CD74HC4051-Q1 Automotive Analog Multiplexer or Demultiplexer

1 Features

- Qualified for automotive applications
- Wide analog input voltage range of ± 5V maximum
- Low ON resistance:
  - 70Ω typical (V_{CC} − V_{EE} = 4.5V)
  - 40Ω typical (V_{CC} − V_{EE} = 9V)
- Low crosstalk between switches
- Fast switching and propagation speeds
- Break-before-make switching
- Operation control voltage = 2V to 6V
- Switch voltage = 0V to 10V
- High noise immunity N_{IL} = 30%, N_{IH} = 30% of V_{CC} , V_{CC} = 5V

2 Applications

- Digital radio
- Signal gating
- Factory automation
- Televisions
- Appliances
- Programmable logic circuits
- Sensors

3 Description

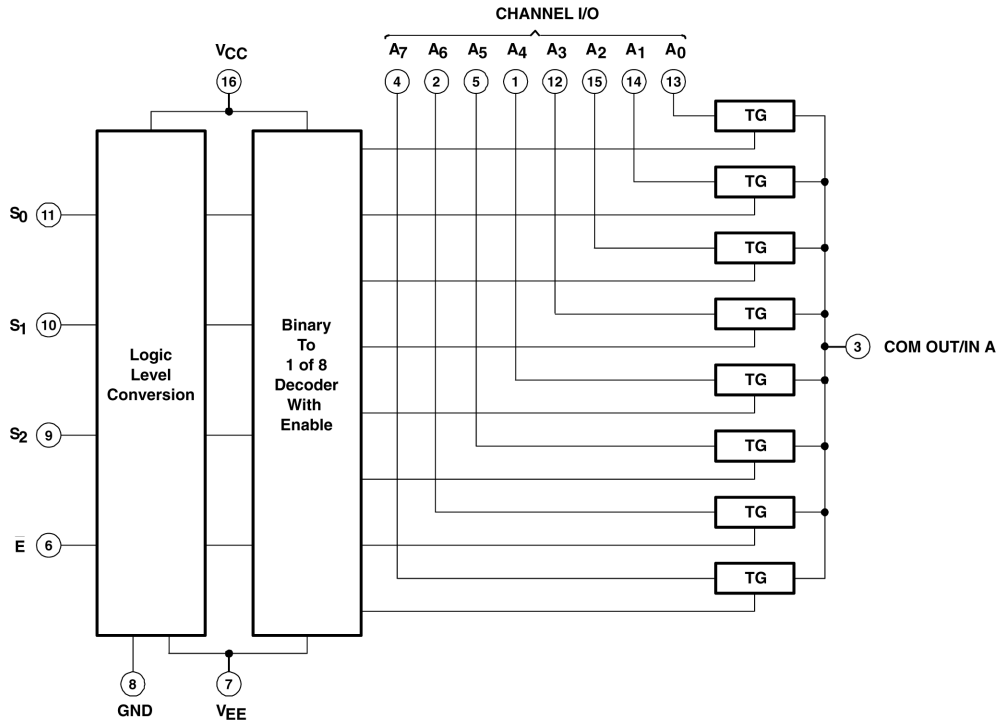
This device is a digitally controlled analog switch that utilizes silicon-gate CMOS technology to achieve operating speeds similar to LSTTL, with the low power consumption of standard CMOS integrated circuits.

This analog multiplexer/demultiplexer controls analog voltages that may vary across the voltage supply range (for example, V_{CC} to V_{EE}). These bidirectional switches allow any analog input to be used as an output and vice versa. The switches have low ON resistance and low OFF leakages. In addition, the device has an enable control ($\overline{E}$) that, when high, disables all switches to their OFF state.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
CD74HC4051-Q1	PW (TSSOP, 16)	5mm × 6.4mm
	D (SOIC, 16)	9.9mm × 3.9mm

(1) For more information see, Section 10
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Logic Diagram (Positive Logic)

Table of Contents

4 Pin Configuration and Functions

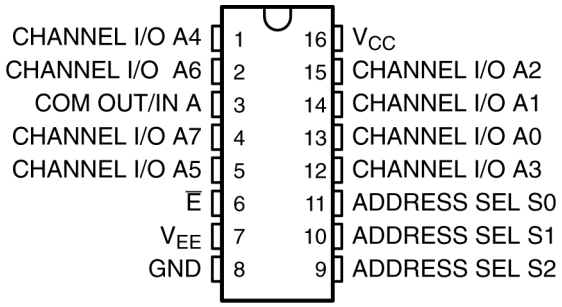


Figure 4-1. PW, D Package, 16-Pin TSSOP, SOIC (Top View)

Table 4-1. Function Table

INPUTS				ON CHANNEL(S)
E	S_2	S_1	S_0	
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

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

			MIN	MAX	UNIT
V_{CC} − V_{EE} (see (2))	Supply voltage range		−0.5	10.5	V
V_{CC}	Supply voltage range		−0.5	7	V
V_{EE}	Supply voltage range		+0.5	−7	V
I_{IK} (V_I < −0.5V or V_I > V_{CC} + 0.5V)	Input clamp current			±20	mA
I_{OK} (V_O < V_{EE} − 0.5V or V_O > V_{CC} + 0.5V)	Output clamp current			±20	mA
(V_I > V_{EE} − 0.5V or V_I < V_{CC} + 0.5V)	Switch current			±25	mA
	Continuous current through V_{CC} or GND			±50	mA
I_{EE}	V_{EE} current			−20	mA
$R_{\theta JA}$	Package thermal impedance	D package		91.6	°C/W
		PW package		116.5	°C/W
T_J	Maximum junction temperature			150	°C
Lead temperature (during soldering):		At distance 1/16 ± 1/32 inch (1,59 ± 0,79 mm) from case for 10 s max		300	°C
T_{stg}	Storage temperature range		−65	150	°C

(1) 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.

(2) All voltages referenced to GND unless otherwise specified.

5.2 Recommended Operating Conditions

(see (1))

			MIN	MAX	UNIT
V_{CC}	Supply voltage (see (2))		2	6	V
	Supply voltage, V_{CC} − V_{EE} (see Figure 5-1)		2	10	V
V_{EE}	Supply voltage, (see (2) and Figure 5-2)		0	−6	V
V_{IH}	High-level input voltage	V_{CC} = 2V	1.5		V
		V_{CC} = 4.5V	3.15		
		V_{CC} = 6V	4.2		
V_{IL}	Low-level input voltage	V_{CC} = 2V		0.5	V
		V_{CC} = 4.5V		1.35	
		V_{CC} = 6V		1.8	
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} = 2V	0	1000	ns
		V_{CC} = 4.5V	0	500	
		V_{CC} = 6V	0	400	
T_A	Operating free-air temperature		−40	125	°C

(1) All unused inputs of the device must be held at V_{CC} or GND for proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

(2) 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

0.6V (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.

5.3 Recommended Operating Area as a Function of Supply Voltages

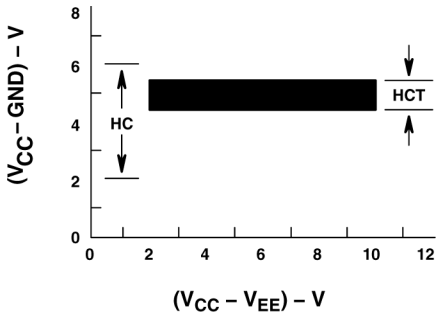


Figure 5-1. $(V_{CC} – V_{EE}) – V$

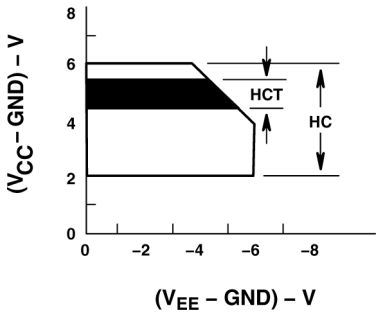


Figure 5-2. $(V_{EE} – GND) – V$

5.4 Electrical Characteristics

over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS		V_{EE}	V_{CC}	T_A = 25 °C			T_A = –40 °C TO 125°C		UNIT
					MIN	TYP	MAX	MIN	MAX	
r_{on}	I_O = 1 mA, V_I = V_{IH} or V_{IL}, See Figure 5-3	V_{IS} = V_{CC} or V_{EE}	0V	4.5V		70	160		240	Ω
			0V	6V		60	140		210	
			–4.5 V	4.5V		40	120		180	
		V_{IS} = V_{CC} to V_{EE}	0V	4.5V		90	180		270	
			0V	6V		80	160		240	
			–4.5 V	4.5V		45	130		195	
Δr_{on}	Between any two channels		0V	4.5V		10				Ω
			0V	6V		8.5				
			–4.5 V	4.5V		5				
I_{IZ}	For switch OFF: When V_{IS} = V_{CC}, V_{OS} = V_{EE}; When V_{IS} = V_{EE}, V_{OS} = V_{CC} For switch ON: All applicable combinations of V_{IS} and V_{OS} voltage levels, V_I = V_{IH} or V_{IL}		0V	6V			±0.2		±2	µA
			–5V	5V			±0.4		±4	
I_{IL}	V_I = V_{CC} or GND		0V	6V			±0.1		±1	µA
I_{CC}	I_O = 0, V_I = V_{CC} or GND	When V_{IS} = V_{EE}, V_{OS} = V_{CC}	0V	6V			12		160	µA
		When V_{IS} = V_{CC}, V_{OS} = V_{EE}	–5V	5V			32		320	

5.5 Switching Characteristics

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 6-5)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAPACITANCE	V_{EE}	V_{CC}	T_A = 25°C			T_A = −40 °C TO 125°C		UNIT
						MIN	TYP	MAX	MIN	MAX	
t_{pd}	IN	OUT	C_L = 15pF		5V		4				ns
			C_L = 50pF	0V	2V			60		90	ns
					4.5V			12		18	
					6V			10		15	
				−4.5 V	4.5V			8		12	
t_{en}	ADDRESS SEL or $\overline{E}$	OUT	C_L = 15pF		5V		19				ns
			C_L = 50pF	0V	2V			325		490	
					4.5V			45		68	
					6V			38		57	
				−4.5 V	4.5V			32		48	
t_{dis}	ADDRESS SEL or $\overline{E}$	OUT	C_L = 15pF		5V		27				ns
			C_L = 50pF	0V	2V			250		400	
					4.5V			50		68	
					6V			44		57	
				−4.5 V	4.5V			44		55	
C_I	Control		C_L = 50pF					10		10	pF

5.6 Operating Characteristics

V_{CC} = 5V, T_A = 25°C, Input t_r, t_f = 6 ns

PARAMETER		TYP	UNIT
C_{pd}	Power dissipation capacitance (see (1))	50	pF

(1) C_{pd} is used to determine the dynamic power consumption, per package.

- $P_D = C_{pd} V_{CC}^2 f_I + \Sigma (C_L + C_S) V_{CC}^2 f_O$
- f_O = output frequency
- f_I = input frequency
- C_L = output load capacitance
- C_S = switch capacitance
- V_{CC} = supply voltage

5.7 Analog Channel Characteristics

T_A = 25°C

PARAMETER		TEST CONDITIONS	V_{EE}	V_{CC}	MIN	TYP	MAX	UNIT
C_I	Switch input capacitance					5		pF
C_{COM}	Common output capacitance					25		pF
f_{max}	Minimum switch frequency response at −3 dB	See Figure 6-1 and Figure 5-4, and (1) and (2)	−2.25V	2.25V		145		MHz
			−4.5V	4.5V		180		

5.7 Analog Channel Characteristics (continued)

T_A = 25°C

PARAMETER		TEST CONDITIONS	V_{EE}	V_{CC}	MIN	TYP	MAX	UNIT
THD	Sine-wave distortion	See Figure 6-2	−2.25V	2.25V		0.035		%
			−4.5V	4.5V		0.018		
O_{ISO}	Switch OFF signal feed through	See Figure 6-4 and Figure 5-5, and (2) and (3)	−2.25V	2.25V		−73		dB
			−4.5V	4.5V		−75		

(1) Adjust input voltage to obtain 0 dBm at V_{OS} for f_{IN} = 1MHz.
(2) V_{IS} is centered at (V_{CC} − V_{EE})/2.
(3) Adjust input for 0 dBm.

5.8 Typical Characteristics

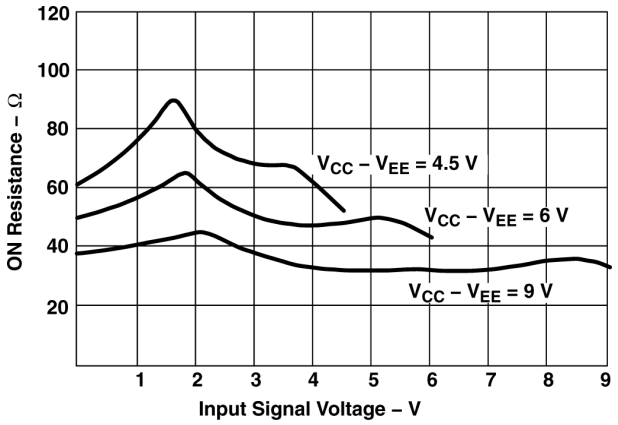


Figure 5-3. Typical on Resistance vs Input Signal Voltage

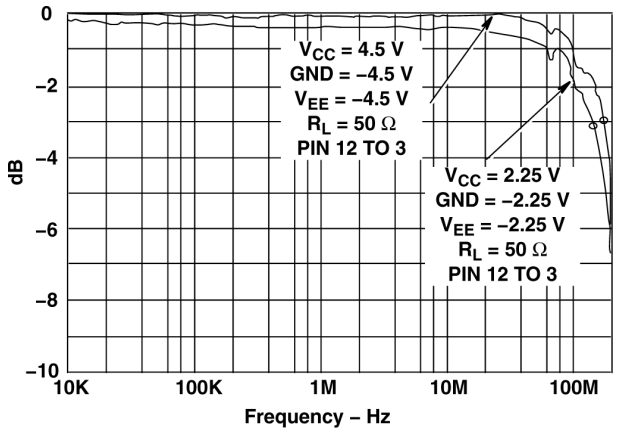


Figure 5-4. Channel on Bandwidth

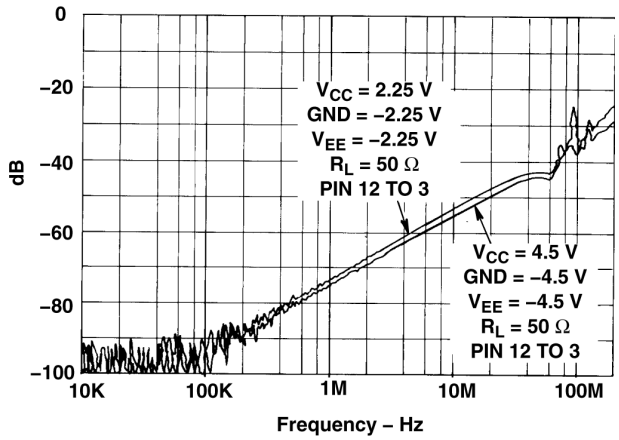


Figure 5-5. Channel off Feed-through

6 Parameter Measurement Information

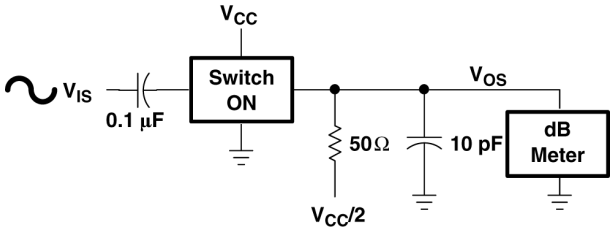
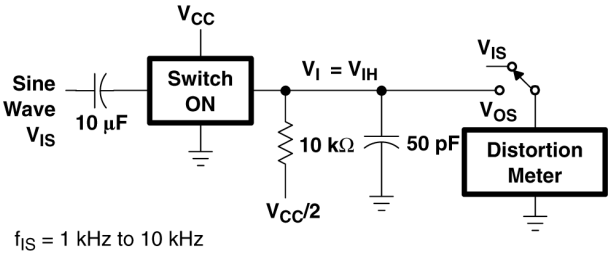


Figure 6-1. Frequency-Response Test Circuit



fIS = 1 kHz to 10 kHz

Figure 6-2. Sine-Wave Distortion Test Circuit

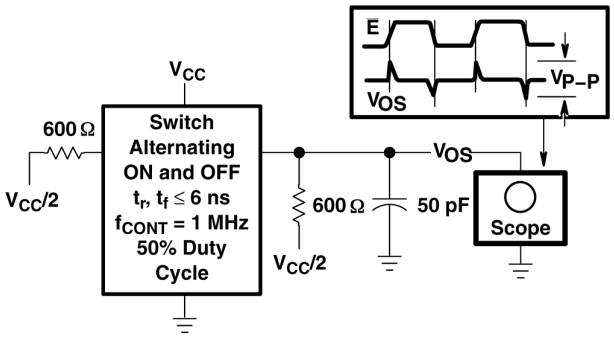


Figure 6-3. Control to Switch Feed-through Noise Test Circuit

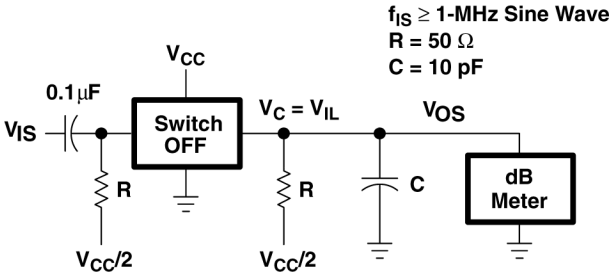
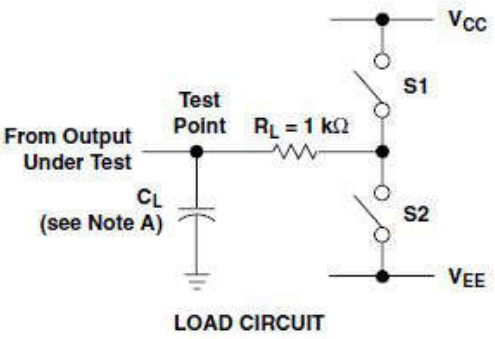
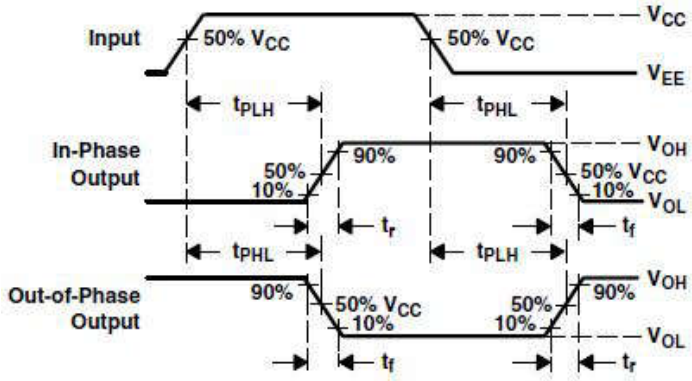


Figure 6-4. Switch off Signal Feed-through Test Circuit

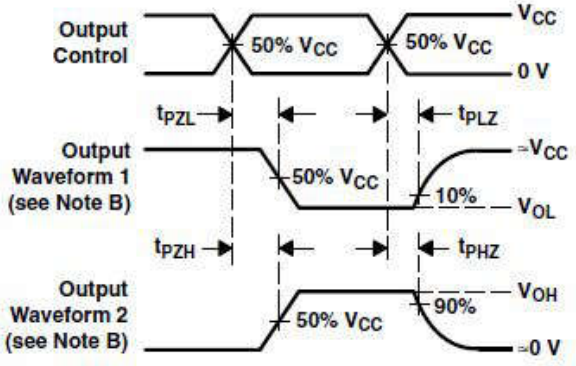


LOAD CIRCUIT

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



VOLTAGE WAVEFORMS
PROPAGATION DELAY AND OUTPUT TRANSITION TIMES



VOLTAGE WAVEFORMS
OUTPUT ENABLE AND DISABLE TIMES

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 ≤ 1MHz, Z_O = 50Ω, 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 6-5. Load Circuit and Voltage Waveforms

7 Detailed Description

7.1 Functional Block Diagram

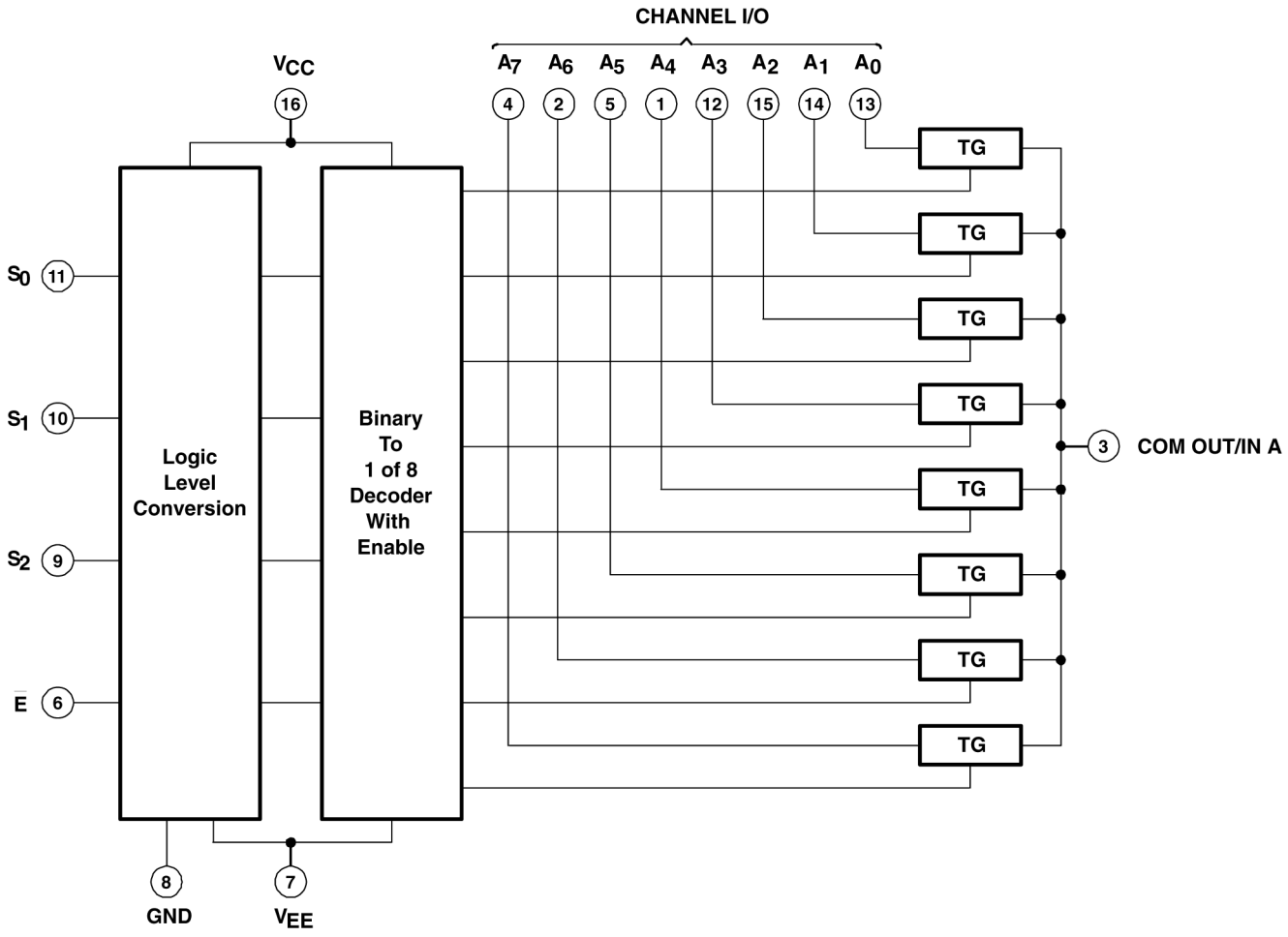


Figure 7-1. Logic Diagram (Positive Logic)

7.2 Device Functional Modes

Table 7-1. Function Table

INPUTS				ON CHANNEL(S)
$\overline{E}$	S_2	S_1	S_0	
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

8 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

8.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

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8.4 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.5 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

9 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (April 2008) to Revision B (April 2024)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Changed M (SOIC, 16) to D (SOIC, 16) to accurately reflect the package drawing	1
• Changed the package thermal impedance for the D package from: *73°C/W* to: *91.6°C/W*	3
• Changed the package thermal impedance for the PW package from: *108°C/W* to: *116.5°C/W*	3
• Changed I_{CC} MAX from: *8µA* to: *12µA* when V_{IS} = V_{EE}, V_{OS} = V_{CC} at a TA = 25°C	4
• Changed I_{CC} MAX from: *16µA* to: *32µA* when V_{IS} = V_{CC}, V_{OS} = V_{EE} at a TA = 25°C	4
• Changed t_{en} MAX from: *225ns* to: *325ns* when C_L = 50pF at a TA = 25°C and from: *340ns* to: *490ns* when C_L = 50pF at a TA = -40°C to 125°C	5
• Changed t_{dis} TYP from: *19ns* to: *27ns* when C_L = 15pF at a TA = 25°C	5
• Changed t_{dis} MAX from: *225ns* to: *250ns* when C_L = 50pF, V_{EE} = 0V, and V_{CC} = 2V at a TA = 25°C, and from: *340ns* to: *400ns* at a TA = -40°C to 125°C	5
• Changed t_{dis} MAX from: *45ns* to: *50ns* when C_L = 50pF, V_{EE} = 0V, and V_{CC} = 4.5V at a TA = 25°C	5
• Changed t_{dis} MAX from: *38ns* to: *44ns* when C_L = 50pF, V_{EE} = 0V, and V_{CC} = 6V at a TA = 25°C	5
• Changed t_{dis} MAX from: *32ns* to: *44ns* when C_L = 50pF, V_{EE} = -4.5V, and V_{CC} = 4.5V at a TA = 25°C, and from: *48ns* to: *55ns* at a TA = -40°C to 125°C	5
• Removed the TBD $\overline{E}$ or ADDRESS SEL to switch feed-through noise parameter	5

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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