5 V to 5.5 V	100	360	490		μA

NOTE 5: For dual-supply systems, theoretical worst case (V<sub>I</sub> = 2.4 V, V<sub>CC</sub> = 5.5 V) specification is 1.8 mA.

#### HCT input loading

TYPE	INPUT	UNIT LOADS†
4051	All	0.5

† Unit load is ΔI<sub>CC</sub> limit specified in the electrical characteristics table, e.g., 360 μA max at 25°C.

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**switching characteristics over recommended operating free-air temperature range (unless otherwise noted) (see Figure 8)**

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	4.5 V	12			18		
			C <sub>L</sub> = 50 pF	-4.5 V	4.5 V	8			12		
t <sub>en</sub>	S or $\bar{E}$	OUT	C <sub>L</sub> = 15 pF		5 V	23					ns
			C <sub>L</sub> = 50 pF	0 V	4.5 V	55			83		
			C <sub>L</sub> = 50 pF	-4.5 V	4.5 V	39			59		
t <sub>dis</sub>	S or $\bar{E}$	OUT	C <sub>L</sub> = 15 pF		5 V	19					ns
			C <sub>L</sub> = 50 pF	0 V	4.5 V	45			68		
			C <sub>L</sub> = 50 pF	-4.5 V	4.5 V	32			48		
C <sub>I</sub>	Control					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 6)	52	pF

NOTE 6: C<sub>pd</sub> is used to determine the dynamic power consumption (P<sub>D</sub>), per package.

$$P_D = (C_{pd} \times V_{CC}^2 \times f_i) + \sum (C_L + C_S) V_{CC}^2 \times f_O$$

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

**analog channel characteristics, T<sub>A</sub> = 25°C**

PARAMETER	TEST CONDITIONS	V <sub>EE</sub>	V <sub>CC</sub>	TYP	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	-2.25 V	2.25 V	145	MHz
		-4.5 V	4.5 V	180	
Sine-wave distortion	See Figure 5	-2.25 V	2.25 V	0.035	%
		-4.5 V	4.5 V	0.018	
$\bar{E}$ or address select (S0, S1, S2) to switch feedthrough noise	See Figure 6 and Notes 8 and 9	-2.25 V	2.25 V	TBE	mV
		-4.5 V	4.5 V	TBE	
Switch OFF signal feedthrough	See Figure 7 and Figure 11 and Notes 8 and 9	-2.25 V	2.25 V	-73	dB
		-4.5 V	4.5 V	-75	

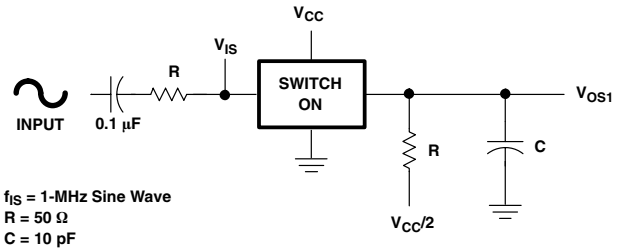
NOTES: 7. Adjust input voltage to obtain 0 dBm at V<sub>OS</sub> for f<sub>IN</sub> = 1 MHz.

8. V<sub>IS</sub> is centered at (V<sub>CC</sub> - V<sub>EE</sub>)/2.

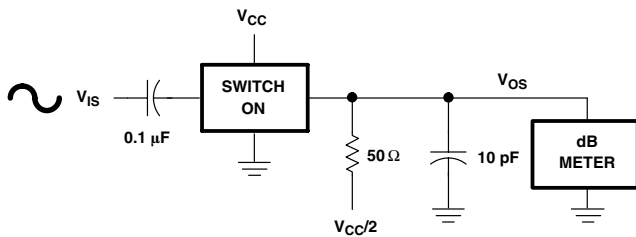
9. Adjust input for 0 dBm.



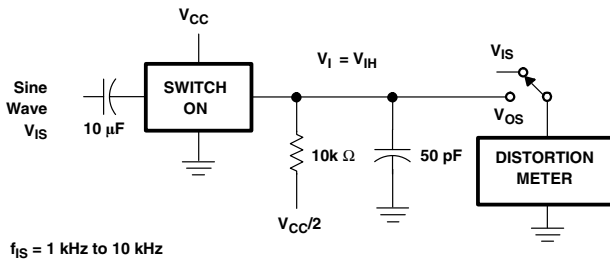
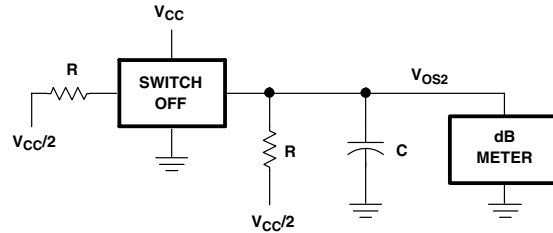
**PARAMETER MEASUREMENT INFORMATION**



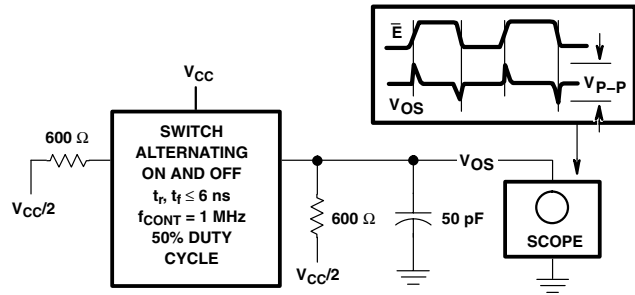
**Figure 4. Crosstalk Between Two Switches Test Circuit**



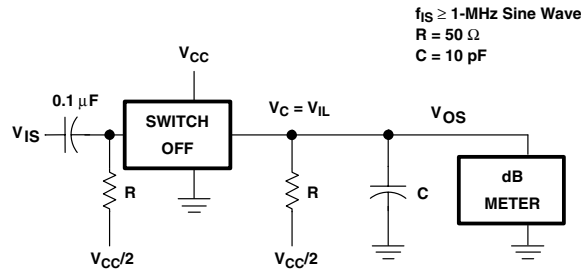
**Figure 3. Frequency-Response Test Circuit**



**Figure 5. Sine-Wave Distortion Test Circuit**

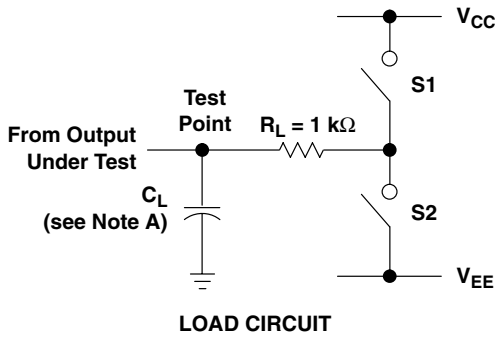


**Figure 6. Control-to-Switch Feedthrough Noise Test Circuit**

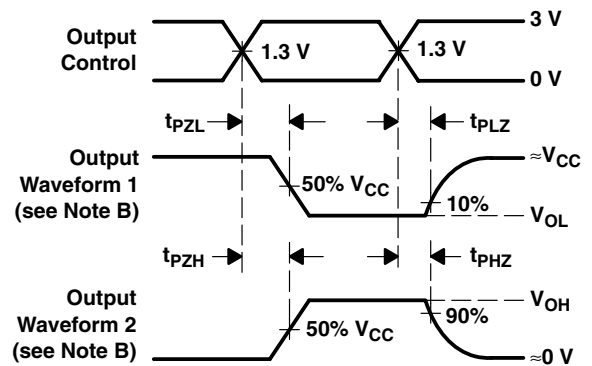
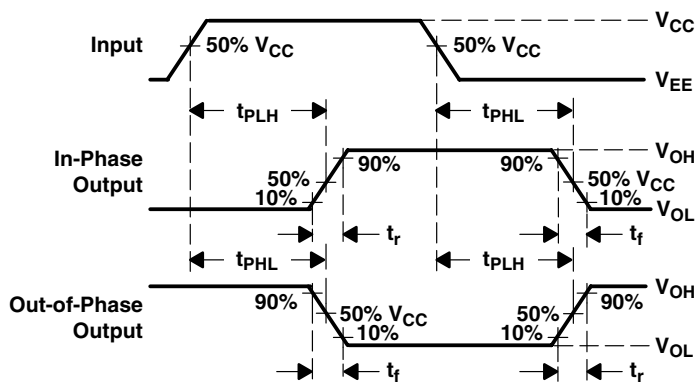


**Figure 7. Switch OFF Signal Feedthrough Test Circuit**

**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	



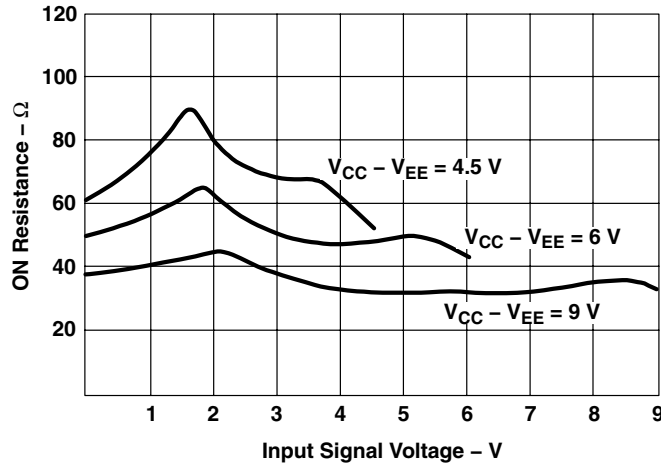
- NOTES:
- A.  $C_L$  includes probe and test-fixture capacitance.
  - B. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled 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 8. Load Circuit and Voltage Waveforms**

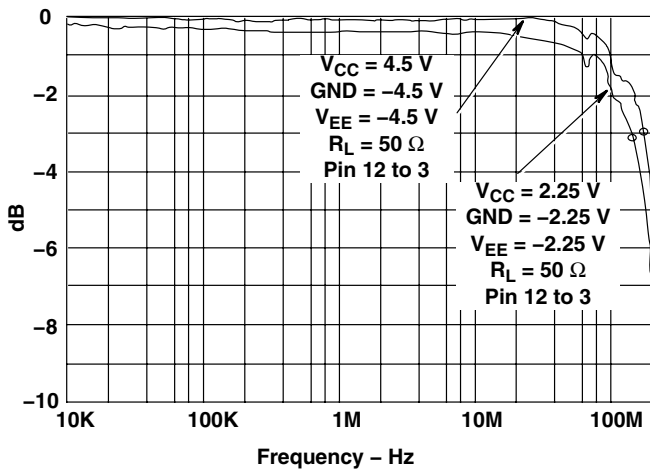
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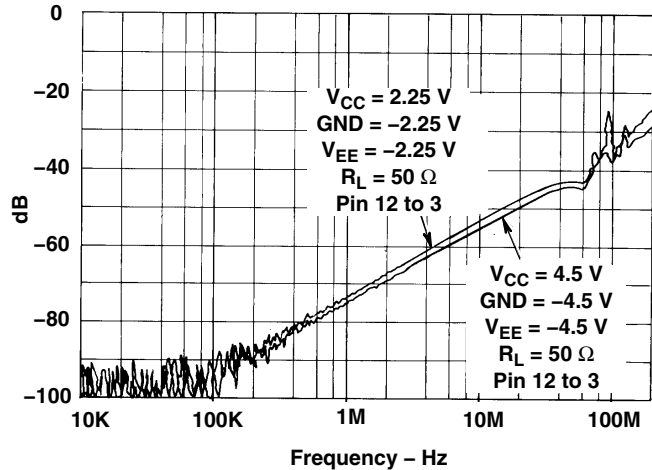
**TYPICAL CHARACTERISTICS**



**Figure 9. Typical ON Resistance vs Input Signal Voltage**



**Figure 10. Channel ON Bandwidth**



**Figure 11. 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>
CD74HCT4051QM96Q1	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
D24051QM96G4Q1	ACTIVE	SOIC	D	16	2500	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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- Catalog: [CD74HCT4051](#)
- Military: [CD54HCT4051](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- 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.
  - $\triangle C$  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.
  - $\triangle D$  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



4211283-4/E 08/12

- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - 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.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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