National Semiconductor

October 1995

74VHC4051
8-Channel Analog Multiplexer
74VHC4052
Dual 4-Channel Analog Multiplexer
74VHC4053
Triple 2-Channel Analog Multiplexer

General Description

These multiplexers are digitally controlled analog switches implemented in advanced silicon-gate CMOS technology. These switches have low ''on'' resistance and low ''off'' leakages. They are bidirectional switches, thus any analog input may be used as an output and vice-versa. Also these switches contain linearization circuitry which lowers the on resistance and increases switch linearity. These devices allow control of up to ±6V (peak) analog signals with digital control signals of 0 to 6V. Three supply pins are provided for V_{CC}, ground, and V_{EE}. This enables the connection of 0–5V logic signals when $V_{CC} = 5V$ and an analog input range of ±5V when $V_{EE} = 5V$. All three devices also have an inhibit control which when high will disable all switches to their off state. All analog inputs and outputs and digital inputs are protected from electrostatic damage by diodes to V_{CC} and ground.

74VHC4051: This device connects together the outputs of 8 switches, thus achieving an 8 channel Multiplexer. The binary code placed on the A, B, and C select lines determines which one of the eight switches is ''on'', and connects one of the eight inputs to the common output.

74VHC4052: This device connects together the outputs of 4 switches in two sets, thus achieving a pair of 4-channel multiplexers. The binary code placed on the A, and B select lines determine which switch in each 4 channel section is ''on'', connecting one of the four inputs in each section to its common output. This enables the implementation of a 4-channel differential multiplexer.

74VHC4053: This device contains 6 switches whose outputs are connected together in pairs, thus implementing a triple 2 channel multiplexer, or the equivalent of 3 single-pole-double throw configurations. Each of the A, B, or C select lines independently controls one pair of switches, selecting one of the two switches to be ''on''.

Features

- Wide analog input voltage range: ±6V
- Low ''on'' resistance: 50 typ. ($V_{CC}-V_{EE} = 4.5V$)
  30 typ. ($V_{CC}-V_{EE} = 9V$)
- Logic level translation to enable 5V logic with ±5V analog signals
- Low quiescent current: 80 μA maximum
- Matched Switch characteristic
- Pin and function compatible with the 74HC4051/4052/4053

Commercial	Package Number	Package Description
74VHC4051M	M16A	16-Lead Molded JEDEC SOIC (0.150″ Wide)
74VHC4051WM	M16B	16-Lead Molded JEDEC SOIC (0.300″ Wide)
74VHC4051N	N16E	16-Lead Molded DIP
74VHC4052M	M16A	16-Lead Molded JEDEC SOIC (0.150″ Wide)
74VHC4052WM	M16B	16-Lead Molded JEDEC SOIC (0.300″ Wide)
74VHC4052N	N16E	16-Lead Molded DIP
74VHC4053M	M16A	16-Lead Molded JEDEC SOIC (0.150″ Wide)
74VHC4053WM	M16B	16-Lead Molded JEDEC SOIC (0.300″ Wide)
74VHC4053N	N16E	16-Lead Molded DIP

Note: Surface mount packages are also available on Tape and Reel. Specify by appending the suffix letter ''X'' to the ordering code.

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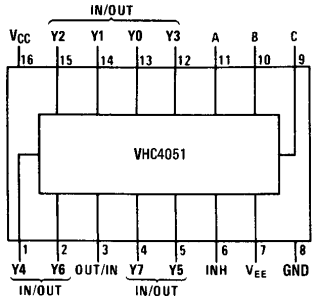
RRD-B30M125/Printed in U. S. A.

Connection Diagrams

Pin Assignments for SOIC and PDIP



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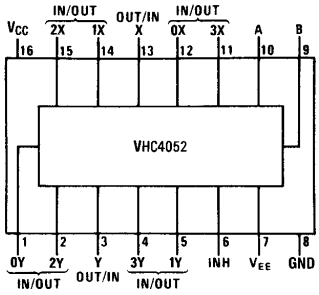
Top View



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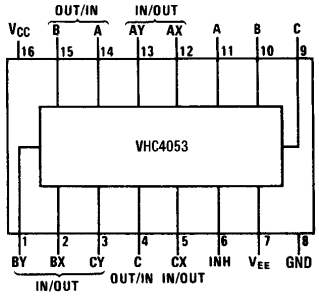
Top View



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Top View

Truth Tables

'4051

Input				"ON" Channel
Inh	C	B	A	
H	X	X	X	None
L	L	L	L	Y0
L	L	L	H	Y1
L	L	H	L	Y2
L	L	H	H	Y3
L	H	L	L	Y4
L	H	L	H	Y5
L	H	H	L	Y6
L	H	H	H	Y7

'4052

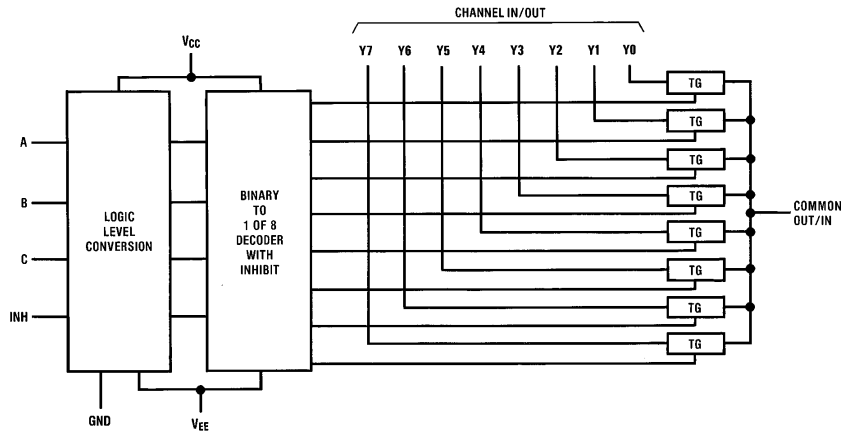
Inputs			"ON" Channels	
Inh	B	A	X	Y
H	X	X	None	None
L	L	L	0X	0Y
L	L	H	1X	1Y
L	H	L	2X	2Y
L	H	H	3X	3Y

'4053

Input				"ON" Channels		
Inh	C	B	A	C	b	a
H	X	X	X	None	None	None
L	L	L	L	CX	BX	AX
L	L	L	H	CX	BX	AY
L	L	H	L	CX	BY	AX
L	L	H	H	CX	BY	AY
L	H	L	L	CY	BX	AX
L	H	L	H	CY	BX	AY
L	H	H	L	CY	BY	AX
L	H	H	H	CY	BY	AY

Logic Diagrams

74VHC4051



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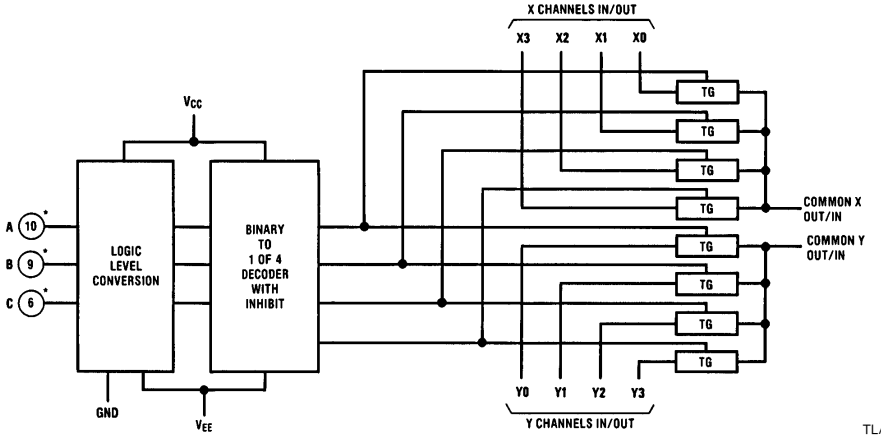
74VHC4052



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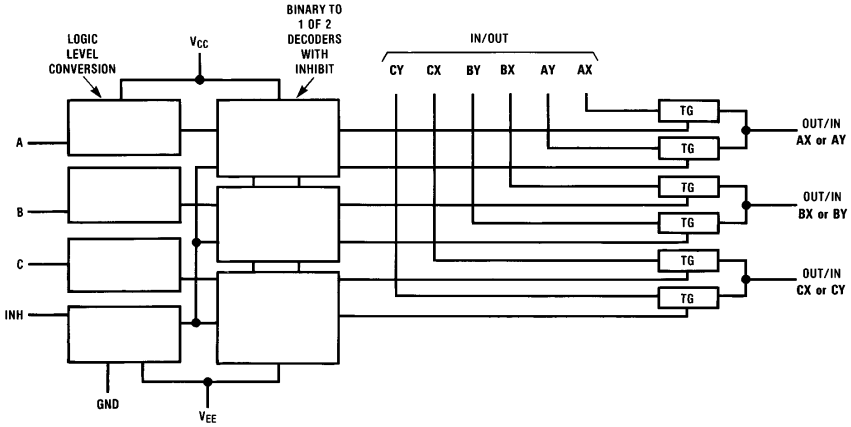
74VHC4053



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Absolute Maximum Ratings (Notes 1 & 2)

Supply Voltage (V_{CC})	−0.5 to +7.5V
Supply Voltage (V_{EE})	+0.5 to −7.5V
Control Input Voltage (V_{IN})	−1.5 to V_{CC} +1.5V
Switch I/O Voltage (V_{IO})	V_{EE} −0.5 to V_{CC} +0.5V
Clamp Diode Current (I_{IK}, I_{OK})	±20 mA
Output Current, per pin (I_{OUT})	±25 mA
V_{CC} or GND Current, per pin (I_{CC})	±50 mA
Storage Temperature Range (T_{STG})	−65°C to +150°C
Power Dissipation (P_D) (Note 3)	600 mW
S.O. Package only	500 mW
Lead Temp. (T_L) (Soldering 10 seconds)	260°C

Operating Conditions

	Min	Max	Units
Supply Voltage (V_{CC})	2	6	V
Supply Voltage (V_{EE})	0	−6	V
DC Input or Output Voltage (V_{IN}, V_{OUT})	0	V_{CC}	V
Operating Temp. Range (T_A) 74VHC	−40	+85	°C
Input Rise or Fall Times (t_r, t_f)	V_{CC} = 2.0V	1000	ns
	V_{CC} = 4.5V	500	ns
	V_{CC} = 6.0V	400	ns

DC Electrical Characteristics (Note 4)

Symbol	Parameter		Conditions	V_{EE}	V_{CC}	T_A = 25°C	74VHC T_A = −40 to 85°C	Units
						Typ	Guaranteed Limits	
V_{IH}	Minimum High Level Input Voltage				2.0V		1.5	1.5	V
					4.5V		3.15	3.15	V
					6.0V		4.2	4.2	V
V_{IL}	Maximum Low Level Input Voltage				2.0V		0.5	0.5	V
					4.5V		1.35	1.35	V
					6.0V		1.8	1.8	V
R_{ON}	Maximum "ON" Resistance (Note 5)		V_{INH} = V_{IL}, I_S = 2.0 mA	GND	4.5V	40	160	200	Ω
			V_{IS} = V_{CC} to V_{EE}	−4.5V	4.5V	30	120	150	Ω
			(Figure 1)	−6.0V	6.0V	20	100	125	Ω
			V_{INH} = V_{IL}, I_S = 2.0 mA	GND	2.0V	100	230	280	Ω
			V_{IS} = V_{CC} or V_{EE}	GND	4.5V	40	110	140	Ω
			(Figure 1)	−4.5V	4.5V	20	90	120	Ω
				−6.0V	6.0V	15	80	100	Ω
R_{ON}	Maximum "ON" Resistance Matching		V_{CTL} = V_{IL}	GND	4.5V	10	20	25	Ω
			V_{IS} = V_{CC} to GND	−4.5V	4.5V	5	10	15	Ω
				−6.0V	6.0V	5	10	12	Ω
I_N	Maximum Control Input Current		V_{IN} = V_{CC} or GND				±.05	±0.5	μA
			V_{CC} = 2–6V						
I_{CC}	Maximum Quiescent Supply Current		V_{IN} = V_{CC} or GND	GND	6.0V		4	40	μA
			I_{OUT} = 0 μA	−6.0V	6.0V		8	80	μA
I_{IZ}	Maximum Switch "OFF" Leakage Current (Switch Input)		V_{OS} = V_{CC} or V_{EE}	GND	6.0V		±60	±300	nA
			V_{IS} = V_{EE} or V_{CC}	−6.0V	6.0V		±100	±500	nA
			V_{INH} = V_{IH} *(Figure 2)*						
I_{IZ}	Maximum Switch "ON" Leakage Current	VHC4051	V_{IS} = V_{CC} to V_{EE}	GND	6.0V		±0.1	±1.0	μA
			V_{INH} = V_{IL}	−6.0V	6.0V		±0.2	±2.0	μA
			(Figure 3)						
		VHC4052	V_{IS} = V_{CC} to V_{EE}	GND	6.0V		±0.050	±0.5	μA
			V_{INH} = V_{IL}	−6.0V	6.0V		±0.1	±1.0	μA
			(Figure 3)						
		VHC4053	V_{IS} = V_{CC} to V_{EE}	GND	6.0V		±0.05	±0.5	μA
			V_{INH} = V_{IL}	−6.0V	6.0V		±0.5	±0.5	μA
			(Figure 3)						

DC Electrical Characteristics (Note 4) (Continued)

Symbol	Parameter		Conditions	V_{EE}	V_{CC}	$T_A = 25°C$		74VHC $T_A = -40$ to $85°C$	Units
						Typ	Guaranteed Limits		
I_{IZ}	Maximum Switch "OFF" Leakage Current (Common Pin)	VHC4051	$V_{OS} = V_{CC}$ or V_{EE} $V_{IS} = V_{EE}$ or V_{CC} $V_{INH} = V_{IH}$	GND −6.0V	6.0V 6.0V		±0.1 ±0.2	±1.0 ±2.0	μA μA
		VHC4052	$V_{OS} = V_{CC}$ or V_{EE} $V_{IS} = V_{EE}$ or V_{CC} $V_{INH} = V_{IH}$	GND −6.0V	6.0V 6.0V		±0.05 ±0.1	±0.5 ±1.0	μA μA
		VHC4053	$V_{OS} = V_{CC}$ or V_{EE} $V_{IS} = V_{EE}$ or V_{CC} $V_{INH} = V_{IH}$	GND −6.0V	6.0V 6.0V		±0.05 ±0.05	±0.5 ±0.5	μA μA

Note 1: Absolute Maximum Ratings are those values beyond which damage to the device may occur.

Note 2: Unless otherwise specified all voltages are referenced to ground.

Note 3: Power Dissipation temperature derating — plastic "N" package: −12 mW/°C from 65°C to 85°C.

Note 4: For a power supply of 5V ±10% the worst case on resistances (R_{ON}) occurs for VHC at 4.5V. Thus the 4.5V values should be used when designing with this supply. Worst case V_{IH} and V_{IL} occur at $V_{CC} = 5.5V$ and 4.5V respectively. (The V_{IH} value at 5.5V is 3.85V.) The worst case leakage current occur for CMOS at the higher voltage and so the 5.5V values should be used.

Note 5: At supply voltages ($V_{CC}-V_{EE}$) approaching 2V the analog switch on resistance becomes extremely non-linear. Therefore it is recommended that these devices be used to transmit digital only when using these supply voltages.

Note 6: Adjust 0 dB for f = 1 kHz (Null R1/R_{ON} Attenuation).

AC Electrical Characteristics $V_{CC} = 2.0V-6.0V$, $V_{EE} = 0V-6V$, $C_L = 50$ pF (unless otherwise specified)

Symbol	Parameter	Conditions		V_{EE}	V_{CC}	$T_A = 25°C$		74VHC $T_A = -40$ to $85°C$	Units
						Typ	Guaranteed Limits		
t_{PHL}, t_{PLH}	Maximum Propagation Delay Switch In to Out			GND GND −4.5V −6.0V	3.3V 4.5V 4.5V 6.0V	25 5 4 3	35 12 8 7	40 15 12 11	ns ns ns ns
t_{PZL}, t_{PZH}	Maximum Switch Turn "ON" Delay	$R_L = 1$ kΩ		GND GND −4.5V −6.0V	3.3V 4.5V 4.5V 6.0V	92 16 15	200 69 46 41	250 87 58 51	ns ns ns ns
t_{PHZ}, t_{PLZ}	Maximum Switch Turn "OFF" Delay			GND GND −4.5V −6.0V	3.3V 4.5V 4.5V 6.0V	65 28 18 16	170 58 37 32	210 73 46 41	ns ns ns ns
f_{MAX}	Minimum Switch Frequency Response 20 log (V_I/V_O) = 3 dB			GND −4.5V	4.5V 4.5V	30 35			MHz MHz
	Control to Switch Feedthrough Noise	$R_L = 600\Omega$, f = 1 MHz, $C_L = 50$ pF	V_{IS} = 4 V_{PP} V_{IS} = 8 V_{PP}	0V −4.5V	4.5V 4.5V	1080 250			mV mV
	Crosstalk between any Two Switches	$R_L = 600\Omega$, f = 1 MHz	$V_{IS} = 4$ V_{PP} $V_{IS} = 8$ V_{PP}	0V −4.5V	4.5 4.5V	−52 −50			dB dB
	Switch OFF Signal Feedthrough Isolation	$R_L = 600\Omega$, f = 1 MHz, $V_{CTL} = V_{IL}$	$V_{IS} = 4$ V_{PP} $V_{IS} = 8$ V_{PP}	0V −4.5V	4.5V 4.5V	−42 −44			dB dB
THD	Sinewave Harmonic Distortion	$R_L = 10$ kΩ, $C_L = 50$ pF, f = 1 kHz	$V_{IS} = 4$ V_{PP} $V_{IS} = 8$ V_{PP}	0V −4.5V	4.5V 4.5V	0.013 0.008			% %

AC Electrical Characteristics

V_{CC} = 2.0V–6.0V, V_{EE} = 0V–6V, C_L = 50 pF (unless otherwise specified) (Continued)

Symbol	Parameter	Conditions	V_{EE}	V_{CC}	T_A = 25°C		74VHC T_A = −40 to 85°C	Units
					Typ	Guaranteed Limits		
C_{IN}	Maximum Control Input Capacitance				5	10	10	pF
C_{IN}	Maximum Switch Input Capacitance	Input 4051 Common 4052 Common 4053 Common			15 90 45 30			pF
C_{IN}	Maximum Feedthrough Capacitance				5			pF

AC Test Circuits and Switching Time Waveforms

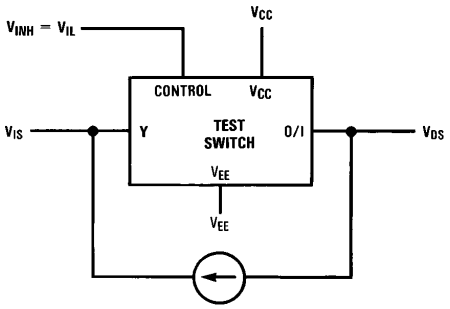

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FIGURE 1. "ON" Resistance

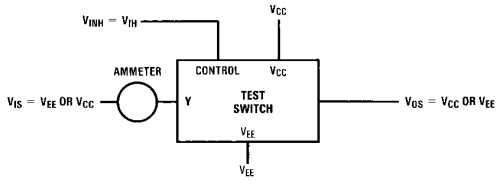

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FIGURE 2. "OFF" Channel Leakage Current

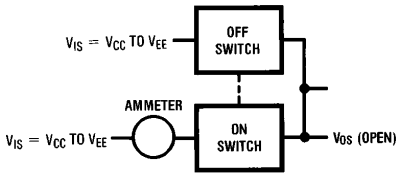

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FIGURE 3. "ON" Channel Leakage Current

AC Test Circuits and Switching Time Waveforms (Continued)

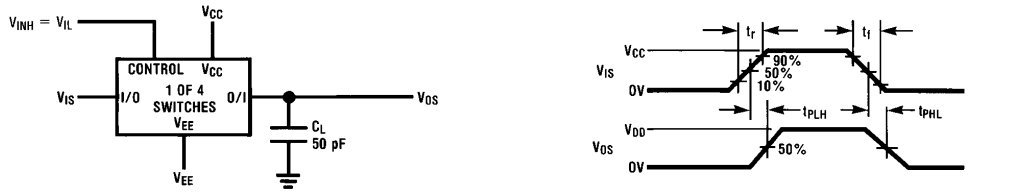

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FIGURE 4. t_{PHL}, t_{PLH} Propagation Delay Time Signal Input to Signal Output

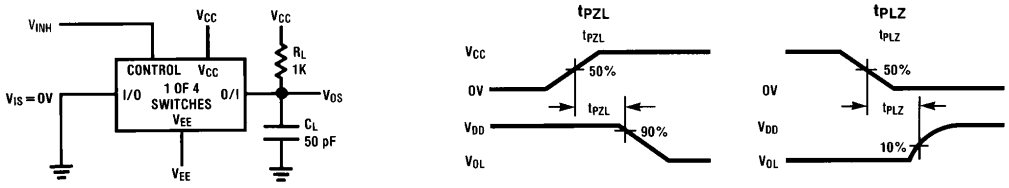

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FIGURE 5. t_{PZL}, t_{PLZ} Propagation Delay Time Control to Signal Output

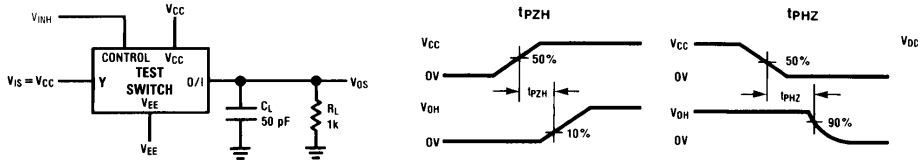

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FIGURE 6. t_{PZH}, t_{PHZ} Propagation Delay TIme Control to Signal Output

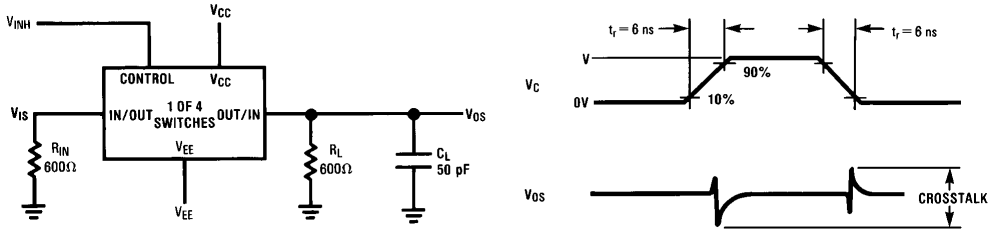

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FIGURE 7. Crosstalk: Control Input to Signal Output

AC Test Circuits and Switching Time Waveforms (Continued)

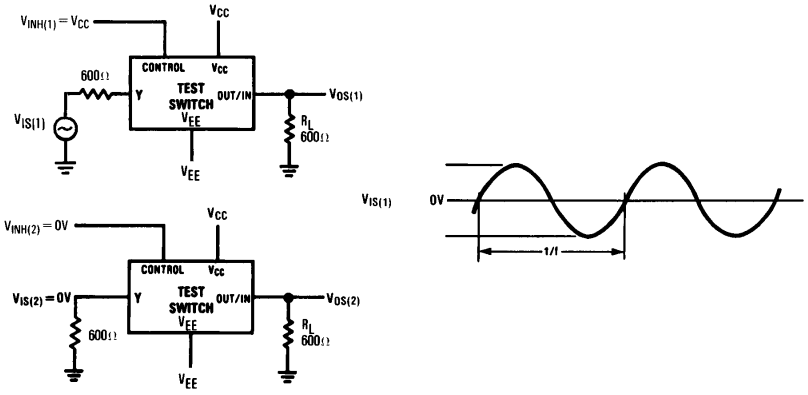

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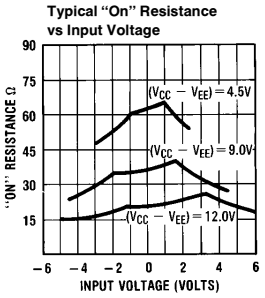
FIGURE 8. Crosstalk Between Any Two Switches

Typical Performance Characteristics



$V_{CC} = -V_{EE}$

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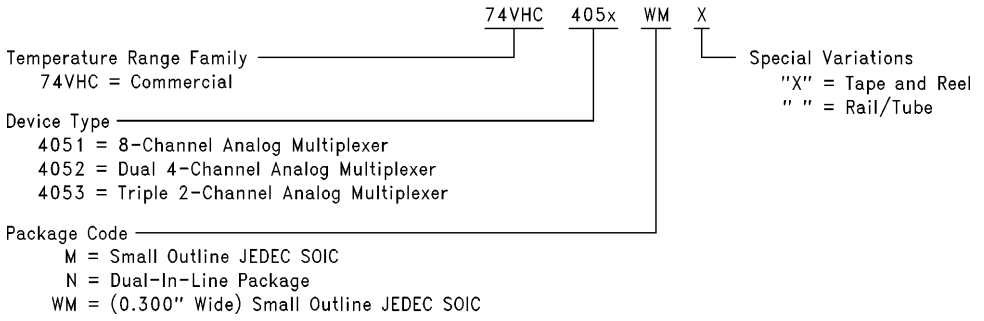
Special Considerations

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 analog switch pins, the voltage drop across the switch must not exceed 1.2V (calculated from the ON resistance).

Ordering Information

The device number is used to form part of a simplified purchasing code, where the package type and temperature range are defined as follows:



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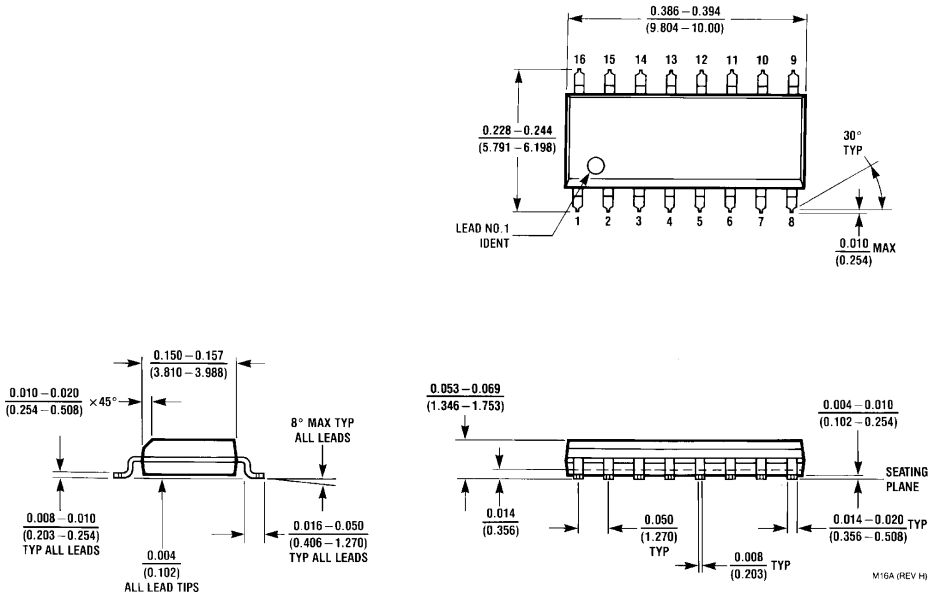
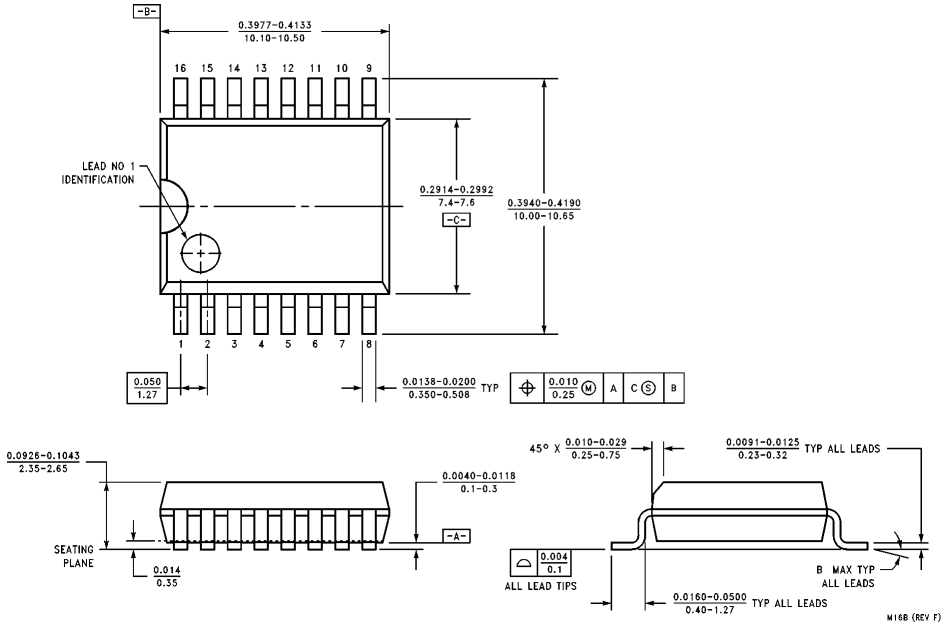
Physical Dimensions inches (millimeters)

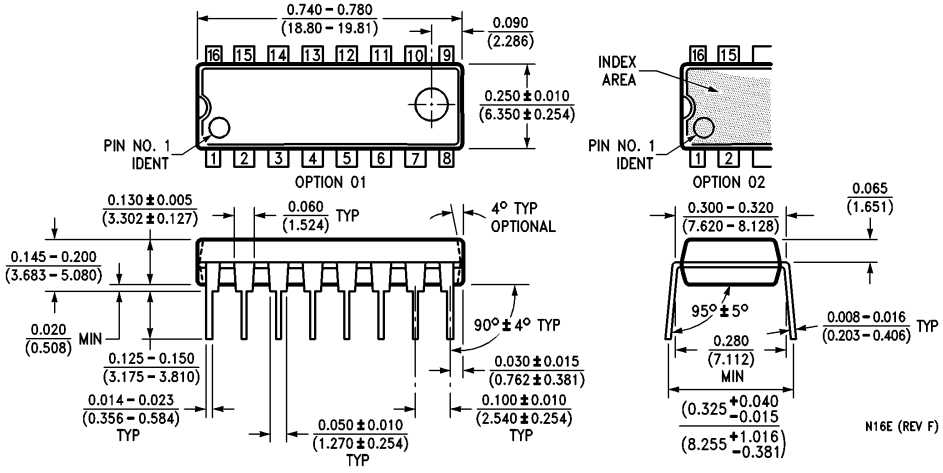


16-Lead (0.150″ Wide) Molded Small Outline Package, JEDEC
Ordering Number 74VHC4051M, 74VHC4052M or 74VHC4053M
NS Package Number M16A



16-Lead (0.300″ Wide) Molded Small Outline Package, JEDEC
Ordering Number 74VHC4051WM, 74VHC4052WM or 74VHC4053WM
NS Package Number M16B

Physical Dimensions inches (millimeters) (Continued)



16-Lead (0.300″ Wide) Molded Dual-In-Line Package
Order Number 74VHC4051N, 74VHC4052N or 74VHC4053N
NS Package Number N16E

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