

CMOS Analog Multiplexers/Demultiplexers with Logic Level Conversion

The CD4051B, CD4052B, and CD4053B analog multiplexers are digitally-controlled analog switches having low ON impedance and very low OFF leakage current. Control of analog signals up to 20V_{P-P} can be achieved by digital signal amplitudes of 4.5V to 20V (if $V_{DD}-V_{SS} = 3V$, a $V_{DD}-V_{EE}$ of up to 13V can be controlled; for $V_{DD}-V_{EE}$ level differences above 13V, a $V_{DD}-V_{SS}$ of at least 4.5V is required). For example, if $V_{DD} = +4.5V$, $V_{SS} = 0V$, and $V_{EE} = -13.5V$, analog signals from -13.5V to +4.5V can be controlled by digital inputs of 0V to 5V. These multiplexer circuits dissipate extremely low quiescent power over the full $V_{DD}-V_{SS}$ and $V_{DD}-V_{EE}$ supply-voltage ranges, independent of the logic state of the control signals. When a logic "1" is present at the inhibit input terminal, all channels are off.

The CD4051B is a single 8-Channel multiplexer having three binary control inputs, A, B, and C, and an inhibit input. The three binary signals select 1 of 8 channels to be turned on, and connect one of the 8 inputs to the output.

The CD4052B is a differential 4-Channel multiplexer having two binary control inputs, A and B, and an inhibit input. The two binary input signals select 1 of 4 pairs of channels to be turned on and connect the analog inputs to the outputs.

The CD4053B is a triple 2-Channel multiplexer having three separate digital control inputs, A, B, and C, and an inhibit input. Each control input selects one of a pair of channels which are connected in a single-pole, double-throw configuration.

When these devices are used as demultiplexers, the "CHANNEL IN/OUT" terminals are the outputs and the "COMMON OUT/IN" terminals are the inputs.

Features

- Wide Range of Digital and Analog Signal Levels
 - Digital 3V to 20V
 - Analog $\leq 20V_{P-P}$
- Low ON Resistance, 125 Ω (Typ) Over 15V_{P-P} Signal Input Range for $V_{DD}-V_{EE} = 18V$
- High OFF Resistance, Channel Leakage of $\pm 100pA$ (Typ) at $V_{DD}-V_{EE} = 18V$
- Logic-Level Conversion for Digital Addressing Signals of 3V to 20V ($V_{DD}-V_{SS} = 3V$ to 20V) to Switch Analog Signals to 20V_{P-P} ($V_{DD}-V_{EE} = 20V$)
- Matched Switch Characteristics, $r_{ON} = 5\Omega$ (Typ) for $V_{DD}-V_{EE} = 15V$
- Very Low Quiescent Power Dissipation Under All Digital-Control Input and Supply Conditions, 0.2 μW (Typ) at $V_{DD}-V_{SS} = V_{DD}-V_{EE} = 10V$
- Binary Address Decoding on Chip
- 5V, 10V and 15V Parametric Ratings
- 10% Tested for Quiescent Current at 20V
- Maximum Input Current of 1 μA at 18V Over Full Package Temperature Range, 100nA at 18V and 25°C
- Break-Before-Make Switching Eliminates Channel Overlap

Applications

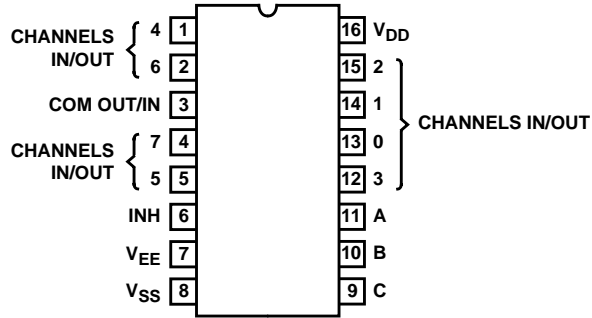
- Analog and Digital Multiplexing and Demultiplexing
- A/D and D/A Conversion
- Signal Gating

Ordering Information

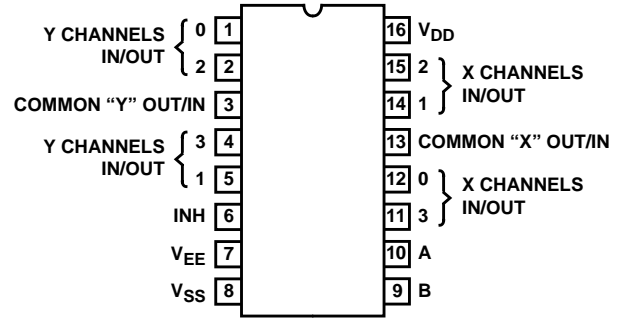
PART NUMBER	TEMP. RANGE (°C)	PACKAGE
CD4051BF, CD4052BF, CD4053BF	-55 to 125	16 Ld CERAMIC DIP
CD4051BE, CD4052BE, CD4053BE	-55 to 125	16 Ld PDIP
CD4051BM, CD4051BNS	-55 to 125	16 Ld SOIC
CD4051BPW, CD4052BPW, CD4053BPW	-55 to 125	16 Ld TSSOP

Pinouts

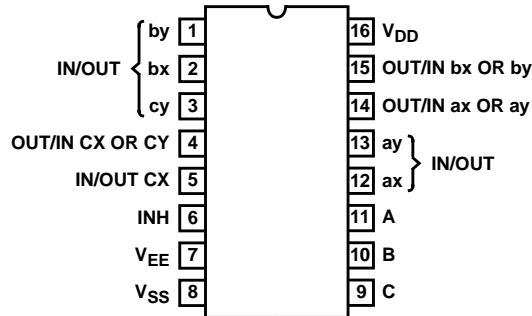
CD4051B (PDIP, CDIP, SOIC, TSSOP)
TOP VIEW



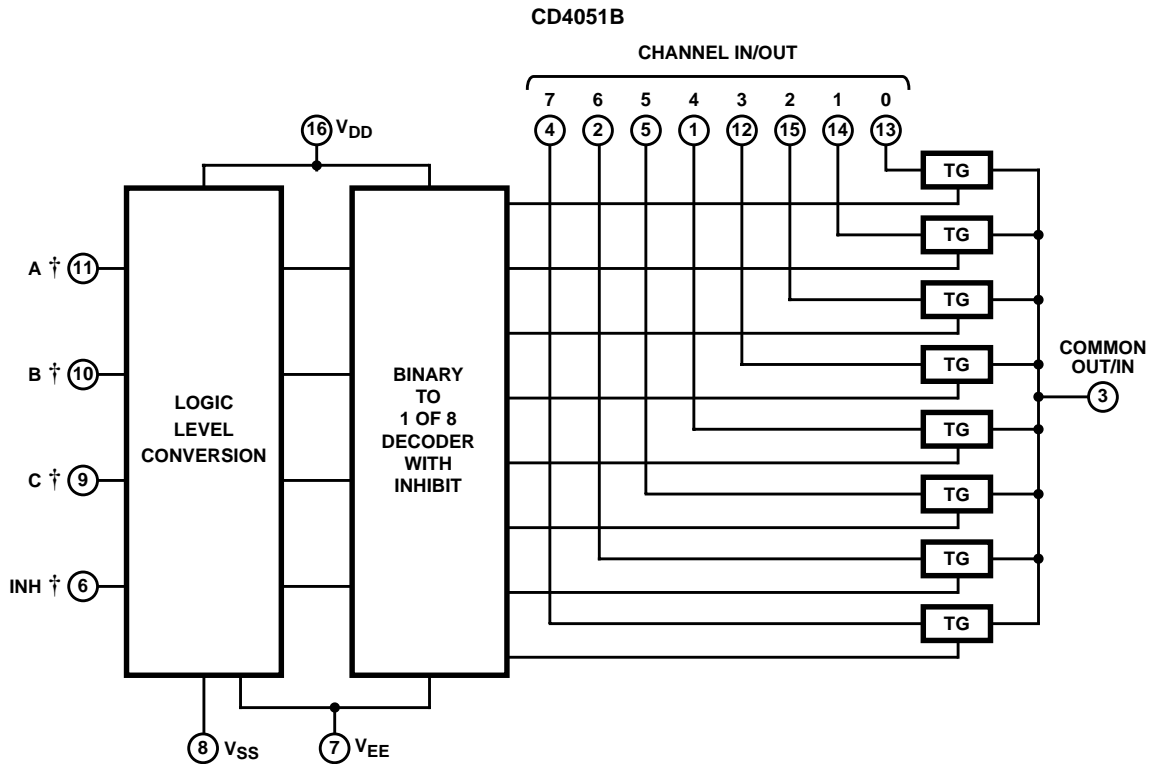
CD4052B (PDIP, CDIP, TSSOP)
TOP VIEW



CD4053B (PDIP, CDIP, TSSOP)
TOP VIEW



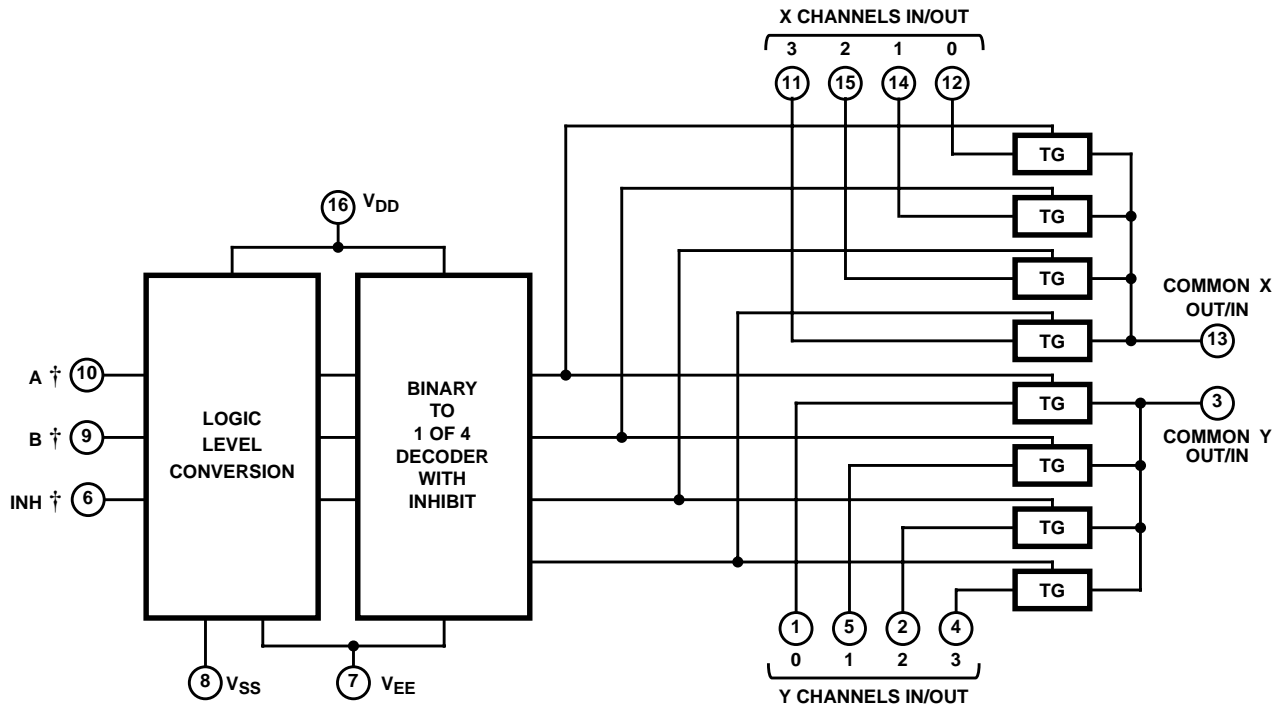
Functional Block Diagrams



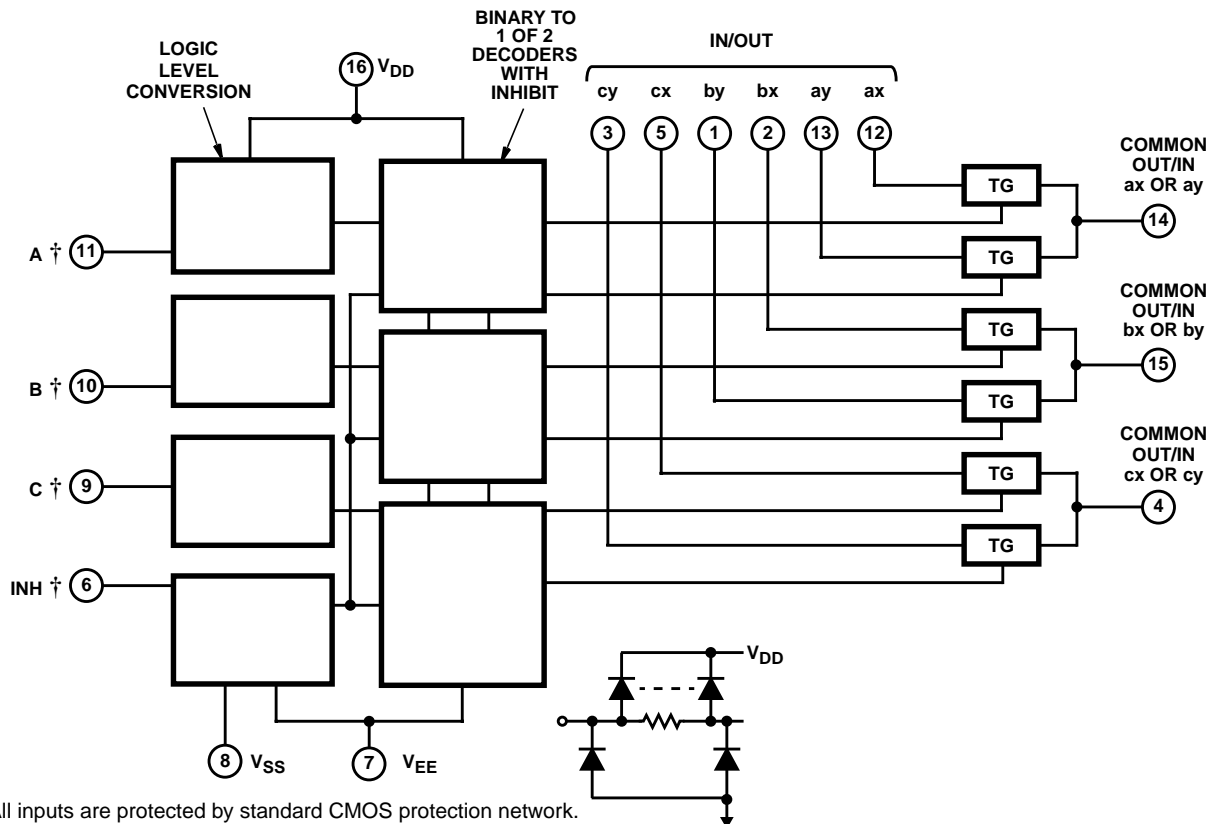
† All inputs are protected by standard CMOS protection network.

Functional Block Diagrams (Continued)

CD4052B



CD4053B



† All inputs are protected by standard CMOS protection network.

CD4051B, CD4052B, CD4053B**TRUTH TABLES**

INPUT STATES				“ON” CHANNEL(S)
INHIBIT	C	B	A	
CD4051B				
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	X	X	X	None
CD4052B				
INHIBIT	B		A	
0	0		0	0x, 0y
0	0		1	1x, 1y
0	1		0	2x, 2y
0	1		1	3x, 3y
1	X		X	None
CD4053B				
INHIBIT	A OR B OR C			
0	0			ax or bx or cx
0	1			ay or by or cy
1	X			None

X = Don't Care

CD4051B, CD4052B, CD4053B

Absolute Maximum Ratings

Supply Voltage (V+ to V-)

Voltages Referenced to V_{SS} Terminal -0.5V to 20V

DC Input Voltage Range -0.5V to V_{DD} +0.5V

DC Input Current, Any One Input. ±10mA

Operating Conditions

Temperature Range -55°C to 125°C

Thermal Information

Thermal Resistance (Typical, Note 1)

θ_{JA} (°C/W)

θ_{JC} (°C/W)

E Package 67

67

N/A

F Package 115

115

45

D Package 73

73

N/A

NS Package 64

64

N/A

PW Package 108

108

N/A

Maximum Junction Temperature (Ceramic Package) 175°C

Maximum Junction Temperature (Plastic Package) 150°C

Maximum Storage Temperature Range -65°C to 150°C

Maximum Lead Temperature (Soldering 10s) 265°C

(SOIC - Lead Tips Only)


CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTE:

1. The package thermal impedance is calculated in accordance with JESD51.

Electrical Specifications

Common Conditions Here: If Whole Table is For the Full Temp. Range, V_{SUPPLY} = ±5V, A_V = +1, R_L = 100Ω, Unless Otherwise Specified (Note 3)

PARAMETER	CONDITIONS				LIMITS AT INDICATED TEMPERATURES (°C)							UNITS
	V _{IS} (V)	V _{EE} (V)	V _{SS} (V)	V _{DD} (V)	-55	-40	85	125	25			
									MIN	TYP	MAX	
SIGNAL INPUTS (V _{IS}) AND OUTPUTS (V _{OS})												
Quiescent Device Current, I _{DD} Max	-	-	-	5	5	5	150	150	-	0.04	5	μA
	-	-	-	10	10	10	300	300	-	0.04	10	μA
	-	-	-	15	20	20	600	600	-	0.04	20	μA
	-	-	-	20	100	100	3000	3000	-	0.08	100	μA
Drain to Source ON Resistance r _{ON} Max 0 ≤ V _{IS} ≤ V _{DD}	-	0	0	5	800	850	1200	1300	-	470	1050	Ω
	-	0	0	10	310	330	520	550	-	180	400	Ω
	-	0	0	15	200	210	300	320	-	125	240	Ω
Change in ON Resistance (Between Any Two Channels), Δr _{ON}	-	0	0	5	-	-	-	-	-	15	-	Ω
	-	0	0	10	-	-	-	-	-	10	-	Ω
	-	0	0	15	-	-	-	-	-	5	-	Ω
OFF Channel Leakage Current: Any Channel OFF (Max) or ALL Channels OFF (Common OUT/IN) (Max)	-	0	0	18	±100 (Note 2)		±1000 (Note 2)		-	±0.01	±100 (Note 2)	nA
Capacitance:	-	-5	5-	5								
Input, C _{IS}					-	-	-	-	-	5	-	pF
Output, C _{OS}												
CD4051					-	-	-	-	-	30	-	pF
CD4052					-	-	-	-	-	18	-	pF
CD4053					-	-	-	-	-	9	-	pF
Feedthrough C _{IOS}												
	-	-	-	-	-	-	-	-	-	0.2	-	pF
Propagation Delay Time (Signal Input to Output)		R _L = 200kΩ, C _L = 50pF, t _r , t _f = 20ns	5	-	-	-	-	-	-	30	60	ns
			10	-	-	-	-	-	-	15	30	ns
			15	-	-	-	-	-	-	10	20	ns

CD4051B, CD4052B, CD4053B

Electrical Specifications Common Conditions Here: If Whole Table is For the Full Temp. Range, $V_{\text{SUPPLY}} = \pm 5\text{V}$, $A_V = +1$, $R_L = 100\Omega$, Unless Otherwise Specified **(Continued)** (Note 3)

PARAMETER	CONDITIONS				LIMITS AT INDICATED TEMPERATURES (°C)							UNITS
	V _{IS} (V)	V _{EE} (V)	V _{SS} (V)	V _{DD} (V)	-55	-40	85	125	25			
									MIN	TYP	MAX	
CONTROL (ADDRESS OR INHIBIT), V _C												
Input Low Voltage, V _{IL} , Max	V _{IL} = V _{DD} through 1kΩ; V _{IH} = V _{DD} through 1kΩ	V _{EE} = V _{SS} , R _L = 1kΩ to V _{SS} , I _{IS} < 2μA on All OFF Channels	5	1.5	1.5	1.5	1.5	-	-	1.5	V	
			10	3	3	3	3	-	-	3	V	
			15	4	4	4	4	-	-	4	V	
Input High Voltage, V _{IH} , Min			5	3.5	3.5	3.5	3.5	3.5	-	-	V	
			10	7	7	7	7	7	-	-	V	
			15	11	11	11	11	11	-	-	V	
Input Current, I _{IN} (Max)	V _{IN} = 0, 18		18	±0.1	±0.1	±1	±1	-	±10 ⁻⁵	±0.1	μA	
Propagation Delay Time: Address-to-Signal OUT (Channels ON or OFF) See Figures 10, 11, 14	t _r , t _f = 20ns, C _L = 50pF, R _L = 10kΩ	0	0	5	-	-	-	-	-	450	720	ns
		0	0	10	-	-	-	-	-	160	320	ns
		0	0	15	-	-	-	-	-	120	240	ns
		-5	0	5	-	-	-	-	-	225	450	ns
Propagation Delay Time: Inhibit-to-Signal OUT (Channel Turning ON) See Figure 11	t _r , t _f = 20ns, C _L = 50pF, R _L = 1kΩ	0	0	5	-	-	-	-	-	400	720	ns
		0	0	10	-	-	-	-	-	160	320	ns
		0	0	15	-	-	-	-	-	120	240	ns
		-10	0	5	-	-	-	-	-	200	400	ns
Propagation Delay Time: Inhibit-to-Signal OUT (Channel Turning OFF) See Figure 15	t _r , t _f = 20ns, C _L = 50pF, R _L = 10kΩ	0	0	5	-	-	-	-	-	200	450	ns
		0	0	10	-	-	-	-	-	90	210	ns
		0	0	15	-	-	-	-	-	70	160	ns
		-10	0	5	-	-	-	-	-	130	300	ns
Input Capacitance, C _{IN} (Any Address or Inhibit Input)					-	-	-	-	-	5	7.5	pF

NOTE:

- Determined by minimum feasible leakage measurement for automatic testing.

Electrical Specifications

PARAMETER	TEST CONDITIONS					LIMITS	UNITS
	V _{IS} (V)	V _{DD} (V)	R _L (kΩ)			TYP	
Cutoff (-3dB) Frequency Channel ON (Sine Wave Input)	5 (Note 3)	10	1	V _{OS} at Common OUT/IN	CD4053	30	MHz
	V _{EE} = V _{SS} , $20\text{Log} \frac{V_{\text{OS}}}{V_{\text{IS}}} = -3\text{dB}$				CD4052	25	MHz
					CD4051	20	MHz
				V _{OS} at Any Channel		60	MHz

Electrical Specifications

PARAMETER	TEST CONDITIONS				LIMITS		UNITS
	V _{IS} (V)	V _{DD} (V)	R _L (kΩ)			TYP	
Total Harmonic Distortion, THD	2 (Note 3)	5	10			0.3	%
	3 (Note 3)	10				0.2	%
	5 (Note 3)	15				0.12	%
	V _{EE} = V _{SS} , f _{IS} = 1kHz Sine Wave					%	
-40dB Feedthrough Frequency (All Channels OFF)	5 (Note 3)	10	1	V _{OS} at Common OUT/IN	CD4053	8	MHz
	V _{EE} = V _{SS} , $20\text{Log}\frac{V_{OS}}{V_{IS}} = -40\text{dB}$				CD4052	10	MHz
				CD4051	12	MHz	
		V _{OS} at Any Channel					8
-40dB Signal Crosstalk Frequency	5 (Note 3)	10	1	Between Any 2 Channels		3	MHz
	V _{EE} = V _{SS} , $20\text{Log}\frac{V_{OS}}{V_{IS}} = -40\text{dB}$		Between Sections, CD4052 Only	Measured on Common	6	MHz	
				Measured on Any Chan- nel	10	MHz	
			Between Any Two Sections, CD4053 Only	In Pin 2, Out Pin 14	2.5	MHz	
				In Pin 15, Out Pin 14	6	MHz	
Address-or-Inhibit-to-Signal Crosstalk	-	10	10 (Note 4)			65	mV _{PEAK}
	V _{EE} = 0, V _{SS} = 0, t _r , t _f = 20ns, V _{CC} = V _{DD} - V _{SS} (Square Wave)					65	mV _{PEAK}

NOTES:

- Peak-to-Peak voltage symmetrical about $\frac{V_{DD} - V_{EE}}{2}$
- Both ends of channel.

Typical Performance Curves

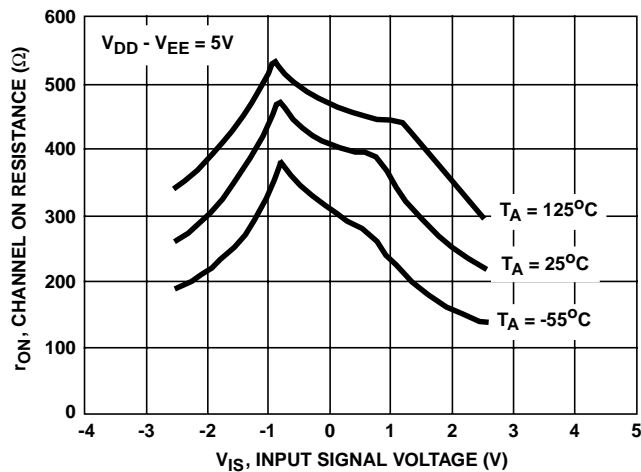


FIGURE 1. CHANNEL ON RESISTANCE vs INPUT SIGNAL VOLTAGE (ALL TYPES)

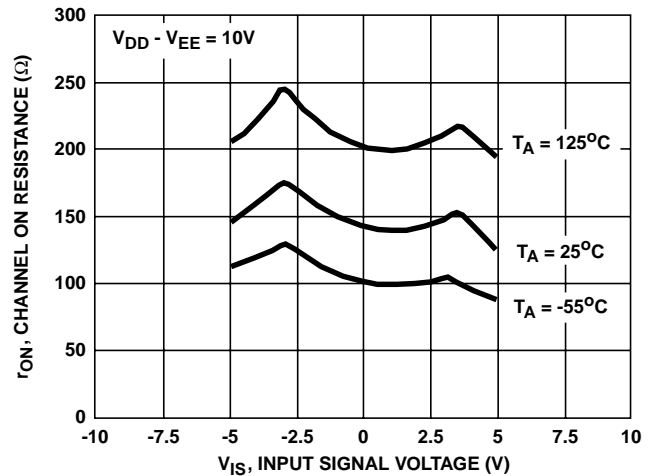


FIGURE 2. CHANNEL ON RESISTANCE vs INPUT SIGNAL VOLTAGE (ALL TYPES)

Typical Performance Curves (Continued)

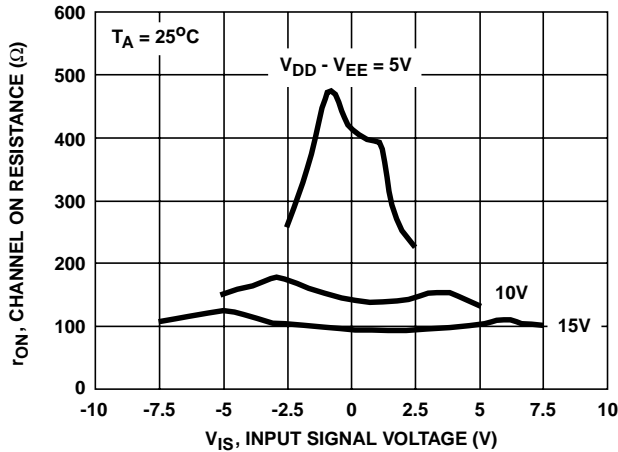


FIGURE 3. CHANNEL ON RESISTANCE vs INPUT SIGNAL VOLTAGE (ALL TYPES)

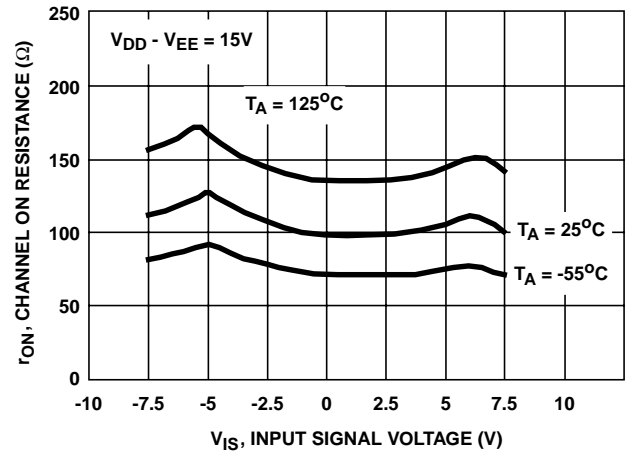


FIGURE 4. CHANNEL ON RESISTANCE vs INPUT SIGNAL VOLTAGE (ALL TYPES)

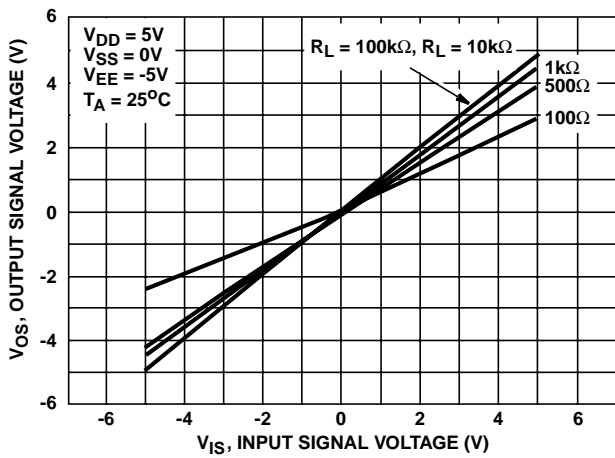


FIGURE 5. ON CHARACTERISTICS FOR 1 OF 8 CHANNELS (CD4051B)

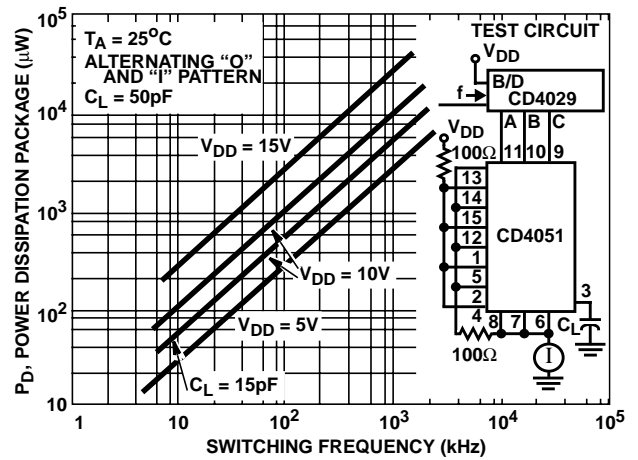


FIGURE 6. DYNAMIC POWER DISSIPATION vs SWITCHING FREQUENCY (CD4051B)

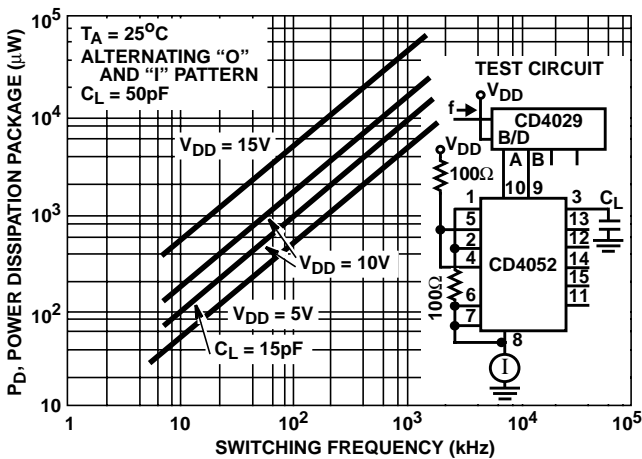


FIGURE 7. DYNAMIC POWER DISSIPATION vs SWITCHING FREQUENCY (CD4052B)

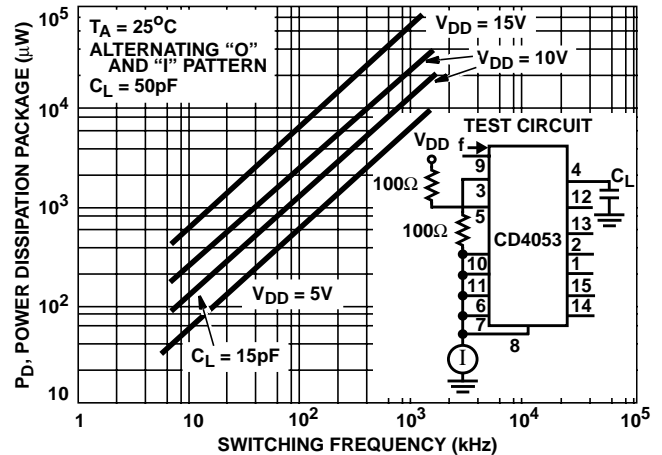
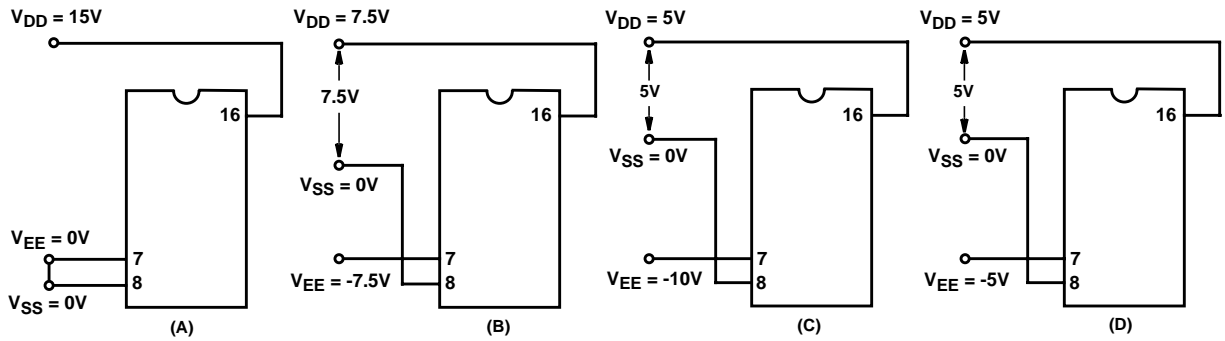


FIGURE 8. DYNAMIC POWER DISSIPATION vs SWITCHING FREQUENCY (CD4053B)

Test Circuits and Waveforms



NOTE: The ADDRESS (digital-control inputs) and INHIBIT logic levels are: "0" = V_{SS} and "1" = V_{DD} . The analog signal (through the TG) may swing from V_{EE} to V_{DD} .

FIGURE 9. TYPICAL BIAS VOLTAGES

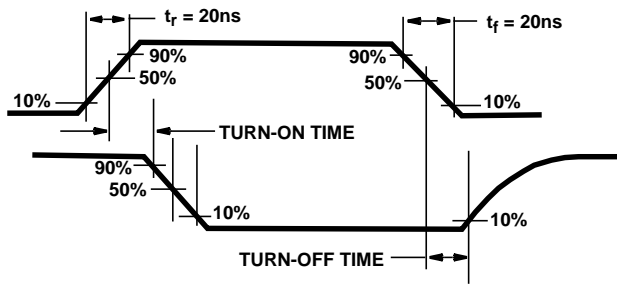


FIGURE 10. WAVEFORMS, CHANNEL BEING TURNED ON ($R_L = 1\text{k}\Omega$)

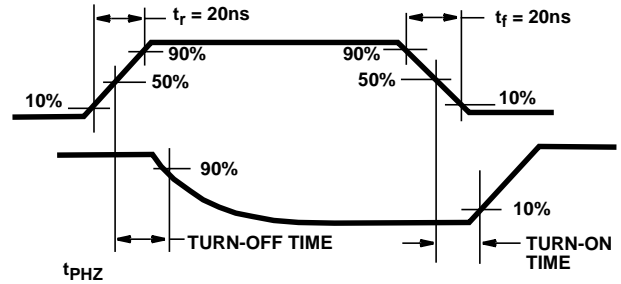


FIGURE 11. WAVEFORMS, CHANNEL BEING TURNED OFF ($R_L = 1\text{k}\Omega$)

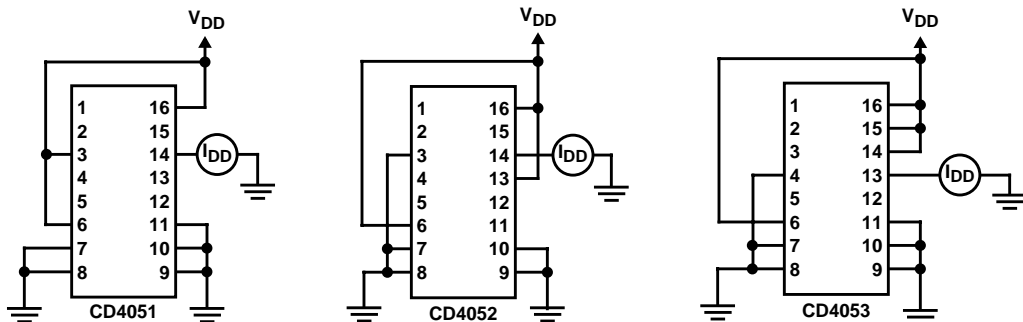


FIGURE 12. OFF CHANNEL LEAKAGE CURRENT - ANY CHANNEL OFF

Test Circuits and Waveforms (Continued)

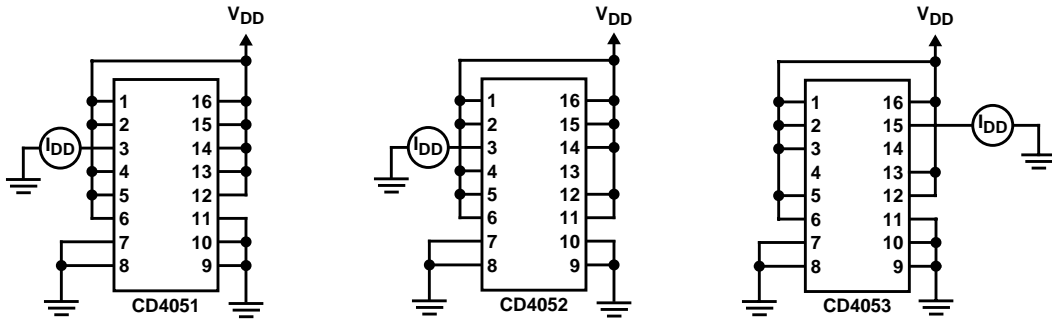


FIGURE 13. OFF CHANNEL LEAKAGE CURRENT - ALL CHANNELS OFF

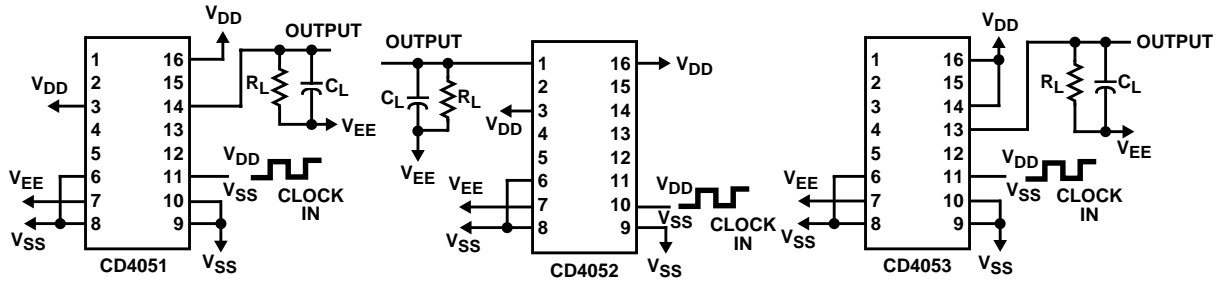


FIGURE 14. PROPAGATION DELAY - ADDRESS INPUT TO SIGNAL OUTPUT

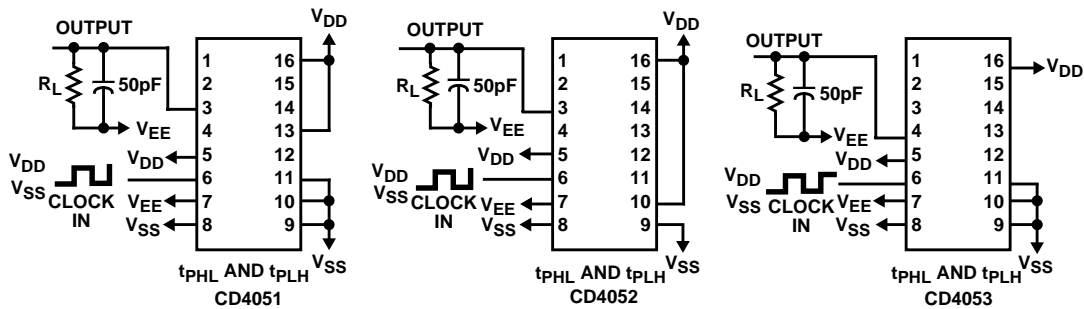


FIGURE 15. PROPAGATION DELAY - INHIBIT INPUT TO SIGNAL OUTPUT

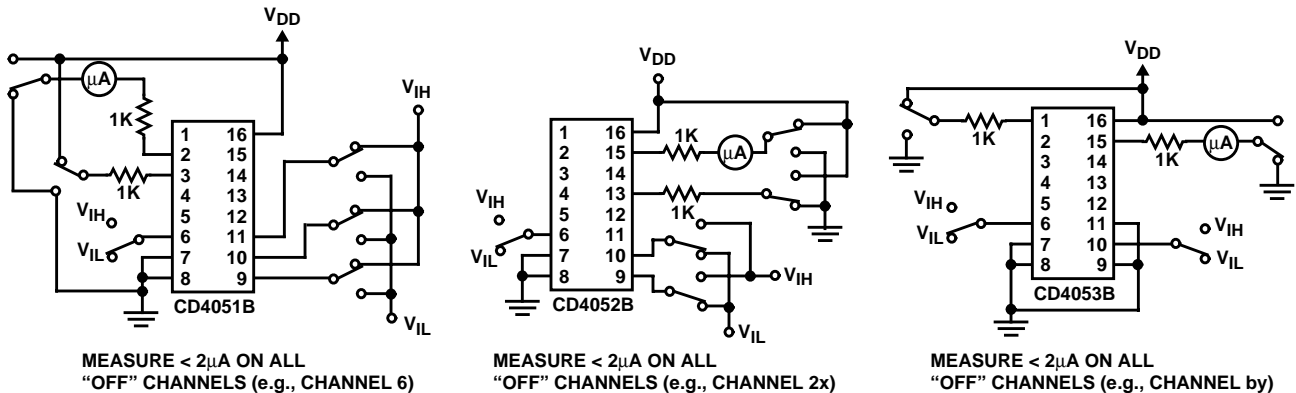


FIGURE 16. INPUT VOLTAGE TEST CIRCUITS (NOISE IMMUNITY)

Test Circuits and Waveforms (Continued)

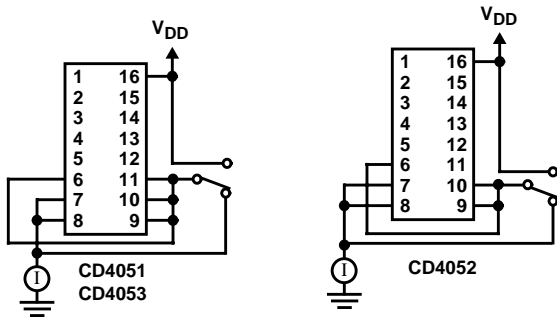


FIGURE 17. QUIESCENT DEVICE CURRENT

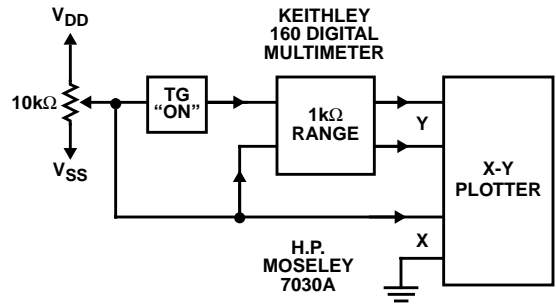


FIGURE 18. CHANNEL ON RESISTANCE MEASUREMENT CIRCUIT

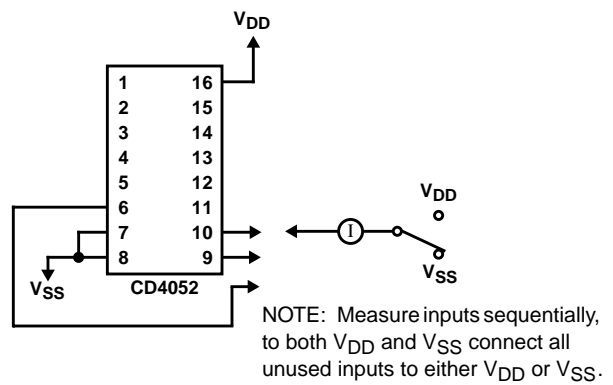
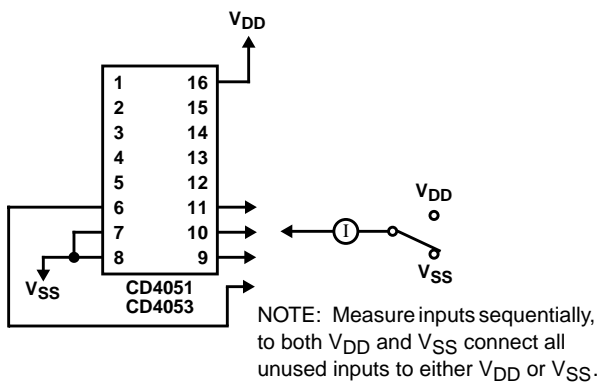


FIGURE 19. INPUT CURRENT

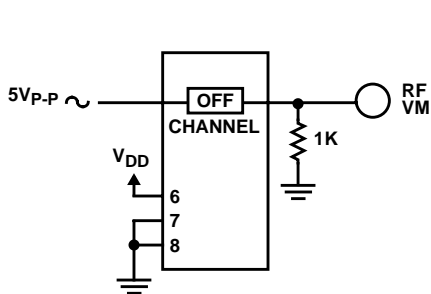


FIGURE 20. FEEDTHROUGH (ALL TYPES)

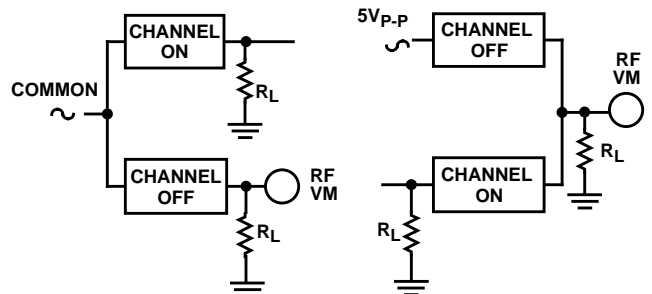


FIGURE 21. CROSSTALK BETWEEN ANY TWO CHANNELS (ALL TYPES)

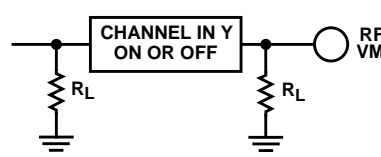
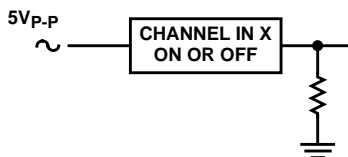


FIGURE 22. CROSSTALK BETWEEN DUALS OR TRIPLETS (CD4052B, CD4053B)

Test Circuits and Waveforms (Continued)

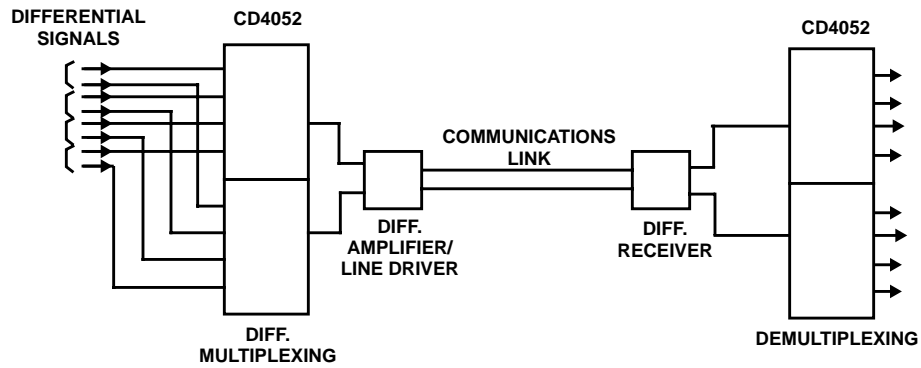


FIGURE 23. TYPICAL TIME-DIVISION APPLICATION OF THE CD4052B

Special Considerations

In applications where separate power sources are used to drive V_{DD} and the signal inputs, the V_{DD} current capability should exceed V_{DD}/R_L (R_L = effective external load). This provision avoids permanent current flow or clamp action on the V_{DD} supply when power is applied or removed from the CD4051B, CD4052B or CD4053B.

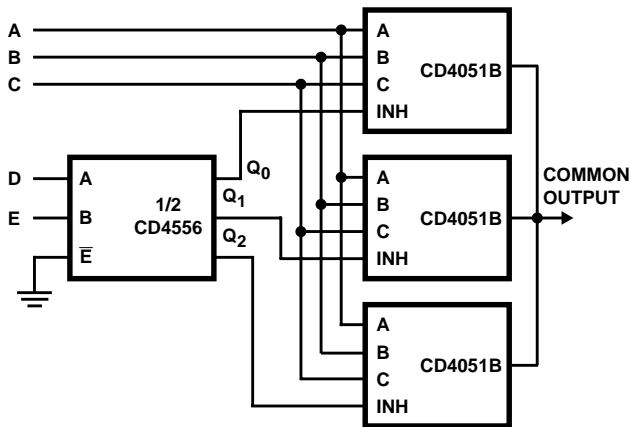


FIGURE 24. 24-TO-1 MUX ADDRESSING

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CD4051 - <http://www.ti.com/product/cd4051?HQS=TI-null-null-dscatalog-df-pf-null-ww>

CD4051BNS - <http://www.ti.com/product/cd4051bns?HQS=TI-null-null-dscatalog-df-pf-null-ww>