

# Advance Information

## Analog Multiplexer/ Demultiplexer

### High-Performance Silicon-Gate CMOS

The MC74VHCT4051 utilizes silicon-gate CMOS technology to achieve fast propagation delays, low ON resistances, and low OFF leakage currents. This analog multiplexer/demultiplexer controls analog voltages that may vary across the complete power supply range (from  $V_{CC}$  to GND).

The VHCT4051 is identical in pinout to the high-speed HC4051A and the metal-gate MC14051B. The Channel-Select inputs determine which one of the Analog Inputs/Outputs is to be connected by means of an analog switch to the Common Output/Input. When the Enable pin is HIGH, all analog switches are turned off.

The Channel-Select and Enable inputs are compatible with TTL-type input thresholds. The input protection circuitry on this device allows overvoltage tolerance on the input, allowing the device to be used as a logic-level translator from 3.0V CMOS logic to 5.0V CMOS Logic or from 1.8V CMOS logic to 3.0V CMOS Logic while operating at the higher-voltage power supply.

The MC74VHCT4051 input structure provides protection when voltages up to 7V are applied, regardless of the supply voltage. This allows the MC74VHCT4051 to be used to interface 5V circuits to 3V circuits.

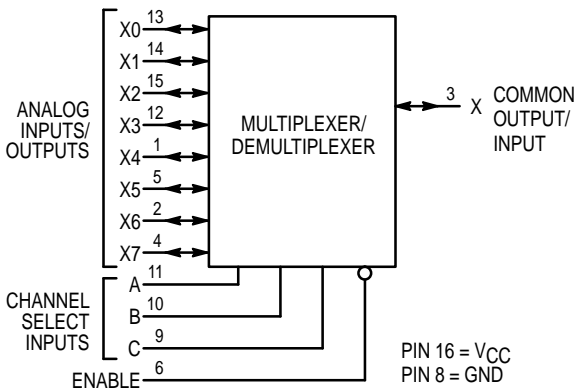
This device has been designed so that the ON resistance ( $R_{ON}$ ) is more linear over input voltage than  $R_{ON}$  of metal-gate CMOS analog switches.

For a multiplexer/demultiplexer with channel-select latches, see VHC4351.

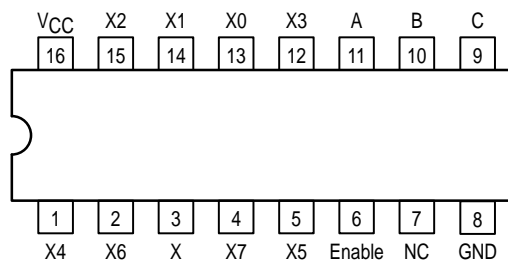
- Fast Switching and Propagation Speeds
- Low Crosstalk Between Switches
- Diode Protection on All Inputs/Outputs
- Analog Power Supply Range ( $V_{CC} - GND$ ) = 2.0 to 6.0 V
- Digital (Control) Power Supply Range ( $V_{CC} - GND$ ) = 2.0 to 6.0 V
- Improved Linearity and Lower ON Resistance Than Metal-Gate Counterparts
- Low Noise
- In Compliance With the Requirements of JEDEC Standard No. 7A

#### LOGIC DIAGRAM MC74VHCT4051

Single-Pole, 8-Position Plus Common Off



#### Pinout: MC74VHCT4051 (Top View)



This document contains information on a new product. Specifications and information herein are subject to change without notice.

## MC74VHCT4051



**D SUFFIX**  
16-LEAD SOIC PACKAGE  
CASE 751B-05



**DT SUFFIX**  
16-LEAD TSSOP PACKAGE  
CASE 948F-01

#### ORDERING INFORMATION

MC74VHCTXXXXD SOIC  
MC74VHCTXXXXDT TSSOP

#### FUNCTION TABLE - MC74VHCT4051

Control Inputs				ON Channels
Enable	Select			
	C	B	A	
L	L	L	L	X0
L	L	L	H	X1
L	L	H	L	X2
L	L	H	H	X3
L	H	L	L	X4
L	H	L	H	X5
L	H	H	L	X6
L	H	H	H	X7
H	X	X	X	NONE

X = Don't Care



# MC74VHCT4051

## MAXIMUM RATINGS\*

Symbol	Parameter	Value	Unit
$V_{CC}$	Positive DC Supply Voltage (Referenced to GND)	- 0.5 to + 7.0	V
$V_{IS}$	Analog Input Voltage	- 0.5 to $V_{CC} + 0.5$	V
$V_{in}$	Digital Input Voltage (Referenced to GND)	- 0.5 to $V_{CC} + 0.5$	V
I	DC Current, Into or Out of Any Pin	-20	mA
$P_D$	Power Dissipation in Still Air, SOIC Package† TSSOP Package†	500 450	mW
$T_{stg}$	Storage Temperature Range	- 65 to + 150	°C
$T_L$	Lead Temperature, 1 mm from Case for 10 Seconds	260	°C

\* Maximum Ratings are those values beyond which damage to the device may occur. Functional operation should be restricted to the Recommended Operating Conditions.

† Derating — SOIC Package: - 7 mW/°C from 65° to 125°C  
TSSOP Package: - 6.1 mW/°C from 65° to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $GND \leq (V_{in} \text{ or } V_{out}) \leq V_{CC}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either GND or  $V_{CC}$ ). Unused outputs must be left open.

## RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Max	Unit
$V_{CC}$	Positive DC Supply Voltage (Referenced to GND)	2.0	6.0	V
$V_{IS}$	Analog Input Voltage	0.0	$V_{CC}$	V
$V_{in}$	Digital Input Voltage (Referenced to GND)	GND	$V_{CC}$	V
$V_{IO}^*$	Static or Dynamic Voltage Across Switch		100	mV
$T_A$	Operating Temperature Range, All Package Types	- 55	+ 125	°C
$t_r, t_f$	Input Rise/Fall Time (Channel Select or Enable Inputs)			ns/V
	$V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$	0	100	
	$V_{CC} = 5.0 \text{ V} \pm 0.5 \text{ V}$	0	20	

\* For voltage drops across switch greater than 100 mV (switch on), excessive  $V_{CC}$  current may be drawn; i.e., the current out of the switch may contain both  $V_{CC}$  and switch input components. The reliability of the device will be unaffected unless the Maximum Ratings are exceeded.

**DC CHARACTERISTICS — Digital Section** (Voltages Referenced to GND)

Symbol	Parameter	Condition	V <sub>CC</sub> V	Guaranteed Limit			Unit
				-55 to 25°C	≤85°C	≤125°C	
V <sub>IH</sub>	Minimum High-Level Input Voltage, Channel-Select or Enable Inputs	R <sub>ON</sub> = Per Spec	3.0	1.2	1.2	1.2	V
			4.5	2.0	2.0	2.0	
			6.0	2.0	2.0	2.0	
V <sub>IL</sub>	Maximum Low-Level Input Voltage, Channel-Select or Enable Inputs	R <sub>ON</sub> = Per Spec	3.0	0.53	0.53	0.53	V
			4.5	0.8	0.8	0.8	
			6.0	0.8	0.8	0.8	
I <sub>in</sub>	Maximum Input Leakage Current, Channel-Select or Enable Inputs	V <sub>in</sub> = V <sub>CC</sub> or GND	6.0	±0.1	±1.0	±1.0	μA
I <sub>CC</sub>	Maximum Quiescent Supply Current (per Package)	Channel Select, Enable and V <sub>IS</sub> = V <sub>CC</sub> or GND; V <sub>IO</sub> = 0 V	6.0	4	40	160	μA

**DC ELECTRICAL CHARACTERISTICS** Analog Section

Symbol	Parameter	Test Conditions	V <sub>CC</sub> V	Guaranteed Limit			Unit
				-55 to 25°C	≤ 85°C	≤ 125°C	
R <sub>ON</sub>	Maximum "ON" Resistance	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> V <sub>IS</sub> = V <sub>CC</sub> to GND I <sub>S</sub> ≤ 2.0 mA (Figures 1, 2)	3.0	25	30	35	Ω
			4.5	18	23	28	
			6.0	15	20	25	
		V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> V <sub>IS</sub> = V <sub>CC</sub> or GND (Endpoints) I <sub>S</sub> ≤ 2.0 mA (Figures 1, 2)	3.0	20	25	30	
			4.5	15	20	25	
			6.0	10	15	20	
ΔR <sub>ON</sub>	Maximum Difference in "ON" Resistance Between Any Two Channels in the Same Package	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> V <sub>IS</sub> = 1/2 (V <sub>CC</sub> - GND) I <sub>S</sub> ≤ 2.0 mA	3.0	15	20	25	Ω
			4.5	8.0	12	15	
			6.0	4.0	7.0	10	
I <sub>off</sub>	Maximum Off-Channel Leakage Current, Any One Channel	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> ; V <sub>IO</sub> = V <sub>CC</sub> or GND; Switch Off (Figure 3)	6.0	0.1	0.5	1.0	μA
	Maximum Off-Channel Leakage Current, Common Channel	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> ; V <sub>IO</sub> = V <sub>CC</sub> or GND; Switch Off (Figure 4)	6.0	0.2	2.0	4.0	
I <sub>on</sub>	Maximum On-Channel Leakage Current, Channel-to-Channel	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> ; Switch-to-Switch = V <sub>CC</sub> or GND; (Figure 5)	6.0	0.2	2.0	4.0	μA

# MC74VHCT4051

## AC CHARACTERISTICS (C<sub>L</sub> = 50 pF, Input t<sub>r</sub> = t<sub>f</sub> = 3 ns)

Symbol	Parameter	V <sub>CC</sub> V	Guaranteed Limit			Unit
			-55 to 25°C	≤85°C	≤125°C	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, Channel–Select to Analog Output (Figure 9)	2.0	30	35	40	ns
		3.0	20	25	30	
		4.5	15	18	22	
		6.0	15	18	20	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, Analog Input to Analog Output (Figure 10)	2.0	4.0	6.0	8.0	ns
		3.0	3.0	5.0	6.0	
		4.5	1.0	2.0	2.0	
		6.0	1.0	2.0	2.0	
t <sub>PLZ</sub> , t <sub>PHZ</sub>	Maximum Propagation Delay, Enable to Analog Output (Figure 11)	2.0	30	35	40	ns
		3.0	20	25	30	
		4.5	15	18	22	
		6.0	15	18	20	
t <sub>PZL</sub> , t <sub>PZH</sub>	Maximum Propagation Delay, Enable to Analog Output (Figure 11)	2.0	20	25	30	ns
		3.0	12	14	15	
		4.5	8.0	10	12	
		6.0	8.0	10	12	
C <sub>in</sub>	Maximum Input Capacitance, Channel–Select or Enable Inputs		10	10	10	pF
C <sub>I/O</sub>	Maximum Capacitance (All Switches Off)	Analog I/O	35	35	35	pF
		Common O/I	130	130	130	
		Feedthrough	1.0	1.0	1.0	
CPD	Power Dissipation Capacitance (Figure 13)*	Typical @ 25°C, V <sub>CC</sub> = 5.0 V			pF	
		45				

\* Used to determine the no-load dynamic power consumption:  $P_D = C_{PD} V_{CC}^2 f + I_{CC} V_{CC}$ .

**ADDITIONAL APPLICATION CHARACTERISTICS (GND = 0 V)**

Symbol	Parameter	Condition	V <sub>CC</sub> V	Limit*	Unit
				25°C	
BW	Maximum On-Channel Bandwidth or Minimum Frequency Response (Figure 6)	f <sub>in</sub> = 1MHz Sine Wave; Adjust f <sub>in</sub> Voltage to Obtain 0dBm at V <sub>OS</sub> ; Increase f <sub>in</sub> Frequency Until dB Meter Reads -3dB; R <sub>L</sub> = 50Ω, C <sub>L</sub> = 10pF	3.0 4.50 6.00	80 80 80	MHz
—	Off-Channel Feedthrough Isolation (Figure 7)	f <sub>in</sub> = Sine Wave; Adjust f <sub>in</sub> Voltage to Obtain 0dBm at V <sub>IS</sub>  f <sub>in</sub> = 10kHz, R <sub>L</sub> = 600Ω, C <sub>L</sub> = 50pF	3.0 4.50 6.00	-50 -50 -50	dB
—		f <sub>in</sub> = 1.0MHz, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 10pF	3.0 4.50 6.00	-40 -40 -40	
—	Feedthrough Noise. Channel-Select Input to Common I/O (Figure 8)	V <sub>in</sub> ≤ 1MHz Square Wave (t <sub>r</sub> = t <sub>f</sub> = 3ns); Adjust R <sub>L</sub> at Setup so that I <sub>S</sub> = 0A; Enable = GND  R <sub>L</sub> = 600Ω, C <sub>L</sub> = 50pF	3.0 4.50 6.00	25 105 135	mV <sub>pp</sub>
—		R <sub>L</sub> = 10kΩ, C <sub>L</sub> = 10pF	3.0 4.50 6.00	35 145 190	
—	Crosstalk Between Any Two Switches (Figure 12)	f <sub>in</sub> = Sine Wave; Adjust f <sub>in</sub> Voltage to Obtain 0dBm at V <sub>IS</sub>  f <sub>in</sub> = 10kHz, R <sub>L</sub> = 600Ω, C <sub>L</sub> = 50pF	3.0 4.50 6.00	-50 -50 -50	dB
—		f <sub>in</sub> = 1.0MHz, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 10pF	3.0 4.50 6.00	-60 -60 -60	
THD	Total Harmonic Distortion (Figure 14)	f <sub>in</sub> = 1kHz, R <sub>L</sub> = 10kΩ, C <sub>L</sub> = 50pF THD = THD <sub>measured</sub> - THD <sub>source</sub> V <sub>IS</sub> = 2.0V <sub>pp</sub> sine wave V <sub>IS</sub> = 4.0V <sub>pp</sub> sine wave V <sub>IS</sub> = 5.5V <sub>pp</sub> sine wave	3.0 4.50 6.00	0.10 0.08 0.05	%

\* Limits not tested. Determined by design and verified by qualification.

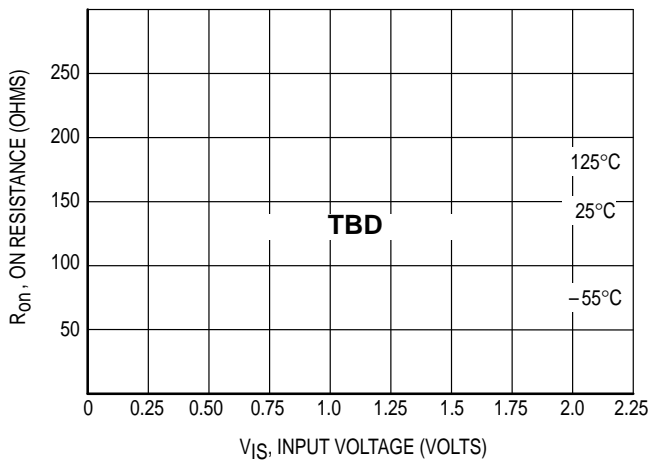


Figure 1a. Typical On Resistance, V<sub>CC</sub> = 2.0 V

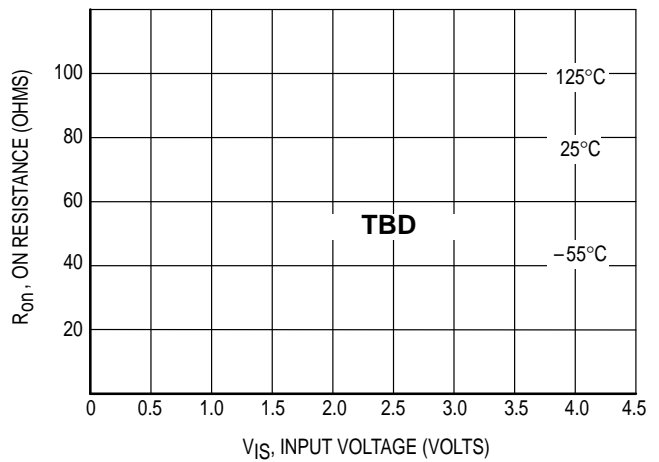


Figure 1b. Typical On Resistance, V<sub>CC</sub> = 3.0 V

MC74VHCT4051

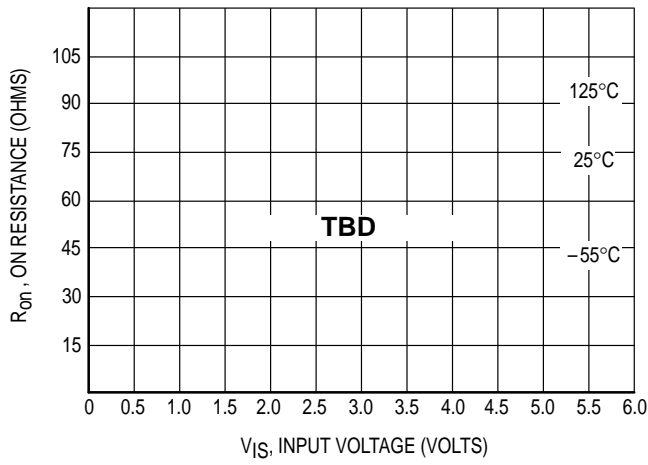


Figure 1c. Typical On Resistance,  $V_{CC} = 4.5$  V

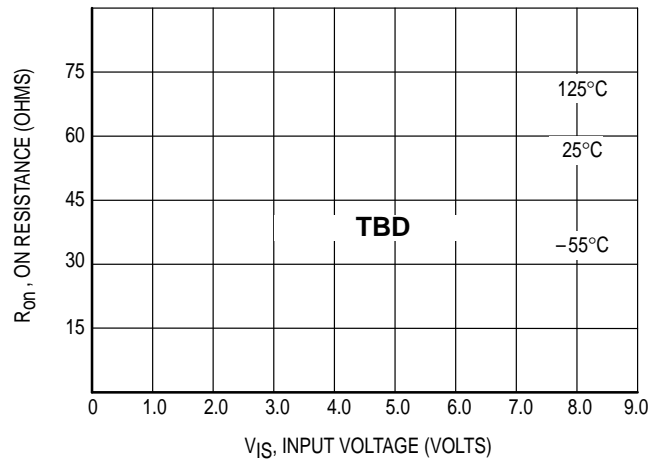


Figure 1d. Typical On Resistance,  $V_{CC} = 6.0$  V

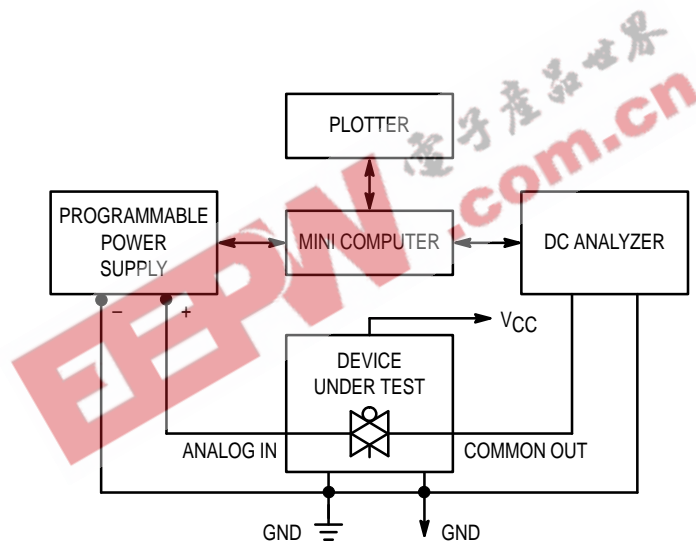


Figure 2. On Resistance Test Set-Up

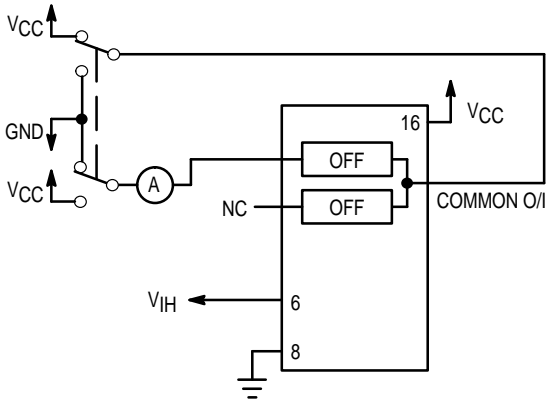


Figure 3. Maximum Off Channel Leakage Current, Any One Channel, Test Set-Up

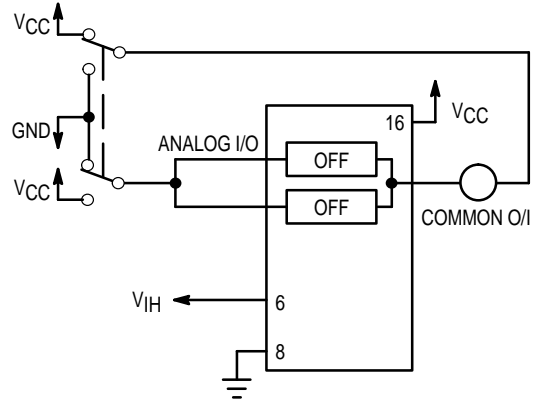


Figure 4. Maximum Off Channel Leakage Current, Common Channel, Test Set-Up

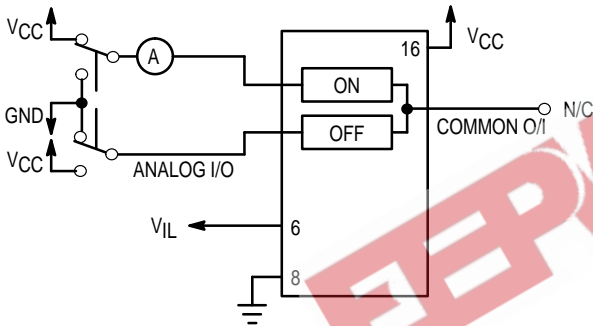


Figure 5. Maximum On Channel Leakage Current, Channel to Channel, Test Set-Up

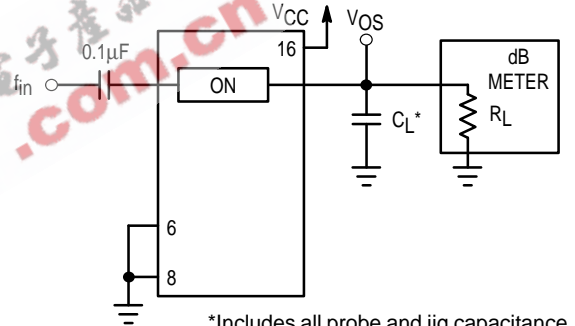


Figure 6. Maximum On Channel Bandwidth, Test Set-Up

\*Includes all probe and jig capacitance

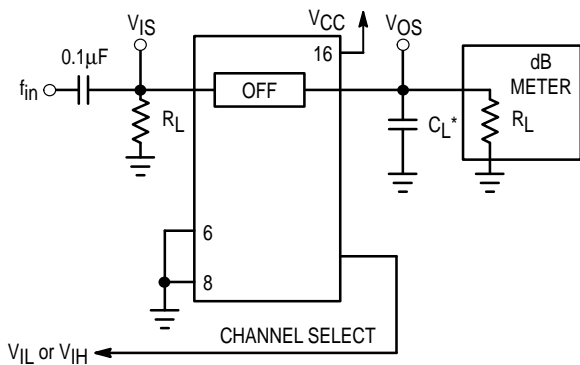


Figure 7. Off Channel Feedthrough Isolation, Test Set-Up

\*Includes all probe and jig capacitance

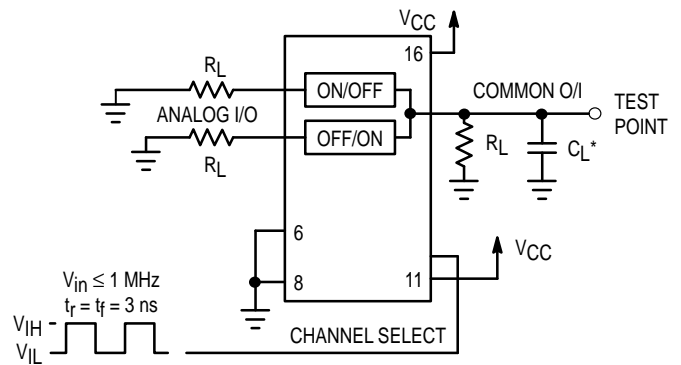


Figure 8. Feedthrough Noise, Channel Select to Common Out, Test Set-Up

\*Includes all probe and jig capacitance

MC74VHCT4051

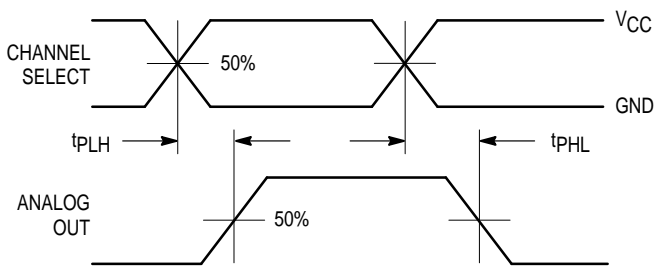
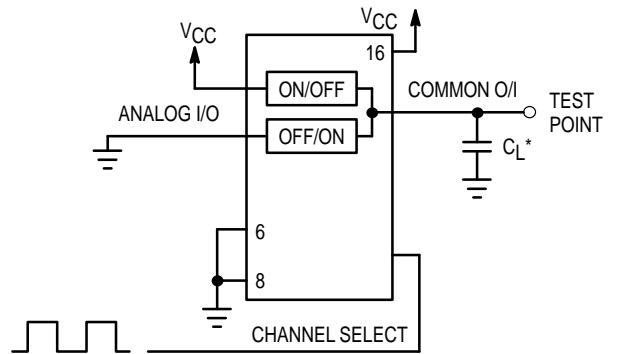


Figure 9a. Propagation Delays, Channel Select to Analog Out



\*Includes all probe and jig capacitance

Figure 9b. Propagation Delay, Test Set-Up Channel Select to Analog Out

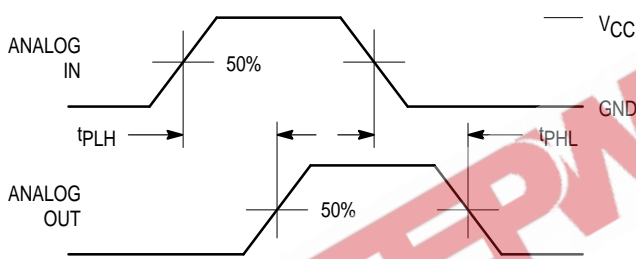
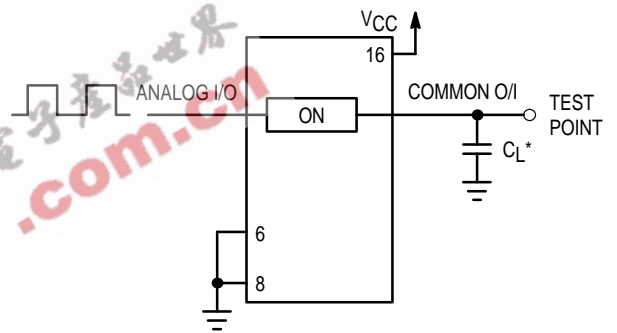


Figure 10a. Propagation Delays, Analog In to Analog Out



\*Includes all probe and jig capacitance

Figure 10b. Propagation Delay, Test Set-Up Analog In to Analog Out

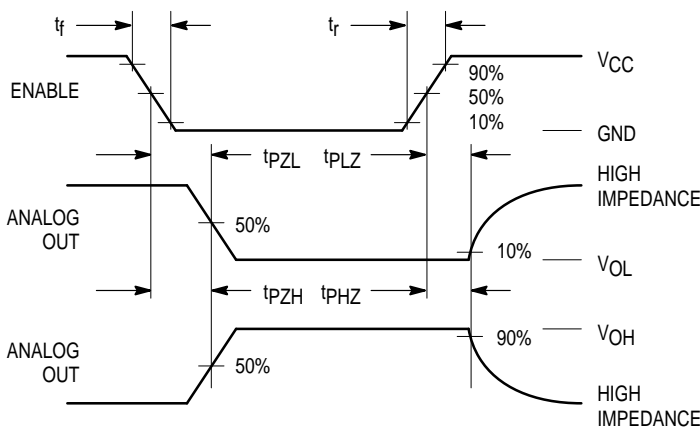


Figure 11a. Propagation Delays, Enable to Analog Out

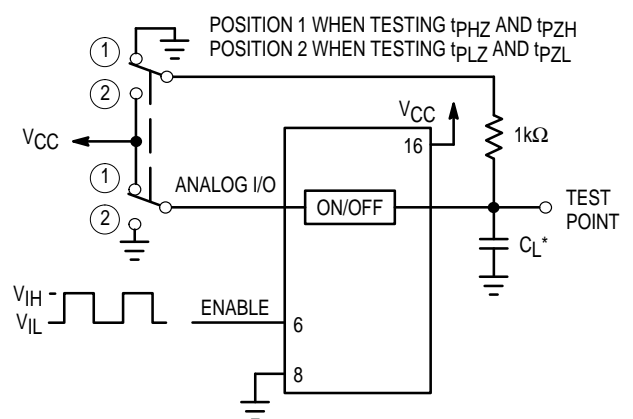
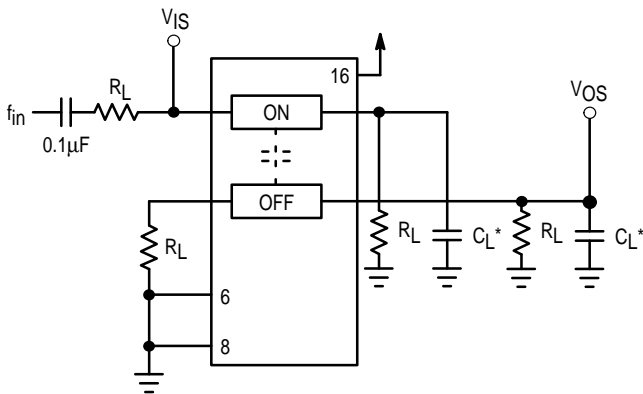


Figure 11b. Propagation Delay, Test Set-Up Enable to Analog Out





\*Includes all probe and jig capacitance

Figure 12. Crosstalk Between Any Two Switches, Test Set-Up

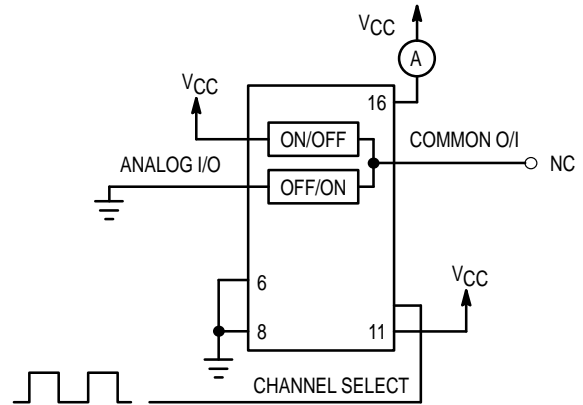
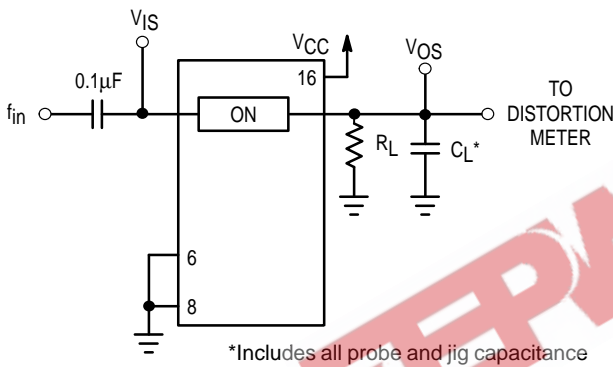


Figure 13. Power Dissipation Capacitance, Test Set-Up



\*Includes all probe and jig capacitance

Figure 14a. Total Harmonic Distortion, Test Set-Up

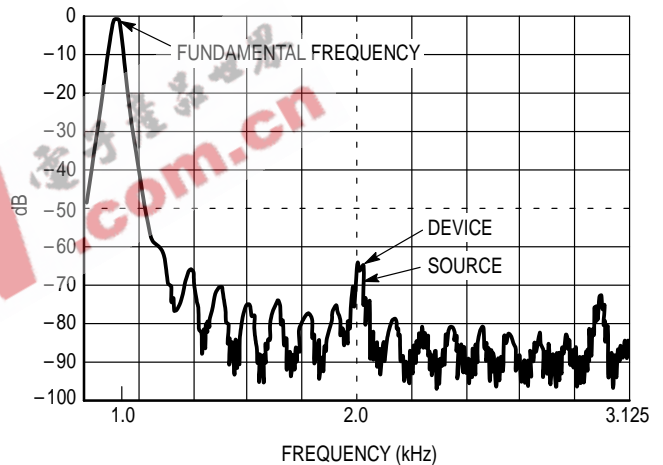


Figure 14b. Plot, Harmonic Distortion

APPLICATIONS INFORMATION

The Channel Select and Enable control pins should be at VCC or GND logic levels. VCC being recognized as a logic high and GND being recognized as a logic low. In this example:

$$V_{CC} = +5V = \text{logic high}$$

$$GND = 0V = \text{logic low}$$

The maximum analog voltage swing is determined by the supply voltage VCC. The positive peak analog voltage should not exceed VCC. Similarly, the negative peak analog voltage should not go below GND. In this example, the difference between VCC and GND is five volts. Therefore, using the configuration of Figure 15, a maximum analog signal of five volts peak-to-peak can be controlled. Unused analog

inputs/outputs may be left floating (i.e., not connected). However, tying unused analog inputs and outputs to VCC or GND through a low value resistor helps minimize crosstalk and feedthrough noise that may be picked up by an unused switch.

Although used here, balanced supplies are not a requirement. The only constraints on the power supplies are that:

$$V_{CC} - GND = 2 \text{ to } 6 \text{ volts}$$

When voltage transients above VCC and/or below GND are anticipated on the analog channels, external Germanium or Schottky diodes (DX) are recommended as shown in Figure 16. These diodes should be able to absorb the maximum anticipated current surges during clipping.

MC74VHCT4051

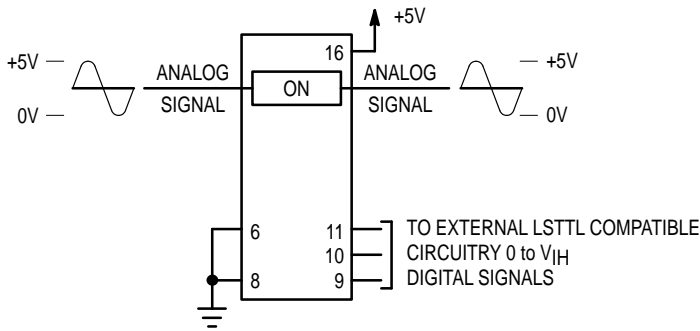


Figure 15. Application Example

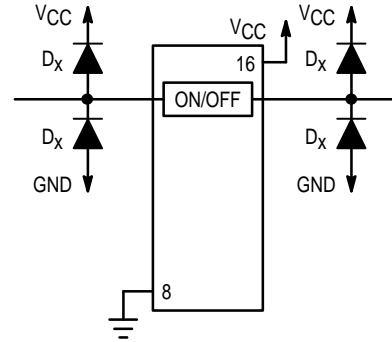
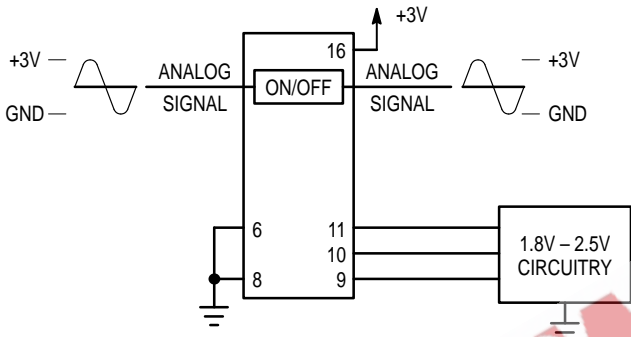
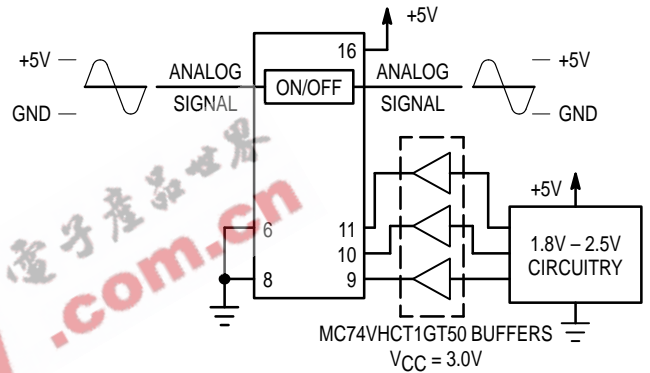


Figure 16. External Germanium or Schottky Clipping Diodes



a. Low Voltage Logic Level Shifting Control



b. 2-Stage Logic Level Shifting Control

Figure 17. Interfacing to Low Voltage CMOS Outputs

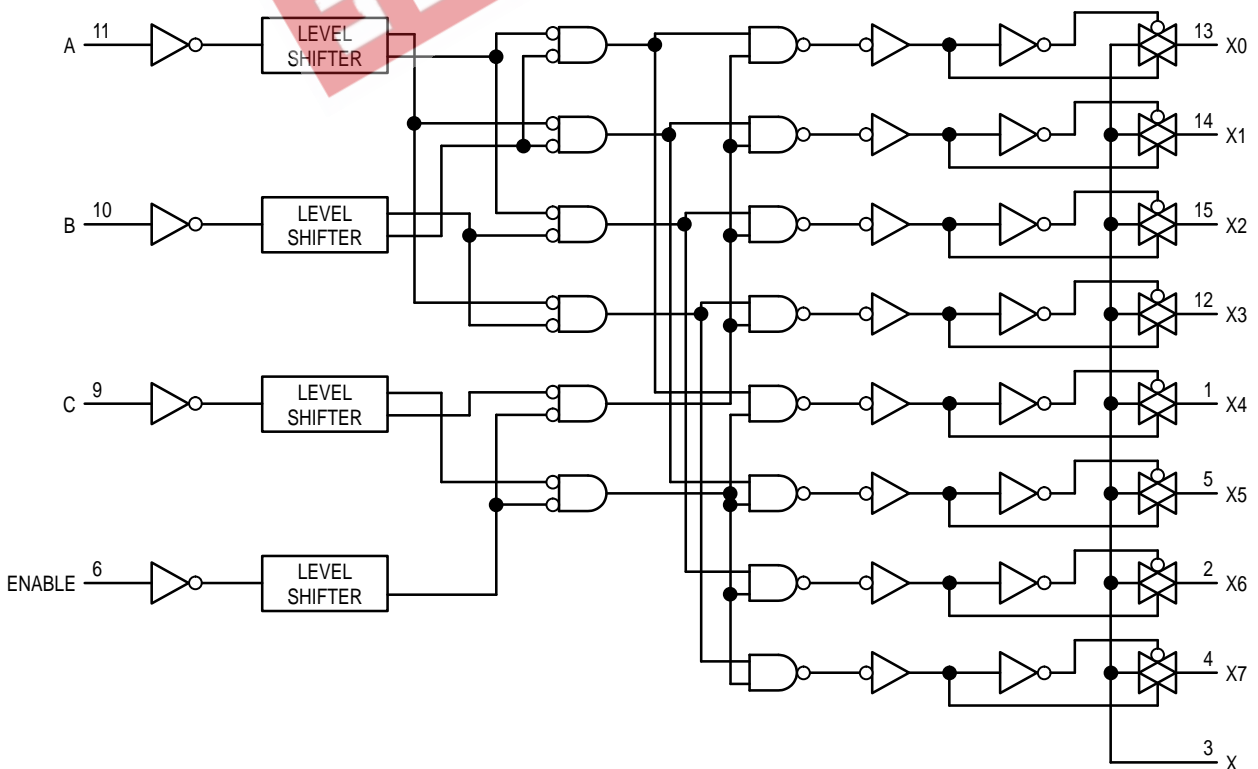
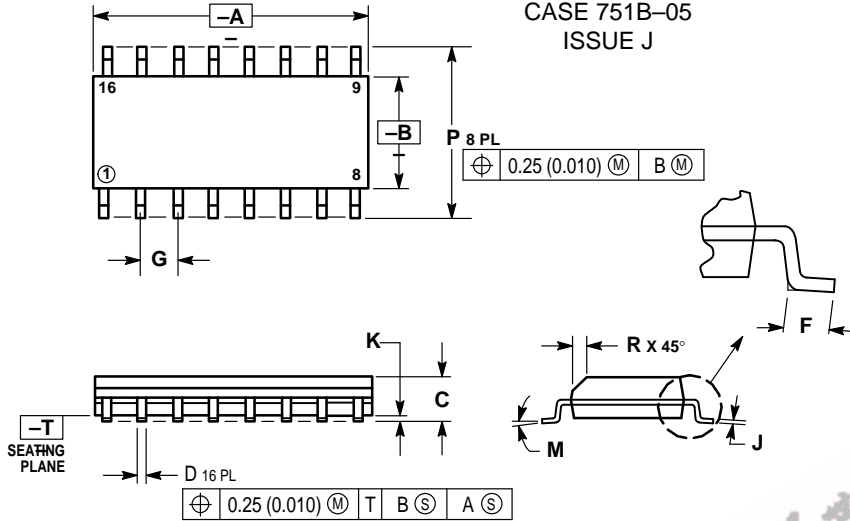


Figure 18. Function Diagram, VHCT4051

OUTLINE DIMENSIONS

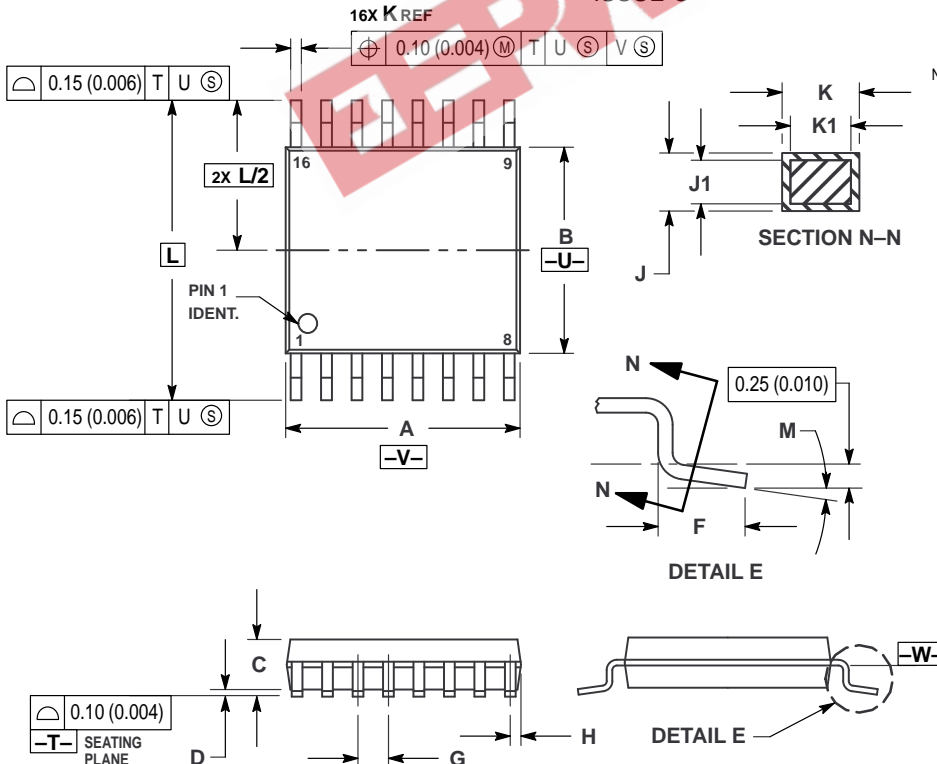
**D SUFFIX**  
**PLASTIC SOIC PACKAGE**  
**CASE 751B-05**  
**ISSUE J**



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
  4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
  5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.80	10.00	0.386	0.393
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

**DT SUFFIX**  
**PLASTIC TSSOP PACKAGE**  
**CASE 948F-01**  
**ISSUE O**




- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
  4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
  5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
  6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
  7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.90	5.10	0.193	0.200
B	4.30	4.50	0.169	0.177
C	—	1.20	—	0.047
D	0.05	0.15	0.002	0.006
F	0.50	0.75	0.020	0.030
G	0.65 BSC		0.026 BSC	
H	0.18	0.28	0.007	0.011
J	0.09	0.20	0.004	0.008
J1	0.09	0.16	0.004	0.006
K	0.19	0.30	0.007	0.012
K1	0.19	0.25	0.007	0.010
L	6.40 BSC		0.252 BSC	
M	0°	8°	0°	8°

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