

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Analog Multiplexers/ Demultiplexers

High-Performance Silicon-Gate CMOS

The MC54/74HC4051, MC74HC4052 and MC54/74HC4053 utilize silicon-gate CMOS technology to achieve fast propagation delays, low ON resistances, and low OFF leakage currents. These analog multiplexers/demultiplexers control analog voltages that may vary across the complete power supply range (from V_{CC} to V_{EE}).

The HC4051, HC4052 and HC4053 are identical in pinout to the metal-gate MC14051B, MC14052B and MC14053B. 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 standard CMOS outputs; with pullup resistors they are compatible with LSTTL outputs.

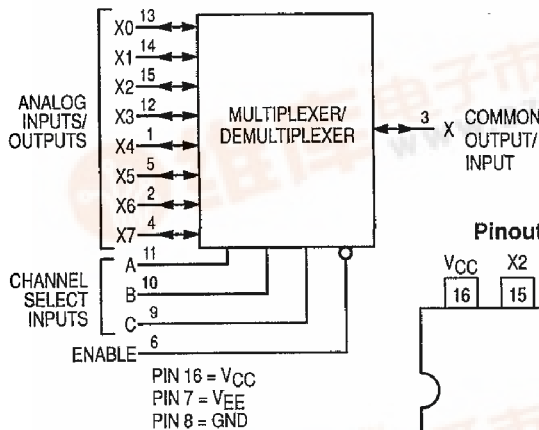
These devices have been designed so that the ON resistance (R_{ON}) is more linear over input voltage than R_{ON} of metal-gate CMOS analog switches.

For multiplexers/demultiplexers with channel-select latches, see HC4351, HC4352 and HC4353.

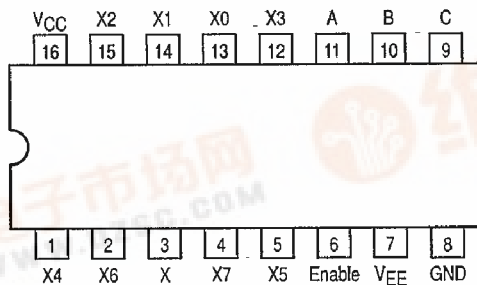
- Fast Switching and Propagation Speeds
- Low Crosstalk Between Switches
- Diode Protection on All Inputs/Outputs
- Analog Power Supply Range ($V_{CC} - V_{EE}$) = 2.0 to 12.0 V
- Digital (Control) Power Supply Range ($V_{CC} - GND$) = 2.0 to 6.0 V
- Improved Linearity and Lower ON Resistance Than Metal-Gate Counterparts
- Low Noise
- In Compliance With the Requirements of JEDEC Standard No. 7A
- Chip Complexity: HC4051 — 184 FETs or 46 Equivalent Gates
 HC4052 — 168 FETs or 42 Equivalent Gates
 HC4053 — 156 FETs or 39 Equivalent Gates

LOGIC DIAGRAM
MC54/74HC4051

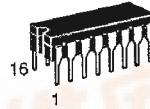
Single-Pole, 8-Position Plus Common Off



Pinout: MC54/74HC4051 (Top View)



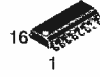
MC54/74HC4051 MC74HC4052 MC54/74HC4053



J SUFFIX
CERAMIC PACKAGE
CASE 620-10



N SUFFIX
PLASTIC PACKAGE
CASE 648-08



D SUFFIX
SOIC PACKAGE
CASE 751B-05



DW SUFFIX
SOIC PACKAGE
CASE 751G-02



DT SUFFIX
TSSOP PACKAGE
CASE 948F-01

ORDERING INFORMATION

MC54HCXXXXJ	Ceramic
MC74HCXXXXN	Plastic
MC74HCXXXXD	SOIC
MC74HCXXXXDW	SOIC Wide
MC74HCXXXXDT	TSSOP

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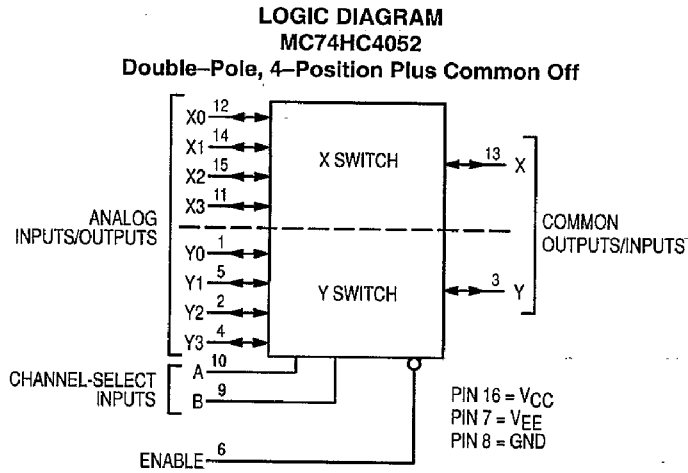
FUNCTION TABLE – MC54/74HC4051

Enable	Select			ON Channels
	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



MC54/74HC4051 MC74HC4052 MC54/74HC4053

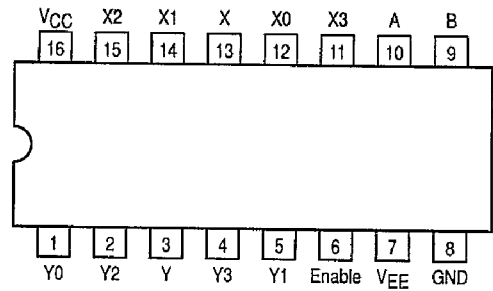


FUNCTION TABLE – MC74HC4052

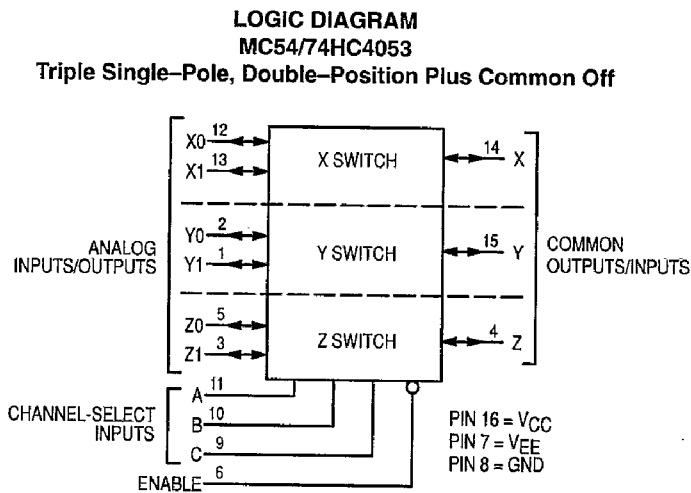
Control Inputs			ON Channels	
Enable	Select			
	B	A	Y	X
L	L	L	Y0	X0
L	L	H	Y1	X1
L	H	L	Y2	X2
L	H	H	Y3	X3
H	X	X	NONE	

X = Don't Care

Pinout: MC74HC4052 (Top View)



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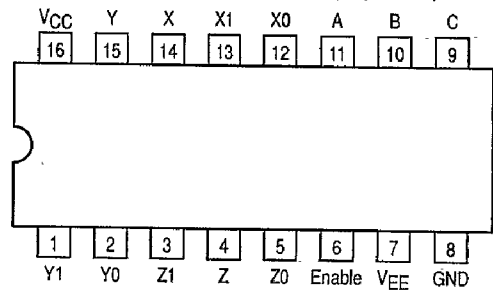
NOTE: This device allows independent control of each switch. Channel-Select Input A controls the X-Switch, Input B controls the Y-Switch and Input C controls the Z-Switch

FUNCTION TABLE – MC54/74HC4053

Control Inputs				ON Channels		
Enable	Select					
	C	B	A	Z	Y	X
L	L	L	L	Z0	Y0	X0
L	L	L	H	Z0	Y0	X1
L	L	H	L	Z0	Y1	X0
L	L	H	H	Z0	Y1	X1
L	H	L	L	Z1	Y0	X0
L	H	L	H	Z1	Y0	X1
L	H	H	L	Z1	Y1	X0
L	H	H	H	Z1	Y1	X1
H	X	X	X	NONE		

X = Don't Care

Pinout: MC54/74HC4053 (Top View)



MAXIMUM RATINGS*

Symbol	Parameter	Value	Unit
V _{CC}	Positive DC Supply Voltage (Referenced to GND) (Referenced to V _{EE})	- 0.5 to + 7.0 - 0.5 to + 14.0	V
V _{EE}	Negative DC Supply Voltage (Referenced to GND)	- 7.0 to + 5.0	V
V _{IS}	Analog Input Voltage	V _{EE} - 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	± 25	mA
P _D	Power Dissipation in Still Air, Plastic or Ceramic DIP† SOIC Package† TSSOP Package†	750 500 450	mW
T _{stg}	Storage Temperature Range	- 65 to + 150	°C
T _L	Lead Temperature, 1 mm from Case for 10 Seconds Plastic DIP, SOIC or TSSOP Package Ceramic DIP	260 300	°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 ≤ (V_{in} or V_{out}) ≤ 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.

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

† Derating — Plastic DIP: - 10 mW/°C from 65° to 125°C
Ceramic DIP: - 10 mW/°C from 100° to 125°C
SOIC Package: - 7 mW/°C from 65° to 125°C
TSSOP Package: - 6.1 mW/°C from 65° to 125°C

For high frequency or heavy load considerations, see Chapter 2.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Max	Unit	
V _{CC}	Positive DC Supply Voltage (Referenced to GND) (Referenced to V _{EE})	2.0 2.0	6.0 12.0	V	
V _{EE}	Negative DC Supply Voltage, Output (Referenced to GND)	- 6.0	GND	V	
V _{IS}	Analog Input Voltage	V _{EE}	V _{CC}	V	
V _{in}	Digital Input Voltage (Referenced to GND)	GND	V _{CC}	V	
V _{IO} *	Static or Dynamic Voltage Across Switch		1.2	V	
T _A	Operating Temperature Range, All Package Types	- 55	+ 125	°C	
t _r , t _f	Input Rise/Fall Time (Channel Select or Enable Inputs)	V _{CC} = 2.0 V V _{CC} = 4.5 V V _{CC} = 6.0 V	0 0 0	1000 500 400	ns

* For voltage drops across switch greater than 1.2V (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.

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DC CHARACTERISTICS — Digital Section (Voltages Referenced to GND) $V_{EE} = \text{GND}$, Except Where Noted

Symbol	Parameter	Condition	V _{CC} V	Guaranteed Limit			Unit
				-55 to 25°C	≤85°C	≤125°C	
V _{IH}	Minimum High-Level Input Voltage, Channel-Select or Enable Inputs	R _{on} = Per Spec	2.0	1.50	1.50	1.50	V
			4.5	3.15	3.15	3.15	
			6.0	4.20	4.20	4.20	
V _{IL}	Maximum Low-Level Input Voltage, Channel-Select or Enable Inputs	R _{on} = Per Spec	2.0	0.3	0.3	0.3	V
			4.5	0.9	0.9	0.9	
			6.0	1.2	1.2	1.2	
I _{in}	Maximum Input Leakage Current, Channel-Select or Enable Inputs	V _{in} = V _{CC} or GND, V _{EE} = -6.0 V	6.0	±0.1	±1.0	±1.0	μA
I _{CC}	Maximum Quiescent Supply Current (per Package)	Channel Select, Enable and V _{IS} = V _{CC} or GND; V _{EE} = GND V _{IO} = 0 V V _{EE} = -6.0	6.0	2	20	40	μA
			6.0	8	80	160	

NOTE: Information on typical parametric values can be found in Chapter 2.

DC CHARACTERISTICS — Analog Section

Symbol	Parameter	Condition	V _{CC}	V _{EE}	Guaranteed Limit			Unit	
					-55 to 25°C	≤85°C	≤125°C		
R _{on}	Maximum "ON" Resistance	V _{in} = V _{IL} or V _{IH} ; V _{IS} = V _{CC} to V _{EE} ; I _S ≤ 2.0 mA (Figures 1, 2)	4.5	0.0	190	240	280	Ω	
			4.5	-4.5	120	150	170		
			6.0	-6.0	100	125	140		
		V _{in} = V _{IL} or V _{IH} ; V _{IS} = V _{CC} or V _{EE} (Endpoints); I _S ≤ 2.0 mA (Figures 1, 2)	4.5	0.0	150	190	230		
			4.5	-4.5	100	125	140		
			6.0	-6.0	80	100	115		
ΔR _{on}	Maximum Difference in "ON" Resistance Between Any Two Channels in the Same Package	V _{in} = V _{IL} or V _{IH} ; V _{IS} = 1/2 (V _{CC} - V _{EE}); I _S ≤ 2.0 mA	4.5	0.0	30	35	40	Ω	
			4.5	-4.5	12	15	18		
			6.0	-6.0	10	12	14		
I _{off}	Maximum Off-Channel Leakage Current, Any One Channel	V _{in} = V _{IL} or V _{IH} ; V _{IO} = V _{CC} - V _{EE} ; Switch Off (Figure 3)	6.0	-6.0	0.1	0.5	1.0	μA	
			Maximum Off-Channel Leakage Current, Common Channel	HC4051	V _{in} = V _{IL} or V _{IH} ;	6.0	-6.0		0.2
	HC4052	V _{IO} = V _{CC} - V _{EE} ;		6.0	-6.0	0.1	1.0		2.0
	HC4053	Switch Off (Figure 4)		6.0	-6.0	0.1	1.0		2.0
I _{on}	Maximum On-Channel Leakage Current, Channel-to-Channel	HC4051 V _{in} = V _{IL} or V _{IH} ; HC4052 Switch-to-Switch = HC4053 V _{CC} - V _{EE} ; (Figure 5).	6.0	-6.0	0.2	2.0	4.0	μA	
			6.0	-6.0	0.1	1.0	2.0		
			6.0	-6.0	0.1	1.0	2.0		

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AC CHARACTERISTICS ($C_L = 50 \text{ pF}$, Input $t_r = t_f = 6 \text{ ns}$)

Symbol	Parameter	VCC V	Guaranteed Limit			Unit
			-55 to 25°C	≤85°C	≤125°C	
tPLH, tPHL	Maximum Propagation Delay, Channel-Select to Analog Output (Figure 9)	2.0	370	465	550	ns
		4.5	74	93	110	
		6.0	63	79	94	
tPLH, tPHL	Maximum Propagation Delay, Analog Input to Analog Output (Figure 10)	2.0	60	75	90	ns
		4.5	12	15	18	
		6.0	10	13	15	
tPLZ, tPHZ	Maximum Propagation Delay, Enable to Analog Output (Figure 11)	2.0	290	364	430	ns
		4.5	58	73	86	
		6.0	49	62	73	
tPZL, tPZH	Maximum Propagation Delay, Enable to Analog Output (Figure 11)	2.0	345	435	515	ns
		4.5	69	87	103	
		6.0	59	74	87	
Cin	Maximum Input Capacitance, Channel-Select or Enable Inputs		10	10	10	pF
C _{I/O}	Maximum Capacitance (All Switches Off)	Analog I/O	35	35	35	pF
		Common O/I: HC4051	130	130	130	
		HC4052	80	80	80	
		HC4053	50	50	50	
	Feedthrough		1.0	1.0	1.0	

NOTE: For propagation delays with loads other than 50 pF, and information on typical parametric values, see Chapter 2.

CPD	Power Dissipation Capacitance (Figure 13)*	HC4051 HC4052 HC4053	Typical @ 25°C, VCC = 5.0 V, VEE = 0 V			pF
			45	80	45	

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

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ADDITIONAL APPLICATION CHARACTERISTICS (GND = 0 V)

Symbol	Parameter	Condition	VCC V	VEE V	Limit*			Unit
					25°C			
BW	Maximum On-Channel Bandwidth or Minimum Frequency Response (Figure 6)	$f_{in} = 1\text{MHz}$ Sine Wave; Adjust f_{in} Voltage to Obtain 0dBm at V_{IS} ; Increase f_{in} Frequency Until dB Meter Reads -3dB; $R_L = 50\Omega$, $C_L = 10\text{pF}$	2.25 4.50 6.00	-2.25 -4.50 -6.00	'51 80 80	'52 95 95	'53 120 120	MHz
—	Off-Channel Feedthrough Isolation (Figure 7)	$f_{in} = \text{Sine Wave}$; Adjust f_{in} Voltage to Obtain 0dBm at V_{IS} $f_{in} = 10\text{kHz}$, $R_L = 600\Omega$, $C_L = 50\text{pF}$	2.25 4.50 6.00	-2.25 -4.50 -6.00	-50 -50 -50			dB
		$f_{in} = 1.0\text{MHz}$, $R_L = 50\Omega$, $C_L = 10\text{pF}$	2.25 4.50 6.00	-2.25 -4.50 -6.00	-40 -40 -40			
—	Feedthrough Noise. Channel-Select Input to Common I/O (Figure 8)	$V_{in} \leq 1\text{MHz}$ Square Wave ($t_r = t_f = 6\text{ns}$); Adjust R_L at Setup so that $I_S = 0\text{A}$; Enable = GND $R_L = 600\Omega$, $C_L = 50\text{pF}$	2.25 4.50 6.00	-2.25 -4.50 -6.00	25 105 135			mVpp
		$R_L = 10\text{k}\Omega$, $C_L = 10\text{pF}$	2.25 4.50 6.00	-2.25 -4.50 -6.00	35 145 190			
—	Crosstalk Between Any Two Switches (Figure 12) (Test does not apply to HC4051)	$f_{in} = \text{Sine Wave}$; Adjust f_{in} Voltage to Obtain 0dBm at V_{IS} $f_{in} = 10\text{kHz}$, $R_L = 600\Omega$, $C_L = 50\text{pF}$	2.25 4.50 6.00	-2.25 -4.50 -6.00	-50 -50 -50			dB
		$f_{in} = 1.0\text{MHz}$, $R_L = 50\Omega$, $C_L = 10\text{pF}$	2.25 4.50 6.00	-2.25 -4.50 -6.00	-60 -60 -60			
THD	Total Harmonic Distortion (Figure 14)	$f_{in} = 1\text{kHz}$, $R_L = 10\text{k}\Omega$, $C_L = 50\text{pF}$ $\text{THD} = \text{THD}_{\text{measured}} - \text{THD}_{\text{source}}$ $V_{IS} = 4.0\text{Vpp}$ sine wave $V_{IS} = 8.0\text{Vpp}$ sine wave $V_{IS} = 11.0\text{Vpp}$ sine wave	2.25 4.50 6.00	-2.25 -4.50 -6.00	0.10 0.08 0.05			%

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

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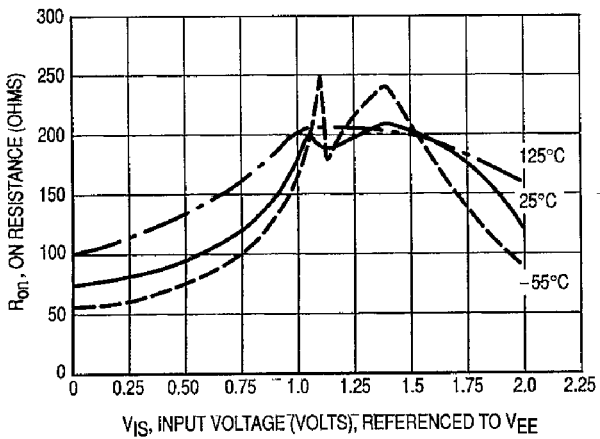


Figure 1a. Typical On Resistance, $V_{CC} - V_{EE} = 2.0 \text{ V}$

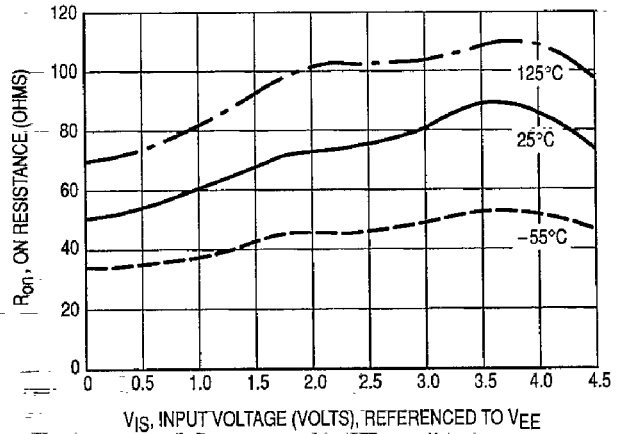


Figure 1b. Typical On Resistance, $V_{CC} - V_{EE} = 4.5 \text{ V}$

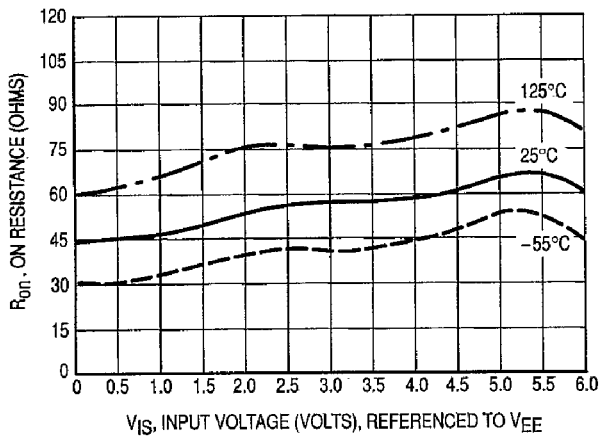


Figure 1c. Typical On Resistance, $V_{CC} - V_{EE} = 6.0 \text{ V}$

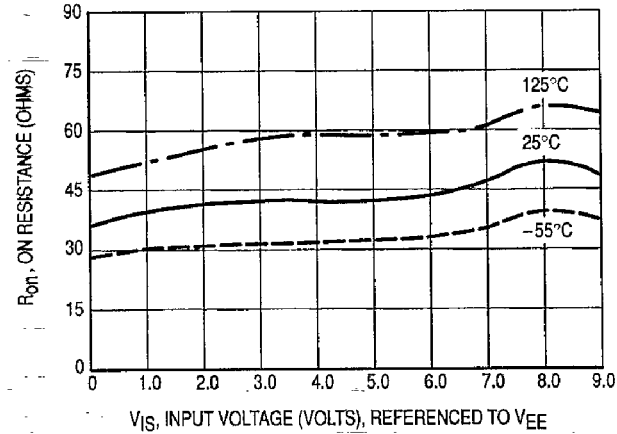


Figure 1d. Typical On Resistance, $V_{CC} - V_{EE} = 9.0 \text{ V}$

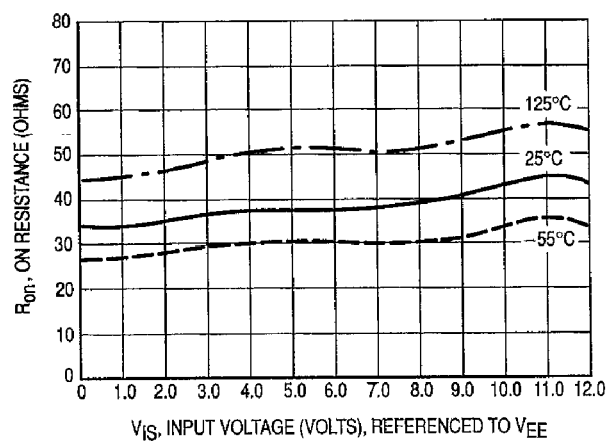


Figure 1e. Typical On Resistance, $V_{CC} - V_{EE} = 12.0 \text{ V}$

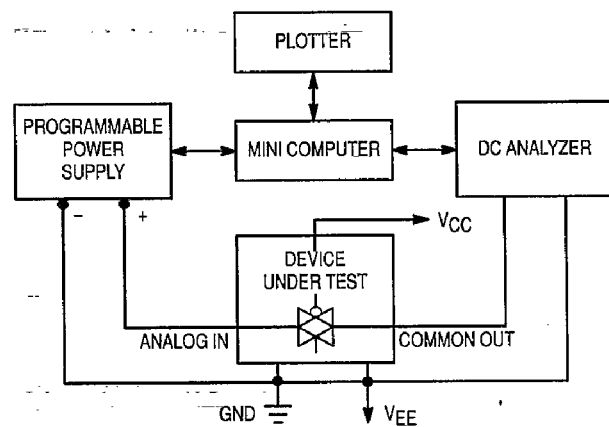


Figure 2. On Resistance Test Set-Up

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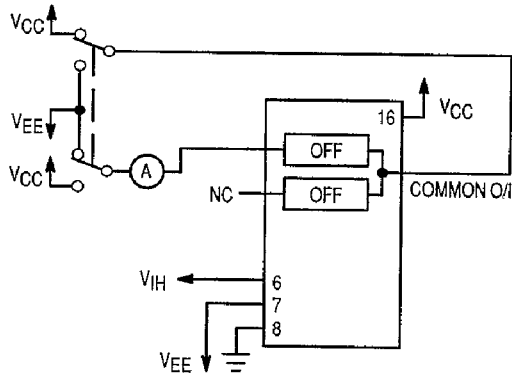


Figure 3. Maximum Off Channel Leakage Current, Any One Channel, Test Set-Up

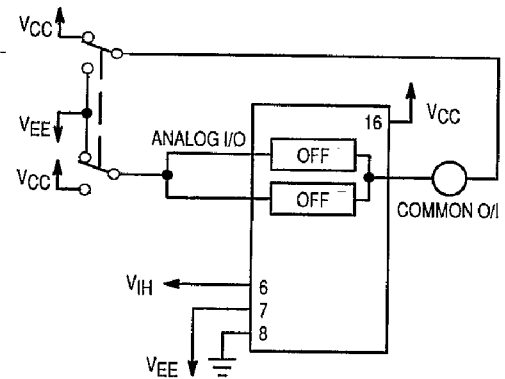


Figure 4. Maximum Off Channel Leakage Current, Common Channel, Test Set-Up

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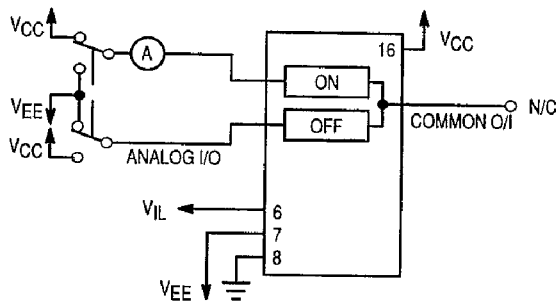
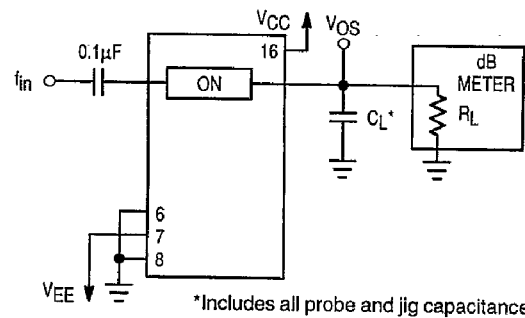
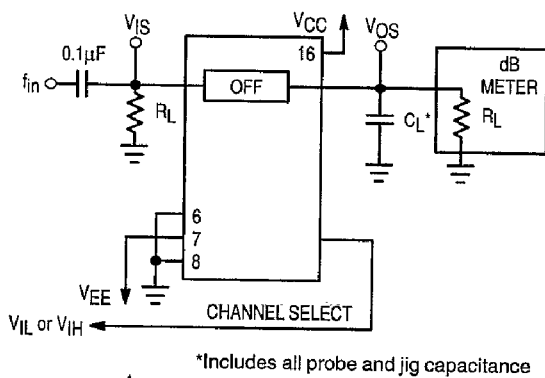


Figure 5. Maximum On Channel Leakage Current, Channel to Channel, Test Set-Up



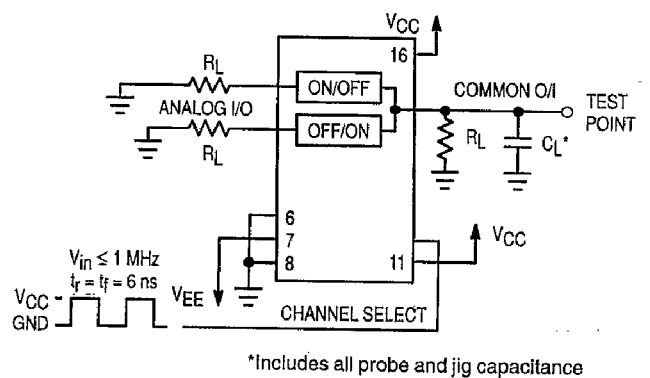
*Includes all probe and jig capacitance

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

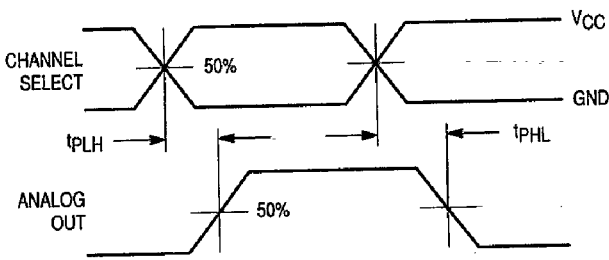
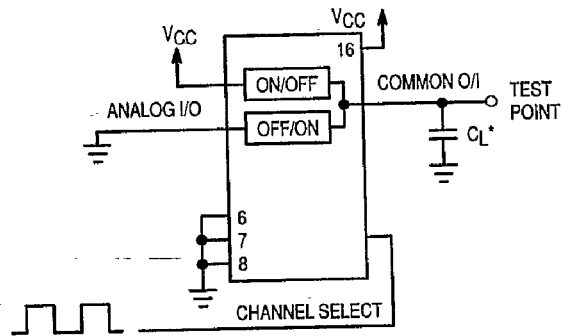


Figure 9a. Propagation Delays, Channel Select to Analog Out



*Includes all probe and jig capacitance

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

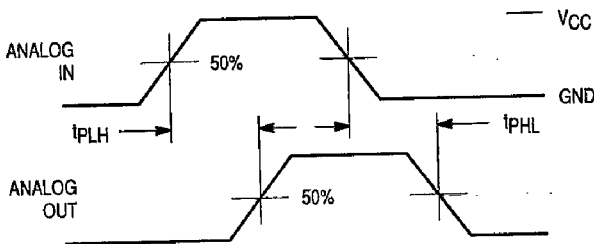
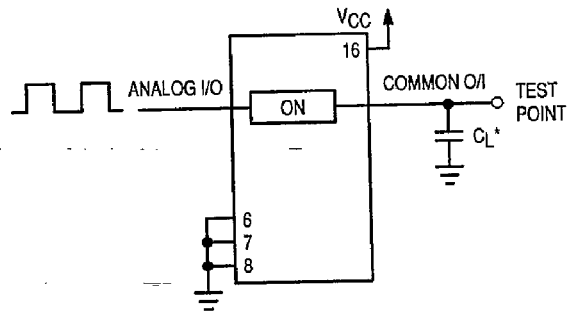


Figure 10a. Propagation Delays, Analog In to Analog Out



*Includes all probe and jig capacitance

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

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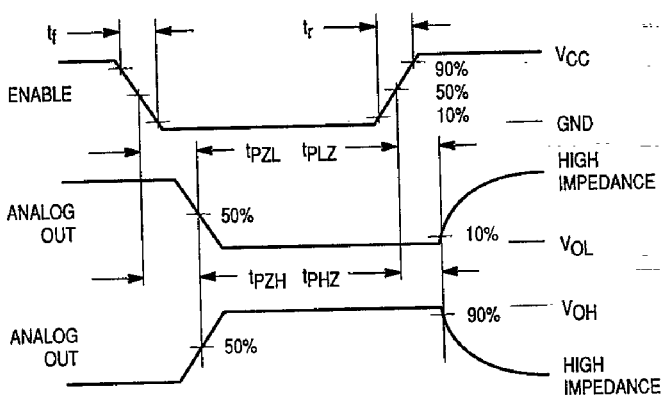


Figure 11a. Propagation Delays, Enable to Analog Out

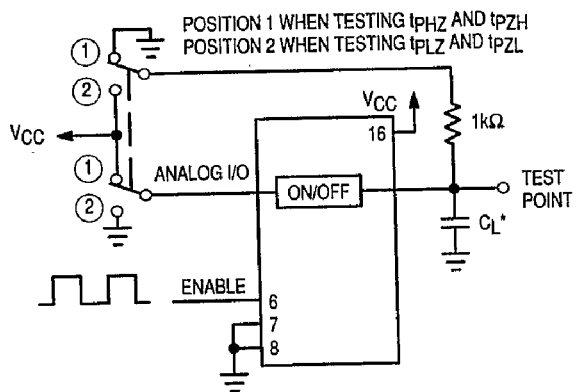


Figure 11b. Propagation Delay, Test Set-Up Enable to Analog Out

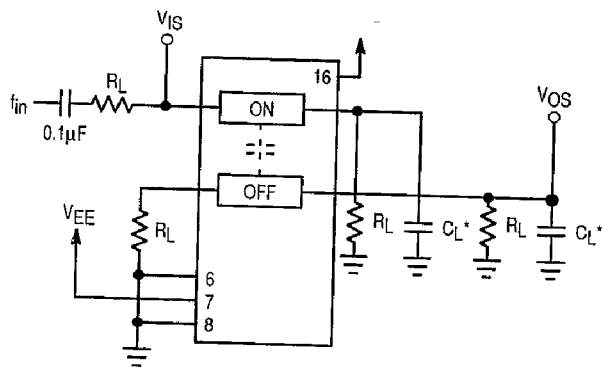


Figure 12. Crosstalk Between Any Two Switches, Test Set-Up

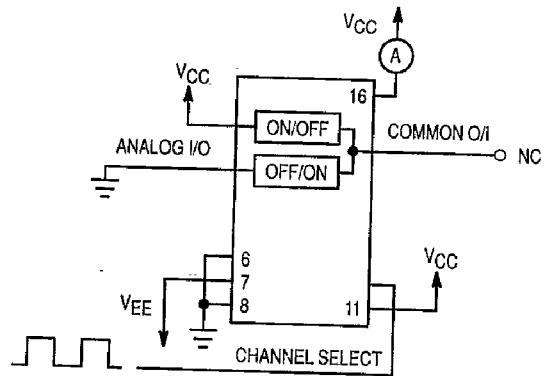


Figure 13. Power Dissipation Capacitance, Test Set-Up

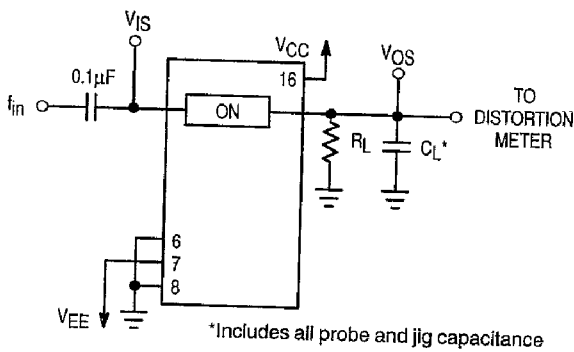


Figure 14a. Total Harmonic Distortion, Test Set-Up

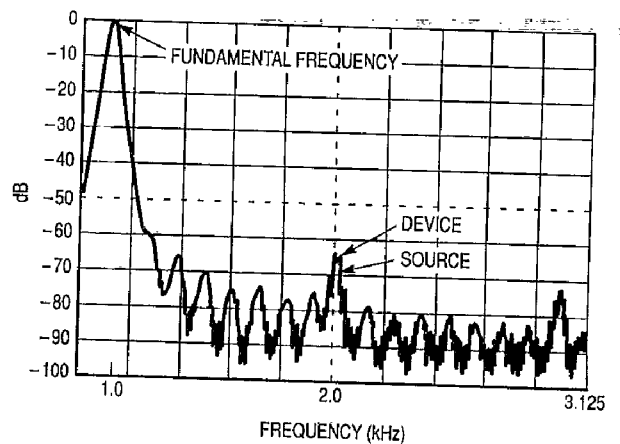


Figure 14b. Plot, Harmonic Distortion

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APPLICATIONS INFORMATION

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

$$\begin{aligned} V_{CC} &= +5V = \text{logic high} \\ GND &= 0V = \text{logic low} \end{aligned}$$

The maximum analog voltage swings are determined by the supply voltages V_{CC} and V_{EE} . The positive peak analog voltage should not exceed V_{CC} . Similarly, the negative peak analog voltage should not go below V_{EE} . In this example, the difference between V_{CC} and V_{EE} is ten volts. Therefore, using the configuration of Figure 15, a maximum analog signal of ten 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

V_{CC} 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:

$$\begin{aligned} V_{CC} - GND &= 2 \text{ to } 6 \text{ volts} \\ V_{EE} - GND &= 0 \text{ to } -6 \text{ volts} \\ V_{CC} - V_{EE} &= 2 \text{ to } 12 \text{ volts} \\ &\text{and } V_{EE} \leq GND \end{aligned}$$

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

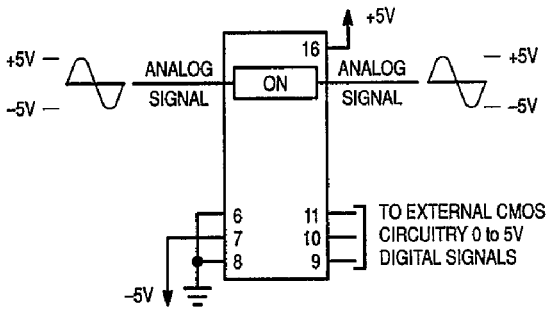


Figure 15. Application Example

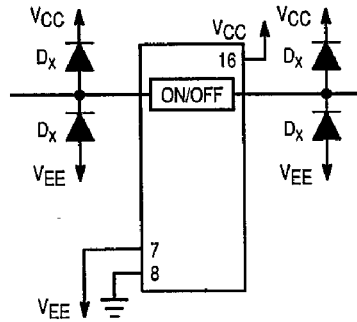
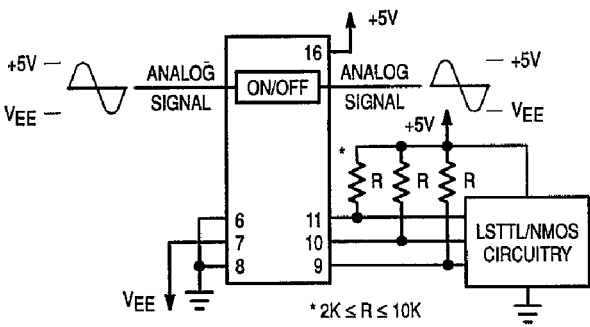
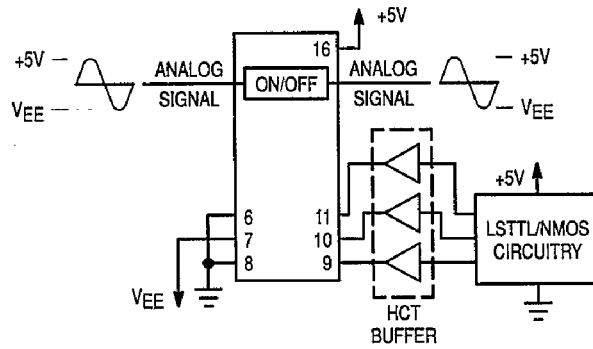


Figure 16. External Germanium or Schottky Clipping Diodes



a. Using Pull-Up Resistors



b. Using HCT Interface

Figure 17. Interfacing LSTTL/NMOS to CMOS Inputs

3

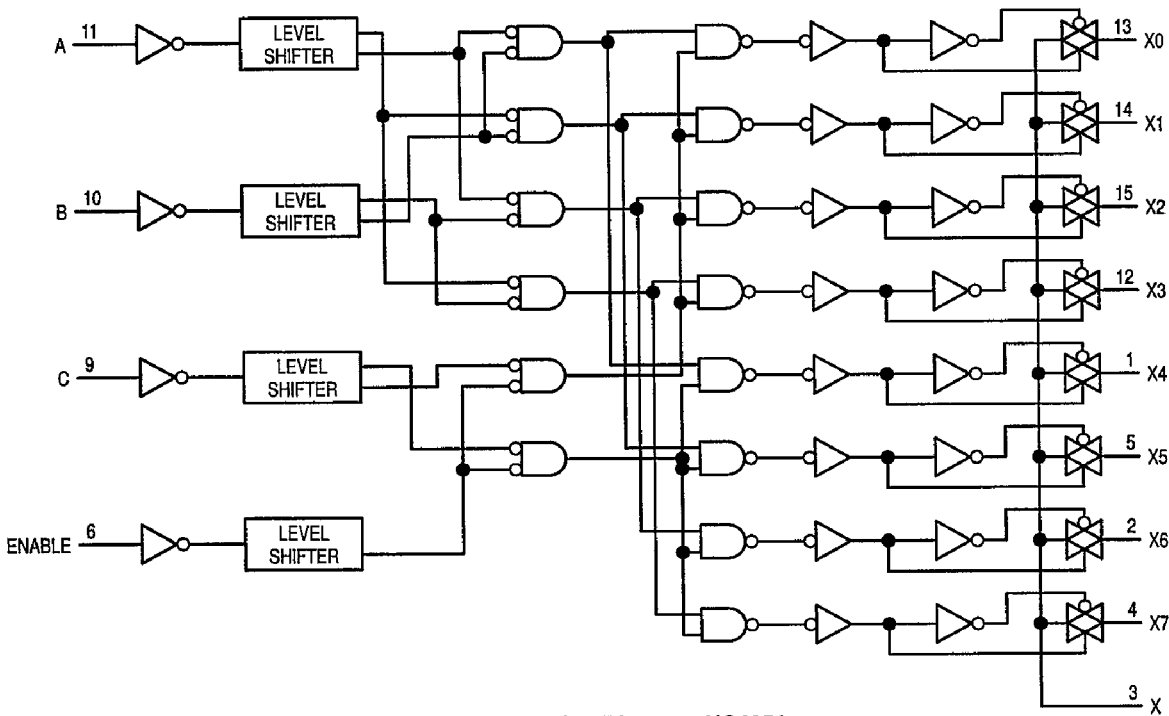


Figure 18. Function Diagram, HC4051

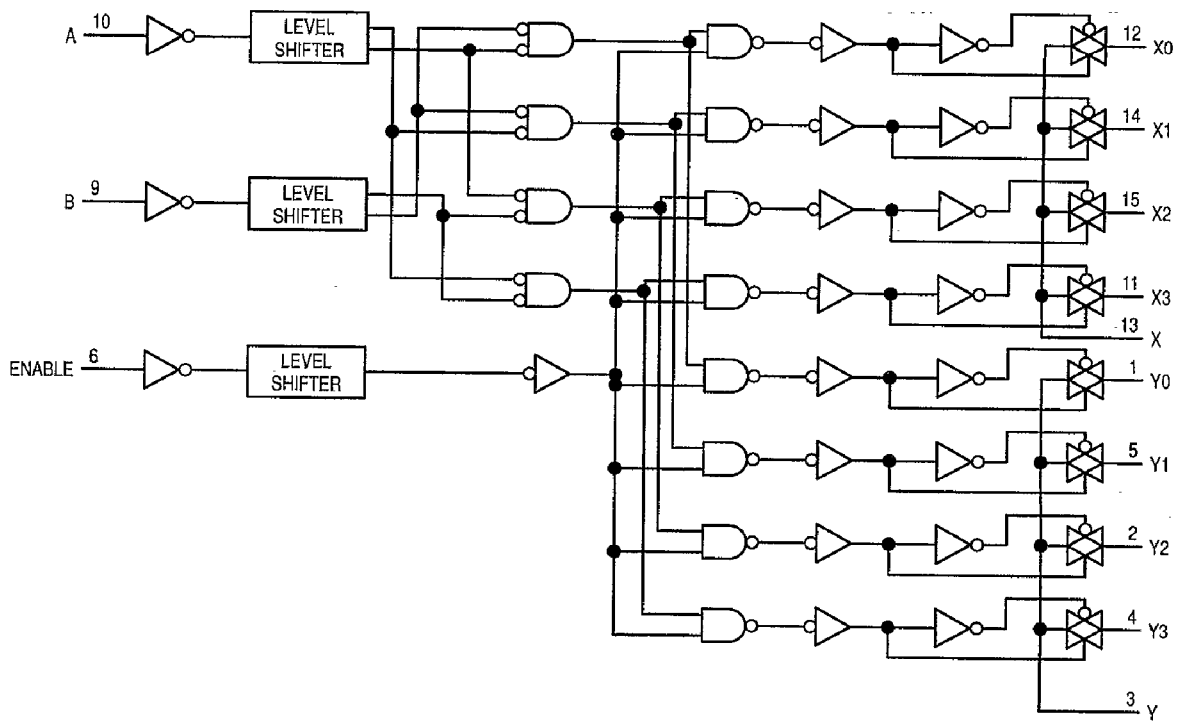


Figure 19. Function Diagram, HC4052

3

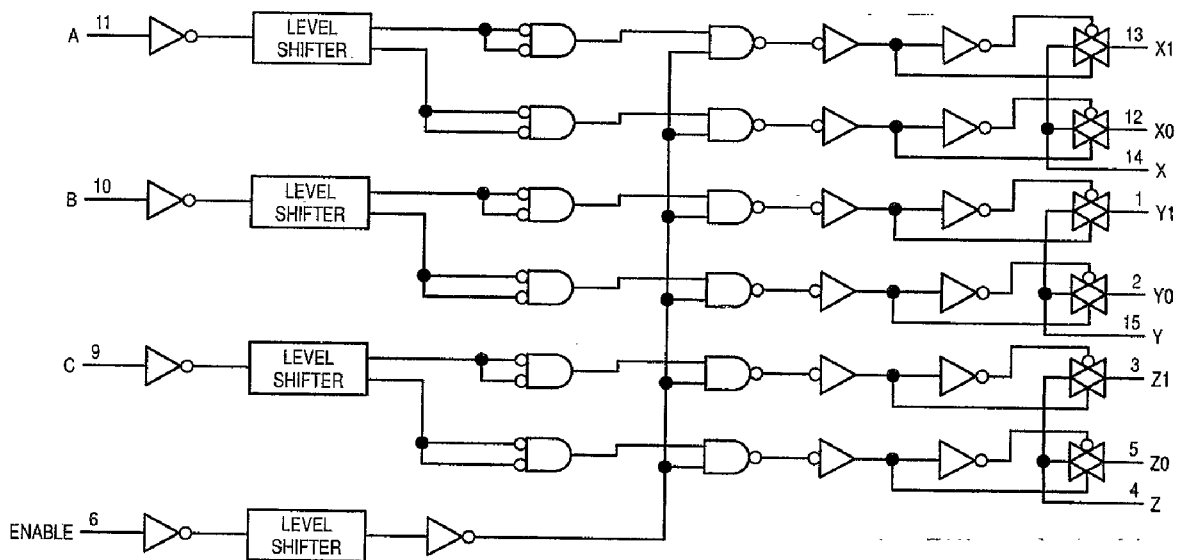


Figure 20. Function Diagram, HC4053