TEXAS INSTRUMENTS
CD4051B-Q1, CD4053B-Q1
SCHS354C – AUGUST 1998 – REVISED MARCH 2023

CD405xB-Q1 Automotive CMOS Single 8-Channel Analog Multiplexer or Demultiplexer with Logic-Level Conversion

1 Features

- AEC-Q100 qualified for automotive applications:
  - Temperature grade 1: –45°C to +125°C, T_A
- Wide range of digital and analog signal levels:
  - Digital: 3 V to 20 V
  - Analog: ≤ 20 V_{P-P}
- Low ON resistance, 125 Ω (typical) over 15 V_{P-P} signal input range for $V_{DD} – V_{EE}$ = 18 V
- High OFF resistance, channel leakage of ±100 pA (typical) at $V_{DD} – V_{EE}$ = 18 V
- Logic-level conversion for digital addressing signals of 3 V to 20 V ($V_{DD} – V_{SS}$ = 3 V to 20 V) to switch analog signals to 20 V_{P-P} ($V_{DD} – V_{EE}$ = 20 V) matched switch characteristics, r_{ON} = 5 Ω (typical) for $V_{DD} – V_{EE}$ = 15 V very low quiescent power dissipation under all digital-control input and supply conditions, 0.2 µW (typical) at $V_{DD} – V_{SS} = V_{DD} – V_{EE}$ = 10 V
- Binary address decoding on chip
- 5 V, 10 V, and 15 V parametric ratings
- 100% tested for quiescent current at 20 V
- Maximum input current of 1 µA at 18 V over full package temperature range, 100 nA at 18 V and 25°C
- Break-before-make switching eliminates channel overlap

2 Applications

- Analog and digital multiplexing and demultiplexing
- Analog to digital and digital to analog conversion
- Signal gating
- Factory automation
- Televisions
- Appliances
- Consumer audio
- Programmable logic circuits
- Sensors

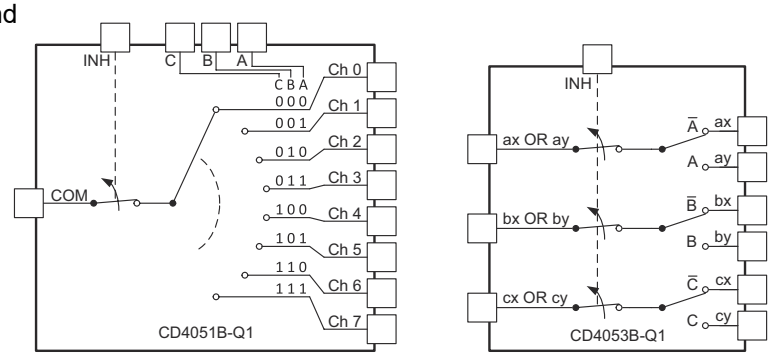
3 Description

The CD405xB-Q1 analog multiplexers and demultiplexers are digitally-controlled analog switches having low ON impedance and very low OFF leakage current. 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.

Package Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
CD405xB-Q1	D (SOIC, 16)	9.90 mm × 3.91 mm
	PW (TSSOP, 16)	5.00 mm × 4.40 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



Functional Diagrams of CD405xB-Q1

Table of Contents

4 Revision History

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

Changes from Revision B (April 2019) to Revision C (March 2023)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Updated CD4051-Q1 specifications throughout the data sheet	1

Changes from Revision A (January 2008) to Revision B (April 2019)	Page
• Added *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section	1
• Deleted part number CD4052B-Q1 from the data sheets	1

5 Pin Configuration and Functions

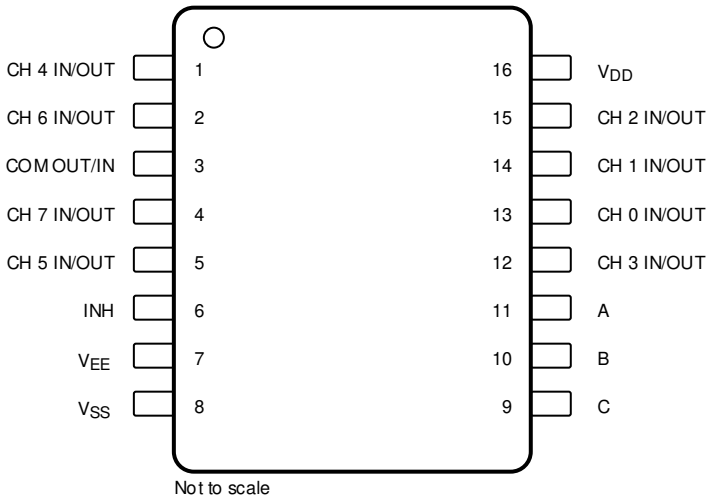


Figure 5-1. CD4051B-Q1 D or PW Package, (Top View)

Table 5-1. Pin Functions CD4051B-Q1

PIN		TYPE(1)	DESCRIPTION
NO.	NAME		
1	CH 4 IN/OUT	I/O	Channel 4 in/out
2	CH 6 IN/OUT	I/O	Channel 6 in/out
3	COM OUT/IN	I/O	Common out/in
4	CH 7 IN/OUT	I/O	Channel 7 in/out
5	CH 5 IN/OUT	I/O	Channel 5 in/out
6	INH	I	Disables all channels. See Table 8-1.
7	V_{EE}	—	Negative power input
8	V_{SS}	—	Ground
9	C	I	Channel select C. See Table 8-1.
10	B	I	Channel select B. See Table 8-1.
11	A	I	Channel select A. See Table 8-1.
12	CH 3 IN/OUT	I/O	Channel 3 in/out
13	CH 0 IN/OUT	I/O	Channel 0 in/out
14	CH 1 IN/OUT	I/O	Channel 1 in/out
15	CH 2 IN/OUT	I/O	Channel 2 in/out
16	V_{DD}	—	Positive power input

(1) I = input, O = output

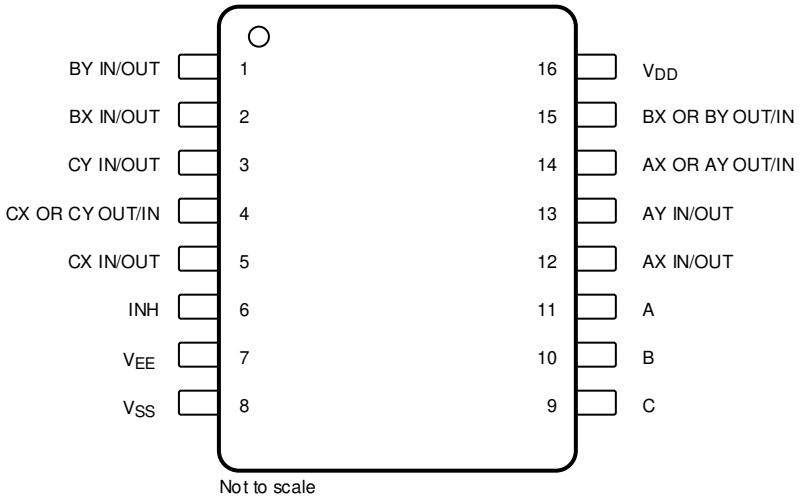


Figure 5-2. CD4053B-Q1 D or PW Package, (Top View)

Table 5-2. Pin Functions CD4053B-Q1

PIN		TYPE(1)	DESCRIPTION
NO.	NAME		
1	BY IN/OUT	I/O	B channel Y in/out
2	BX IN/OUT	I/O	B channel X in/out
3	CY IN/OUT	I/O	C channel Y in/out
4	CX OR CY OUT/IN	I/O	C common out/in
5	CX IN/OUT	I/O	C channel X in/out
6	INH	I	Disables all channels. See Table 8-1.
7	V_{EE}	—	Negative power input
8	V_{SS}	—	Ground
9	C	I	Channel select C. See Table 8-1.
10	B	I	Channel select B. See Table 8-1.
11	A	I	Channel select A. See Table 8-1.
12	AX IN/OUT	I/O	A channel X in/out
13	AY IN/OUT	I/O	A channel Y in/out
14	AX OR AY OUT/IN	I/O	A common out/in
15	BX OR BY OUT/IN	I/O	B common out/in
16	V_{DD}	—	Positive power input

(1) I = input, O = output

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1) (2)

			MIN	MAX	UNIT
	Supply Voltage	V+ to V-, Voltages Referenced to V_{SS} Terminal	–0.5	20	V
	DC Input Voltage		–0.5	V_{DD}+0.5	V
	DC Input Current	Any One Input	–10	10	mA
T_{JMAX1}	Maximum junction temperature, ceramic package			175	°C
T_{JMAX2}	Maximum junction temperature, plastic package			150	°C
T_{stg}	Storage temperature		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Rating* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltages are with respect to ground, unless otherwise specified.

6.2 ESD Ratings

			VALUE	UNIT
CD4051B-Q1				
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1)	±2000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins(2)	±750	
CD4053B-Q1				
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1)	±2500	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins(2)	±1500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

	MIN	NOM	MAX	UNIT
Temperature Range	–55		125	°C

6.4 Thermal Information

THERMAL METRIC[1]		CD405xB-Q1		UNIT
		D (SOIC)	PW (TSSOP)	
		16 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	86.7	116.5	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	47.3	47.2	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	45.3	63.0	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	12.1	6.4	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	44.9	62.1	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

6.5 Electrical Characteristics - CD4051B-Q1

Over operating free-air temperature range, V_{SUPPLY} = ±5 V, and R_L = 100 Ω, (unless otherwise noted)(1)

PARAMETER	TEST CONDITIONS					MIN	TYP	MAX	UNIT
	V_{IS} (V)	V_{EE} (V)	V_{SS} (V)	V_{DD} (V)	TEMP				
SIGNAL INPUTS (V_{IS}) AND OUTPUTS (V_{OS}) - CD4051B-Q1									
Quiescent Device Current, I_{DD} (Max)		0 V	0 V	5 V	–55°C			60	µA
					–40°C			60	
					25°C		17	60	
					85°C			150	
					125°C			150	
		0 V	0 V	10 V	–55°C			60	
					–40°C			60	
					25°C		18	60	
					85°C			300	
					125°C			300	
		0 V	0 V	15 V	–55°C			60	
					–40°C			60	
					25°C		18	60	
					85°C			600	
					125°C			600	
		0 V	0 V	20 V	–55°C			100	
					–40°C			100	
					25°C		18	100	
					85°C			3000	
					125°C			3000	
Drain to Source ON Resistance r_{ON} (Max) $0 \le V_{IS} \le V_{DD}$		0 V	0 V	5 V	–55°C			800	Ω
					–40°C			850	
					25°C		470	1050	
					85°C			1200	
					125°C			1300	
		0 V	0 V	10 V	–55°C			310	
					–40°C			300	
					25°C		180	400	
					85°C			520	
					125°C			550	
		0 V	0	15 V	–55°C			200	
					–40°C			210	
					25°C		125	240	
					85°C			300	
					125°C			300	
Change in ON Resistance (Between Any Two Channels), ΔR_{ON}		0 V	0 V	5 V	25°C		15		Ω
		0 V	0 V	10 V			10		
		0 V	0 V	15 V			5		

6.5 Electrical Characteristics - CD4051B-Q1 (continued)

Over operating free-air temperature range, V_{SUPPLY} = ±5 V, and R_L = 100 Ω, (unless otherwise noted)(1)

PARAMETER			TEST CONDITIONS					MIN	TYP	MAX	UNIT
			V_{IS} (V)	V_{EE} (V)	V_{SS} (V)	V_{DD} (V)	TEMP				
OFF Channel Leakage Current: Any Channel OFF (Max) or ALL Channels OFF (COMMON OUT/IN) (Max)				0 V	0 V	18 V	–55°C			± 100	nA
							–40°C				
							25°C		± 0.3	± 100(2)	
							85°C			± 1000 (2)	
							125°C				
ON Channel Leakage Current: Any Channel ON (Max) or ALL Channels ON (COMMON OUT/IN) (Max)			5 or 0	–5 V	0 V	10.5 V	85°C			± 800	nA
			5	0 V	0 V	18 V	85°C			± 800	
Capacitance	Input, C_{IS}			0 V	0 V	10 V	25°C		5		pF
	Output, C_{OS}	CD4051-Q1							30		
	Feed-through, C_{IOS}								0.2		
Prop Delay			V_{DD}	R_L = 200 kΩ		5 V	25°C		30	60	ns
				C_L = 50 pF		10 V			15	30	
				t_r, t_f = 20 ns		15 V			10	20	

6.5 Electrical Characteristics - CD4051B-Q1 (continued)

Over operating free-air temperature range, V_{SUPPLY} = ±5 V, and R_L = 100 Ω, (unless otherwise noted)(1)

PARAMETER		TEST CONDITIONS					MIN	TYP	MAX	UNIT
		V_{IS} (V)	V_{EE} (V)	V_{SS} (V)	V_{DD} (V)	TEMP				
CONTROL (ADDRESS OR INHIBIT), V_C - CD4051B-Q1										
Input Low Voltage, V_{IL}, (Max)					5 V	–55°C			0.8	V
						–40°C			0.8	
						25°C			0.8	
						85°C			0.8	
						125°C			0.8	
					10 V	–55°C			0.8	
						–40°C			0.8	
						25°C			0.8	
						85°C			0.8	
						125°C			0.8	
					15 V	–55°C			0.8	
						–40°C			0.8	
						25°C			0.8	
						85°C			0.8	
						125°C			0.8	
Input High Voltage, V_{IH}, (Min)					5 V	–55°C			3.5	V
						–40°C			3.5	
						25°C	3.5			
						85°C			3.5	
						125°C			3.5	
					10 V	–55°C			7	
						–40°C			7	
						25°C	7			
						85°C			7	
						125°C			7	
					15 V	–55°C			11	
						–40°C			11	
						25°C	11			
						85°C			11	
						125°C			11	
Input current, I_{IN} (Max)		V_{IN} = 0, 18			18 V	–55°C			±1	µA
						–40°C			±1	
						25°C		±0.6	±1	
						85°C			±1	
						125°C			±1	
Propagation Delay Time	Address-to-Signal OUT (Channels ON or OFF) (See Figure 7-2 Figure 7-3, and Figure 7-8)	t_r , t_f = 20ns, C_L = 50 pF, R_L = 10 kΩ	0 V	0 V	5 V			450	720	ns
			0 V	0 V	10 V			160	320	
			0 V	0 V	15 V			120	240	
			–5 V	0 V	5 V			225	450	

6.5 Electrical Characteristics - CD4051B-Q1 (continued)

Over operating free-air temperature range, V_{SUPPLY} = ±5 V, and R_L = 100 Ω, (unless otherwise noted)(1)

PARAMETER		TEST CONDITIONS					MIN	TYP	MAX	UNIT
		V_{IS} (V)	V_{EE} (V)	V_{SS} (V)	V_{DD} (V)	TEMP				
Propagation Delay Time	Inhibit-to-Signal OUT (Channel Turning ON) (See Figure 7-3)	t_r , t_f = 20 ns, C_L = 50 pF, R_L = 1 kΩ	0 V	0 V	5 V			400	720	ns
			0 V	0 V	10 V			160	320	
			0 V	0 V	15 V			120	240	
			–10 V	0 V	5 V			200	400	
Propagation Delay Time	Inhibit-to-Signal OUT (Channel Turning OFF) (See Figure 7-10)	t_r , t_f = 20 ns, C_L = 50 pF, R_L = 10 kΩ	0 V	0 V	5 V			200	450	ns
			0 V	0 V	10 V			90	210	
			0 V	0 V	15 V			70	160	
			–10 V	0 V	5 V			130	300	
Input Capacitance, C_{IN} (Any Address or Inhibit Input)			–5 V	0 V	5 V	25°C		5	7.5	pF

(1) Peak-to-Peak voltage symmetrical about (V_{DD} – V_{EE}) / 2.
(2) Determined by minimum feasible leakage measurement for automatic testing.

6.6 AC Performance Characteristics - CD4051B-Q1

V_{DD} = +15 V, V_{SS} = V_{EE} = 0 V,
T_A = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS					TYP	UNIT
	V_{IS} (V)	V_{DD} (V)	R_L (kΩ)				
Cutoff (–3 dB) Frequency Channel ON (Sine Wave Input)	5(1)	10	1	V_{OS} at Common OUT/IN	CD4051-Q1	20	MHz
	V_{EE} = V_{SS} , 20Log(V_{OS}/V_{IS}) = –3 dB			V_{OS} at Any Channel		60	
Total Harmonic Distortion, THD	2(1)	5	10			0.3%	%
	3(1)	10	10			0.2%	
	5(1)	15	10			0.12%	
	V_{EE} = V_{SS}, f_{IS} = 1 kHz Sine Wave						
–40 dB Feed-through Frequency (All Channels OFF)	5(1)	10	1	V_{OS} at Common OUT/IN	CD4051-Q1	12	MHz
	V_{EE} = V_{SS} , 20Log(V_{OS}/V_{IS}) = –40 dB			V_{OS} at Any Channel		8	MHz
–40 dB Signal Crosstalk Frequency	5(1)	10	1			3	MHz
Address-or-Inhibit-to-Signal Crosstalk		10	10(2)			65	mV_{PEAK}
	V_{EE} = 0, V_{SS} = 0, t_r , t_f = 20 ns, mVPEAK V_{CC} = V_{DD} – V_{SS} (Square Wave)					65	mV_{PEAK}

(1) Peak-to-Peak voltage symmetrical about (V_{DD} - V_{EE}) / 2.
(2) Both ends of channel.

6.7 Electrical Characteristics - CD4053B-Q1

Over operating free-air temperature range, V_{SUPPLY} = ±5 V, and R_L = 100 Ω, (unless otherwise noted)(1)

PARAMETER	TEST CONDITIONS					MIN	TYP	MAX	UNIT
	V_{IS} (V)	V_{EE} (V)	V_{SS} (V)	V_{DD} (V)	TEMP				
SIGNAL INPUTS (V_{IS}) AND OUTPUTS (V_{OS}) - CDIP, PDIP, SOIC and SOP Packages									
Quiescent Device Current, I_{DD} (Max)		0 V	0 V	5 V	–55°C			5	µA
					–40°C			5	
					25°C		0.04	5	
					85°C			150	
					125°C			150	
		0 V	0 V	10 V	–55°C			10	
					–40°C			10	
					25°C		0.04	10	
					85°C			300	
					125°C			300	
		0 V	0 V	15 V	–55°C			20	
					–40°C			20	
					25°C		0.04	20	
					85°C			600	
					125°C			600	
		0 V	0 V	20 V	–55°C			100	
					–40°C			100	
					25°C		18	100	
					85°C			3000	
					125°C			3000	
Drain to Source ON Resistance r_{ON} (Max) $0 \le V_{IS} \le V_{DD}$		0 V	0 V	5 V	–55°C			800	Ω
					–40°C			850	
					25°C		470	1050	
					85°C			1200	
					125°C			1300	
		0 V	0 V	10 V	–55°C			310	
					–40°C			300	
					25°C		180	400	
					85°C			520	
					125°C			550	
		0 V	0	15 V	–55°C			200	
					–40°C			210	
					25°C		125	240	
					85°C			300	
					125°C			300	
Change in ON Resistance (Between Any Two Channels), ΔR_{ON}		0 V	0 V	5 V	25°C		15		Ω
		0 V	0 V	10 V			10		
		0 V	0 V	15 V			5		

6.7 Electrical Characteristics - CD4053B-Q1 (continued)

Over operating free-air temperature range, V_{SUPPLY} = ±5 V, and R_L = 100 Ω, (unless otherwise noted)(1)

PARAMETER			TEST CONDITIONS					MIN	TYP	MAX	UNIT
			V_{IS} (V)	V_{EE} (V)	V_{SS} (V)	V_{DD} (V)	TEMP				
OFF Channel Leakage Current: Any Channel OFF (Max) or ALL Channels OFF (COMMON OUT/IN) (Max)				0 V	0 V	18 V	–55°C			± 100	nA
							–40°C				
							25°C		± 0.01	± 100(2)	
							85°C			± 1000 (2)	
							125°C				
ON Channel Leakage Current: Any Channel ON (Max) or ALL Channels ON (COMMON OUT/IN) (Max)			5 or 0	–5 V	0 V	10.5 V	85°C			± 300	nA
			5	0 V	0 V	18 V	85°C			± 300	
Capacitance	Input, C_{IS}			0 V	0 V	10 V	25°C		5		pF
	Output, C_{OS}	CD4053-Q1							9		
	Feed-through, C_{IOS}								0.2		
Prop Delay			V_{DD}	R_L = 200 kΩ		5 V	25°C		30	60	ns
				C_L = 50 pF		10 V			15	30	
				t_r, t_f = 20 ns		15 V			10	20	

6.7 Electrical Characteristics - CD4053B-Q1 (continued)

Over operating free-air temperature range, V_{SUPPLY} = ±5 V, and R_L = 100 Ω, (unless otherwise noted)(1)

PARAMETER		TEST CONDITIONS					MIN	TYP	MAX	UNIT
		V_{IS} (V)	V_{EE} (V)	V_{SS} (V)	V_{DD} (V)	TEMP				
CONTROL (ADDRESS OR INHIBIT), V_C - CDIP, PDIP, SOIC and SOP Packages										
Input Low Voltage, V_{IL}, (Max)					5 V	–55°C			1.5	V
						–40°C			1.5	
						25°C			1.5	
						85°C			1.5	
						125°C			1.5	
					10 V	–55°C			3	
						–40°C			3	
						25°C			3	
						85°C			3	
						125°C			3	
					15 V	–55°C			4	
						–40°C			4	
						25°C			4	
						85°C			4	
						125°C			4	
Input High Voltage, V_{IH}, (Min)					5 V	–55°C			3.5	V
						–40°C			3.5	
						25°C	3.5			
						85°C			3.5	
						125°C			3.5	
					10 V	–55°C			7	
						–40°C			7	
						25°C	7			
						85°C			7	
						125°C			7	
					15 V	–55°C			11	
						–40°C			11	
						25°C	11			
						85°C			11	
						125°C			11	
Input current, I_{IN} (Max)		V_{IN} = 0, 18			18 V	–55°C			± 0.1	µA
						–40°C			± 0.1	
						25°C		$±10^{-5}$	± 0.1	
						85°C			± 1	
						125°C			± 1	
Propagation Delay Time	Address-to-Signal OUT (Channels ON or OFF) (See Figure 7-2 Figure 7-3, and Figure 7-8)	t_r , t_f = 20ns, C_L = 50 pF, R_L = 10 kΩ	0 V	0 V	5 V			450	720	ns
			0 V	0 V	10 V			160	320	
			0 V	0 V	15 V			120	240	
			–5 V	0 V	5 V			225	450	

6.7 Electrical Characteristics - CD4053B-Q1 (continued)

Over operating free-air temperature range, V_{SUPPLY} = ±5 V, and R_L = 100 Ω, (unless otherwise noted)(1)

PARAMETER		TEST CONDITIONS					MIN	TYP	MAX	UNIT
		V_{IS} (V)	V_{EE} (V)	V_{SS} (V)	V_{DD} (V)	TEMP				
Propagation Delay Time	Inhibit-to-Signal OUT (Channel Turning ON) (See Figure 7-3)	t_r , t_f = 20 ns, C_L = 50 pF, R_L = 1 kΩ	0 V	0 V	5 V			400	720	ns
			0 V	0 V	10 V			160	320	
			0 V	0 V	15 V			120	240	
			–10 V	0 V	5 V			200	400	
Propagation Delay Time	Inhibit-to-Signal OUT (Channel Turning OFF) (See Figure 7-10)	t_r , t_f = 20 ns, C_L = 50 pF, R_L = 10 kΩ	0 V	0 V	5 V			200	450	ns
			0 V	0 V	10 V			90	210	
			0 V	0 V	15 V			90	160	
			–10 V	0 V	5 V			130	300	
Input Capacitance, C_{IN} (Any Address or Inhibit Input)			–5 V	0 V	5 V	25°C		5	7.5	pF

(1) Peak-to-Peak voltage symmetrical about (V_{DD} – V_{EE}) / 2.
(2) Determined by minimum feasible leakage measurement for automatic testing.

6.8 AC Performance Characteristics - CD4053B-Q1

V_{DD} = +15 V, V_{SS} = V_{EE} = 0 V,
T_A = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS					TYP	UNIT
	V_{IS} (V)	V_{DD} (V)	R_L (kΩ)				
Cutoff (–3 dB) Frequency Channel ON (Sine Wave Input)	5(1)	10	1	V_{OS} at Common OUT/IN	CD4053-Q1	30	MHz
	V_{EE} = V_{SS} , 20Log(V_{OS}/V_{IS}) = –3 dB			V_{OS} at Any Channel		60	MHz
Total Harmonic Distortion, THD	2(1)	5	10			0.3%	%
	3(1)	10	10			0.2%	%
	5(1)	15	10			0.12%	%
	V_{EE} = V_{SS}, f_{IS} = 1 kHz Sine Wave						%
–40 dB Feed-through Frequency (All Channels OFF)	5(1)	10	1	V_{OS} at Common OUT/IN	CD4053-Q1	8	MHz
	V_{EE} = V_{SS} , 20Log(V_{OS}/V_{IS}) = –40 dB			V_{OS} at Any Channel		8	MHz
–40 dB Signal Crosstalk Frequency	5(1)	10	1			3	MHz
	V_{EE} = V_{SS} , 20Log(V_{OS}/V_{IS}) = –3 dB			Between Any Two Sections, CD4053-Q1 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(2)			65	mV_{PEAK}
	V_{EE} = 0, V_{SS} = 0, t_r , t_f = 20 ns, mVPEAK V_{CC} = V_{DD} – V_{SS} (Square Wave)					65	mV_{PEAK}

(1) Peak-to-Peak voltage symmetrical about (V_{DD} - V_{EE}) / 2.
(2) Both ends of channel.

6.9 Typical Characteristics

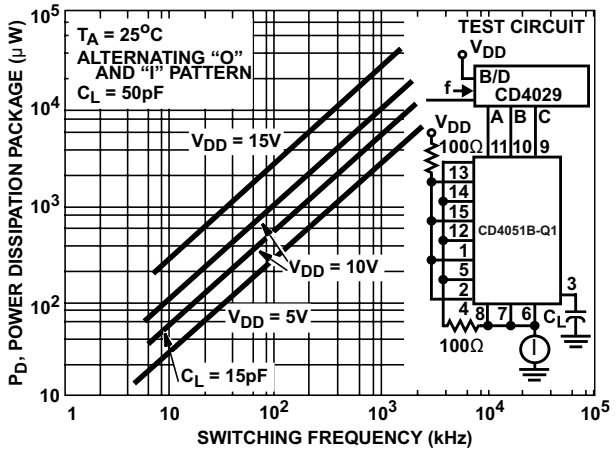


Figure 6-1. Dynamic Power Dissipation vs Switching Frequency (CD4051B)

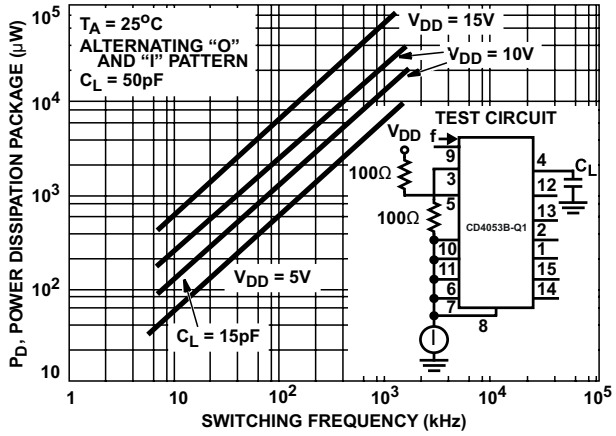


Figure 6-2. Dynamic Power Dissipation vs Switching Frequency (CD4053B)

7 Parameter Measurement Information

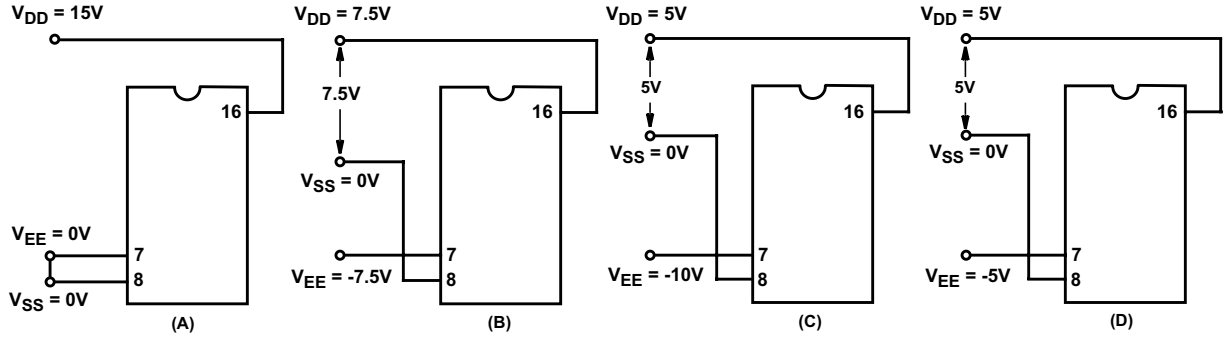


Figure 7-1. Typical Bias Voltages

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}.

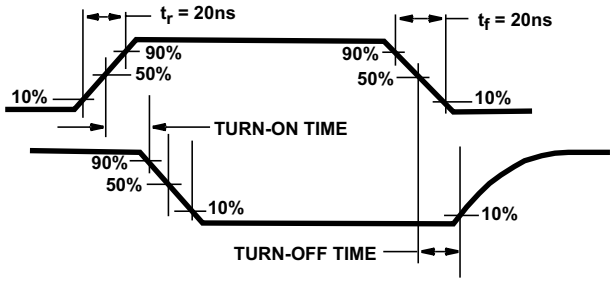


Figure 7-2. Waveforms, Channel Being Turned ON (R_L = 1 kΩ)

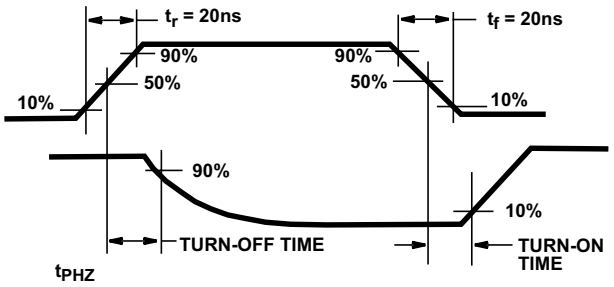


Figure 7-3. Waveforms, Channel Being Turned OFF (R_L = 1 kΩ)

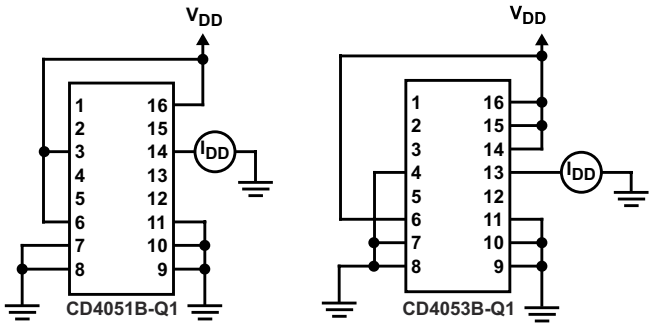


Figure 7-4. OFF Channel Leakage Current – Any Channel OFF

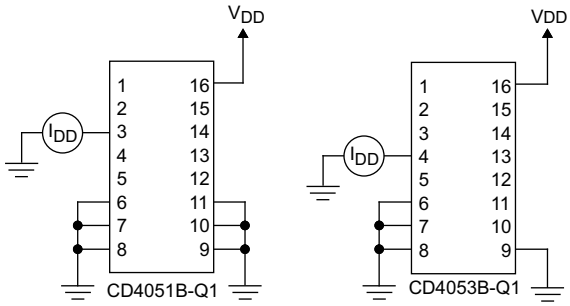


Figure 7-5. On Channel Leakage Current – Any Channel On

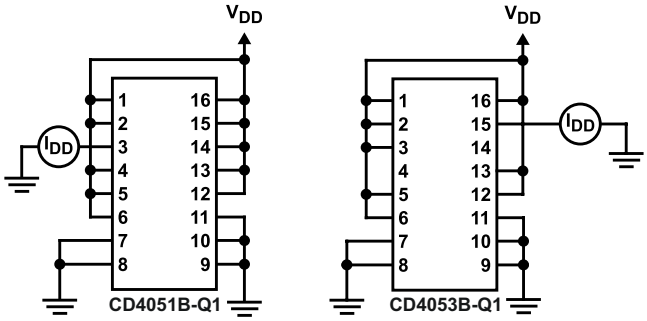


Figure 7-6. OFF Channel Leakage Current – All Channels OFF

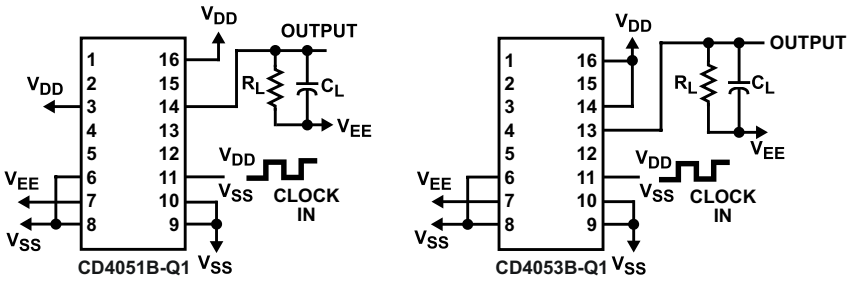


Figure 7-7. Propagation Delay – Address Input to Signal Output

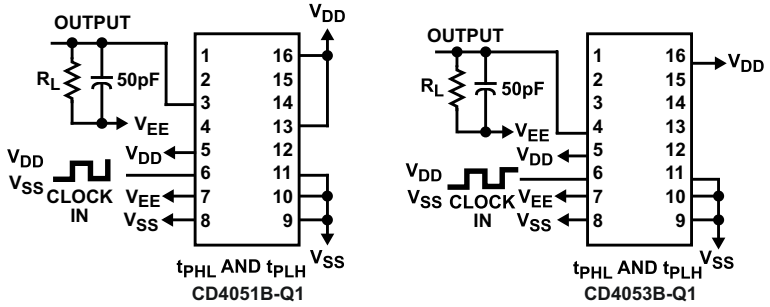


Figure 7-8. Propagation Delay – Inhibit Input to Signal Output

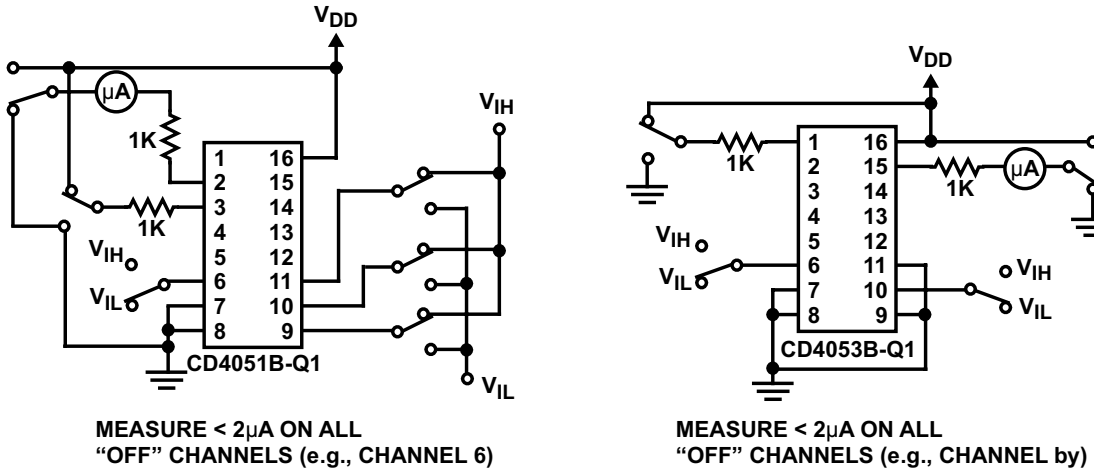


Figure 7-9. Input Voltage Test Circuits (Noise Immunity)

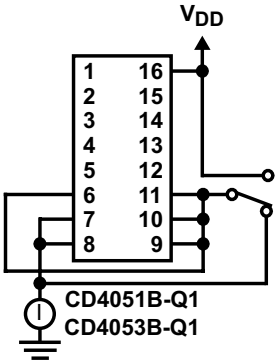


Figure 7-10. Quiescent Device Current

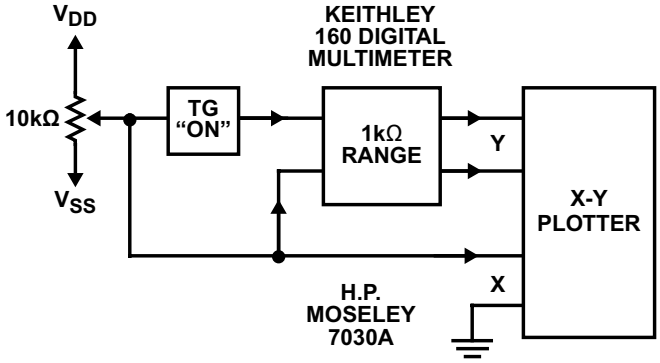


Figure 7-11. Channel ON Resistance Measurement Circuit

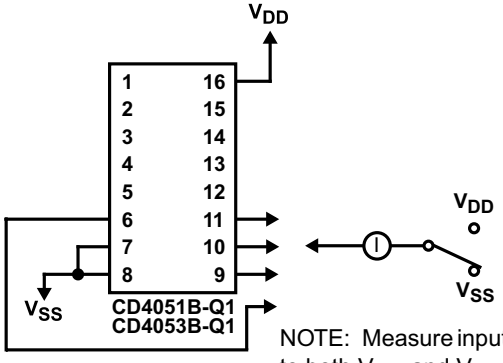


Figure 7-12. Input Current

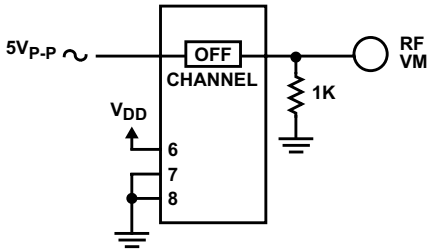


Figure 7-13. Feed-Through (All Types)

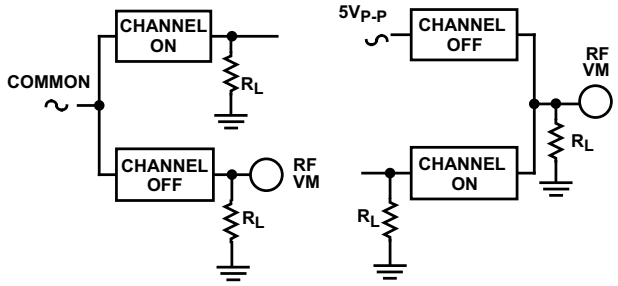


Figure 7-14. Crosstalk Between Any Two Channels (All Types)

Figure 7-15. Crosstalk Between Duals or Triplets (CD4053B-Q1)

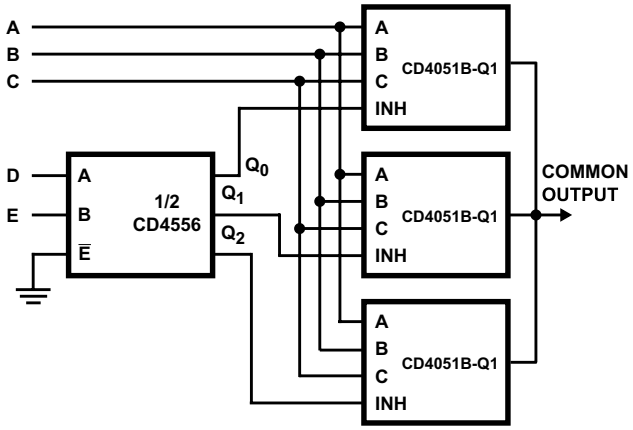


Figure 7-16. 24-to-1 MUX Addressing

8 Detailed Description

8.1 Overview

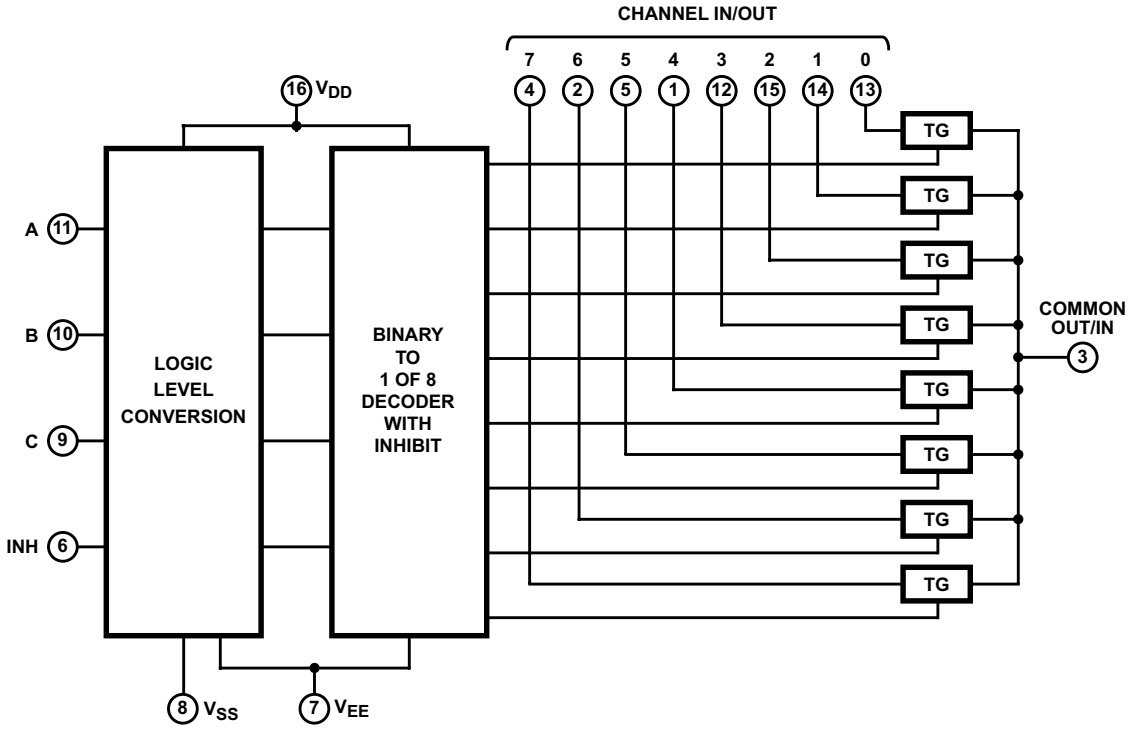
The CD4051B-Q1 and CD4053B-Q1 analog multiplexers are digitally-controlled analog switches having low ON impedance and very low OFF leakage current. Control of analog signals up to 20 V_{P-P} can be achieved by digital signal amplitudes of 4.5 V to 20 V (if $V_{DD} – V_{SS}$ = 3 V, a $V_{DD} – V_{EE}$ of up to 13 V can be controlled; for $V_{DD} – V_{EE}$ level differences above 13 V, a $V_{DD} – V_{SS}$ of at least 4.5 V is required). For example, if V_{DD} = +4.5 V, V_{SS} = 0 V, and V_{EE} = –13.5 V, analog signals from –13.5 V to +4.5 V can be controlled by digital inputs of 0 V to 5 V. 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-Q1 device 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 CD4053B-Q1 device 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.

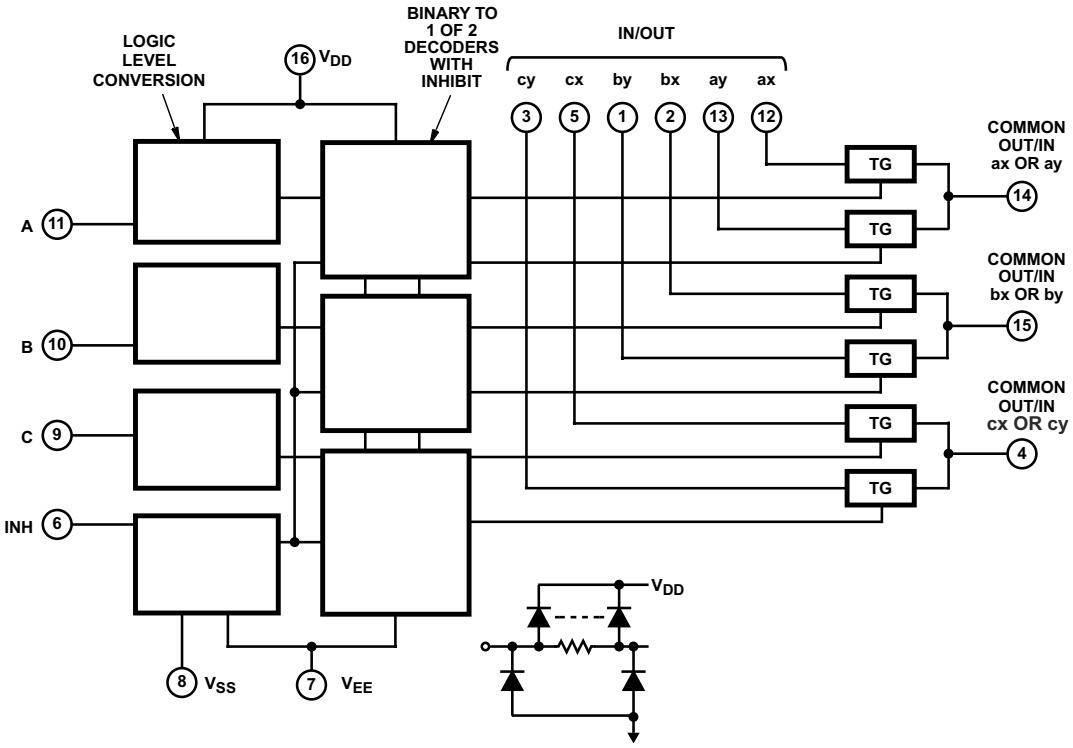
When these devices are used as demultiplexers, the CHANNEL IN/OUT terminals are the outputs and the COMMON OUT/IN terminals are the inputs.

8.2 Functional Block Diagrams



All inputs are protected by standard CMOS protection network.

Figure 8-1. Functional Block Diagram, CD4051B-Q1



All inputs are protected by standard CMOS protection network.

Figure 8-2. Functional Block Diagram, CD4053B-Q1

8.3 Feature Description

The CD405xB-Q1 line of multiplexers and demultiplexers can accept a wide range of digital and analog signal levels. Digital signals range from 3 V to 20 V, and analog signals are accepted at levels ≤ 20 V. The devices have low ON resistance, typically 125 Ω over 15 V_{P-P} signal input range for $V_{DD} – V_{EE}$ = 18 V. This feature allows for very little signal loss through the switch. Matched switch characteristics are typically r_{ON} = 5 Ω for $V_{DD} – V_{EE}$ = 15 V.

The CD405xB-Q1 devices also have high OFF resistance, which keeps from wasting power when the switch is in the OFF position, with typical channel leakage of ±100 pA at $V_{DD} – V_{EE}$ = 18 V. Very low quiescent power dissipation under all digital-control input and supply conditions, typically 0.2 µW at $V_{DD} – V_{SS} = V_{DD} – V_{EE}$ = 10 V keeps power consumption total very low. All devices have been 100% tested for quiescent current at 20 V with maximum input current of 1 µA at 18 V over the full package temperature range, and only 100 nA at 18 V and 25°C.

Logic-level conversion for digital addressing signals of 3 V to 20 V ($V_{DD} – V_{SS}$ = 3 V to 20 V) to switch analog signals to 20 V_{P-P} ($V_{DD} – V_{EE}$ = 20 V). Binary address decoding on chip makes channel selection easy. When channels are changed, a break-before-make system eliminates channel overlap.

8.4 Device Functional Modes

Table 8-1. Truth Table(1)

INPUT STATES				ON CHANNEL(S)
INHIBIT	C	B	A	
CD4051B-Q1				
L	L	L	L	0
L	L	L	H	1
L	L	H	L	2
L	L	H	H	3
L	H	L	L	4
L	H	L	H	5
L	H	H	L	6
L	H	H	H	7
H	X	X	X	None
CD4053B-Q1				
L	L	L	L	ay or by or cy
L	H	H	H	ay or by or cy
H	X	X	X	None

(1) X = Do not care

9 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

9.1 Application Information

The CD405xB-Q1 multiplexers and demultiplexers can be used for a wide variety of applications.

9.2 Typical Application

One application of the CD4051B-Q1 is to use it in conjunction with a microcontroller to poll a keypad. Figure 9-1 shows the basic schematic for such a polling system. The microcontroller uses the channel select pins to cycle through the different channels while reading the input to see if a user is pressing any of the keys. This application is a very robust setup, allowing for multiple simultaneous key-presses with very little power consumption. This setup also uses very few pins on the microcontroller. The down side of polling is that the microcontroller must continually scan the keys for a press and can do little else during this process.

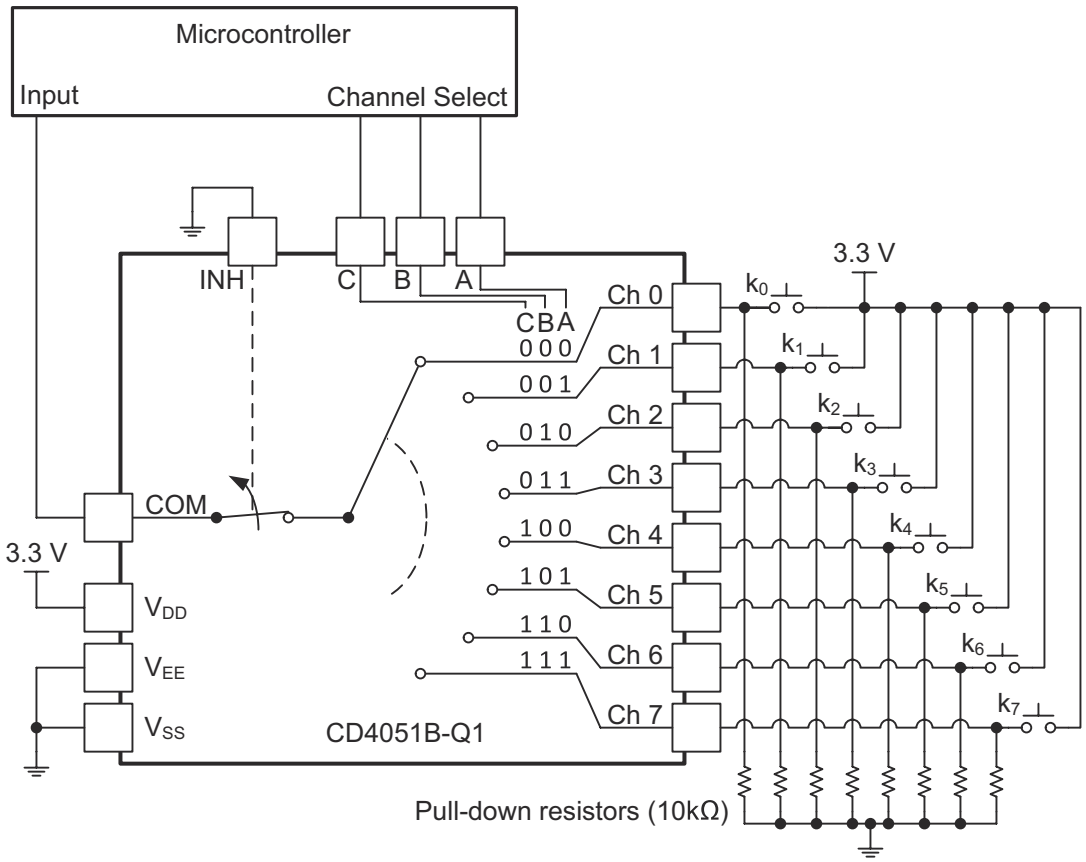


Figure 9-1. The CD4051B-Q1 Being Used to Help Read Button Presses on a Keypad

9.2.1 Design Requirements

These devices use CMOS technology and have balanced output drive. Take care to avoid bus contention because it can drive currents that would exceed maximum limits. The high drive will also create fast edges into light loads, so routing and load conditions should be considered to prevent ringing.

9.2.2 Detailed Design Procedure

1. Recommended Input Conditions:
   - For switch time specifications, see propagation delay times in *Electrical Characteristics*.
   - Inputs should not be pushed more than 0.5 V above V_{DD} or below V_{EE}.
   - For input voltage level specifications for control inputs, see V_{IH} and V_{IL} in *Electrical Characteristics*.
2. Recommended Output Conditions:
   - Outputs should not be pulled above V_{DD} or below V_{EE}.
3. Input or output current consideration:
   - The CD405xB-Q1 series of parts do not have internal current drive circuitry and thus cannot sink or source current. Any current will be passed through the device.

9.2.3 Application Curve

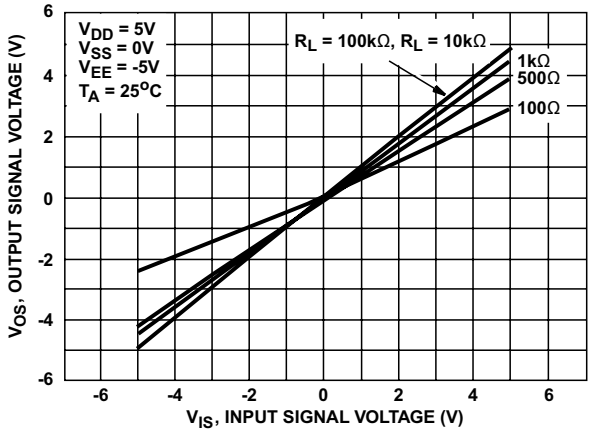


Figure 9-2. ON Characteristics for 1 of 8 Channels (CD4051B-Q1)

9.3 Power Supply Recommendations

The power supply can be any voltage between the minimum and maximum supply voltage rating located in the *Electrical Characteristics*.

Each V_{CC} terminal should have a good bypass capacitor to prevent power disturbance. For devices with a single supply, a 0.1-µF bypass capacitor is recommended. If there are multiple pins labeled V_{CC}, then a 0.01-µF or 0.022-µF capacitor is recommended for each V_{CC} because the V_{CC} pins will be tied together internally. For devices with dual supply pins operating at different voltages, for example V_{CC} and V_{DD}, a 0.1-µF bypass capacitor is recommended for each supply pin. It is acceptable to parallel multiple bypass capacitors to reject different frequencies of noise. 0.1-µF and 1-µF capacitors are commonly used in parallel. The bypass capacitor should be installed as close to the power terminal as possible for best results.

9.4 Layout

9.4.1 Layout Guidelines

Reflections and matching are closely related to loop antenna theory, but different enough to warrant their own discussion. When a PCB trace turns a corner at a 90° angle, a reflection can occur. This reflection is primarily due to the change of width of the trace. At the apex of the turn, the trace width is increased to 1.414 times its width. This upsets the transmission line characteristics, especially the distributed capacitance and self–inductance of the trace — resulting in the reflection. It is a given that not all PCB traces can be straight, and so they will have to turn corners. Figure 9-3 shows progressively better techniques of rounding corners. Only the last example maintains constant trace width and minimizes reflections.

9.4.2 Layout Example

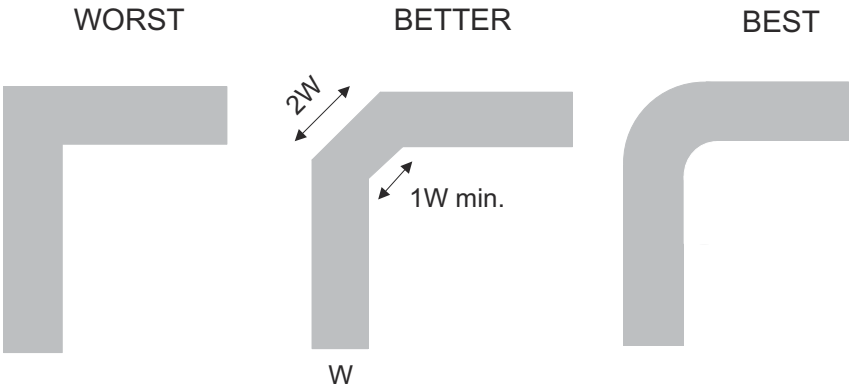


Figure 9-3. Trace Example

10 Device and Documentation Support

10.1 Documentation Support

10.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *Implications of Slow or Floating CMOS Inputs*

10.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* 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.

10.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

10.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

10.5 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.

10.6 Glossary

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

11 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.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
CD4051BQPWRG4Q1	LIFEBUY	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	CM051BQ	
CD4051BQPWRQ1	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	CM051BQ	Samples
CD4053BQM96G4Q1	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	CD4053Q	Samples
CD4053BQM96Q1	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	CD4053Q	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF CD4051B-Q1, CD4053B-Q1 :

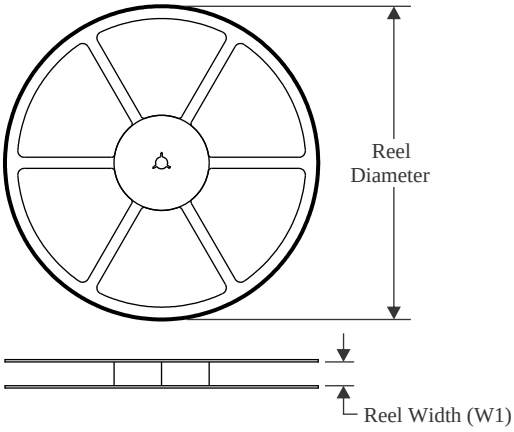
- Catalog : CD4051B, CD4053B
- Military : CD4051B-MIL, CD4053B-MIL

NOTE: Qualified Version Definitions:

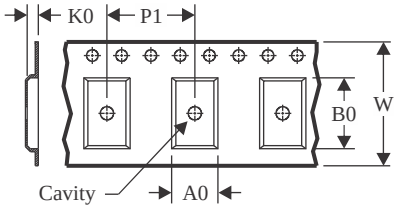
- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

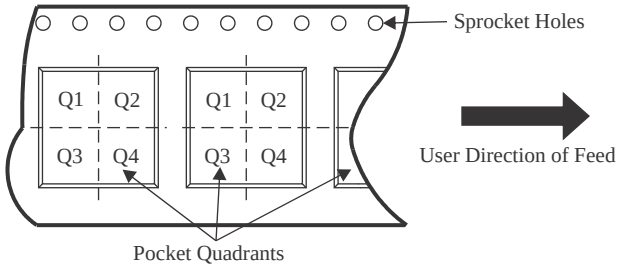


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

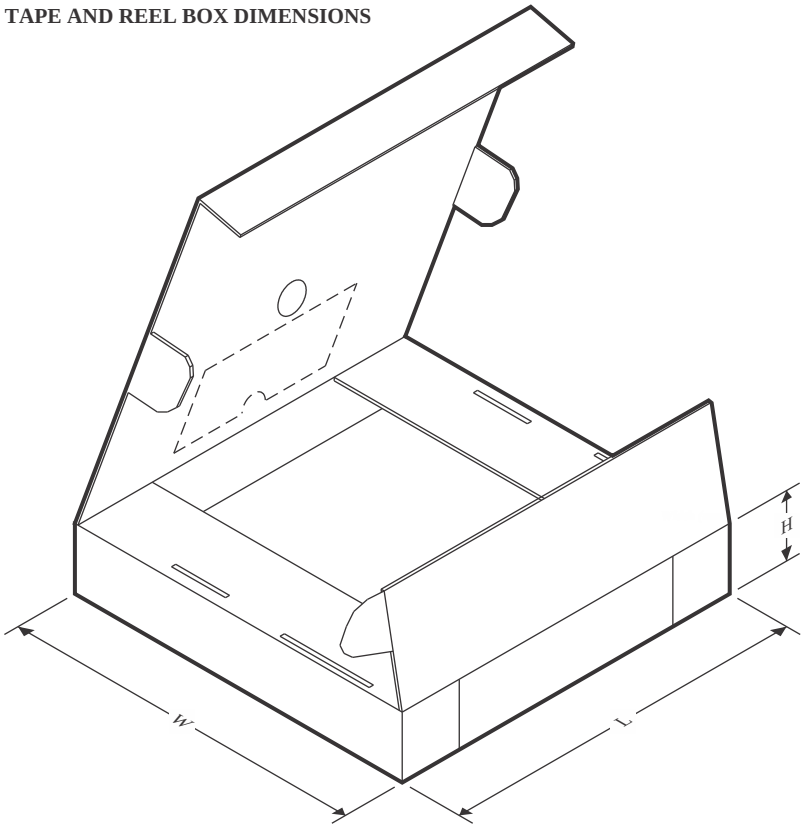
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CD4051BQPWRG4Q1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
CD4051BQPWRQ1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
CD4051BQPWRQ1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

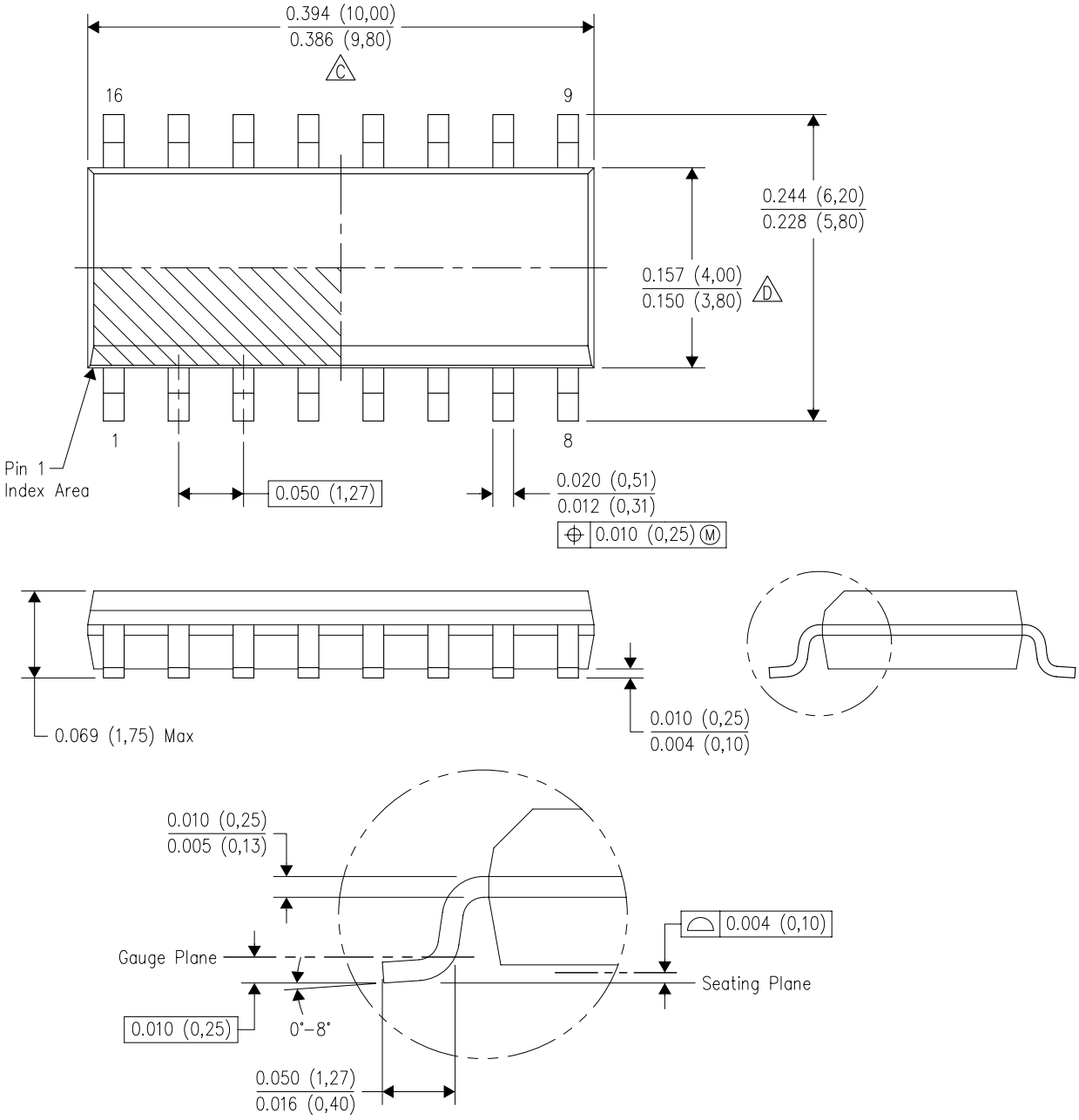
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CD4051BQPWRG4Q1	TSSOP	PW	16	2000	367.0	367.0	35.0
CD4051BQPWRQ1	TSSOP	PW	16	2000	367.0	367.0	35.0
CD4051BQPWRQ1	TSSOP	PW	16	2000	367.0	367.0	35.0

D (R–PDSO–G16) PLASTIC SMALL OUTLINE



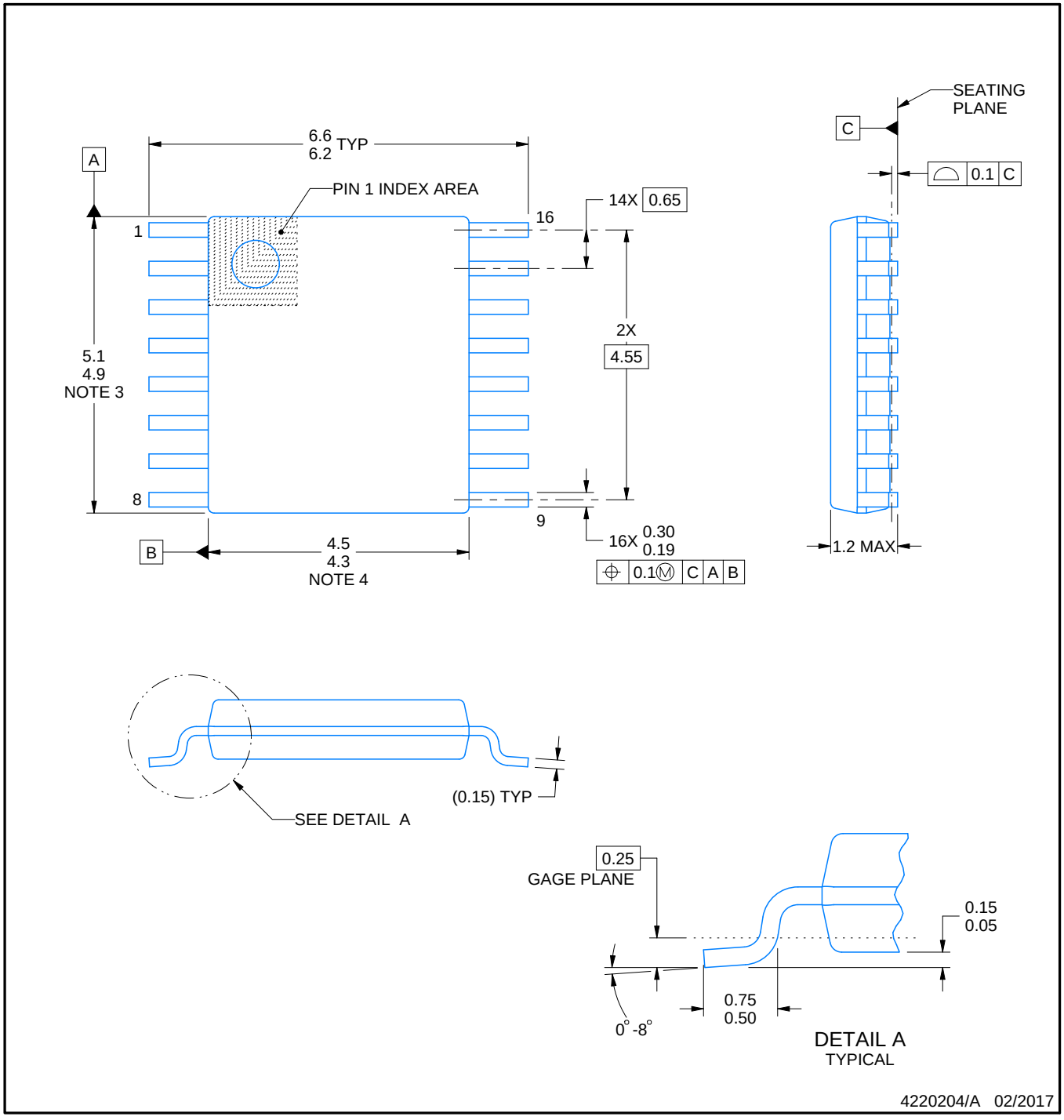
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AC.

PACKAGE OUTLINE

PW0016A

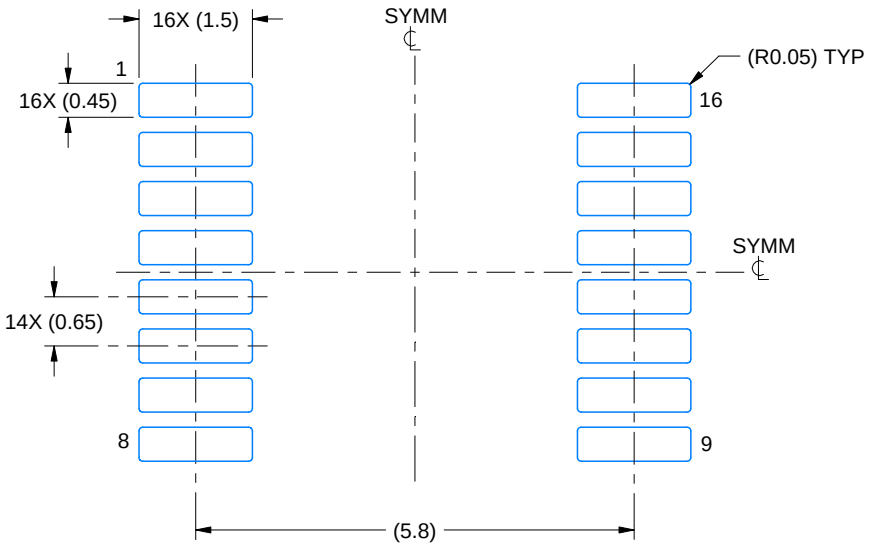
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

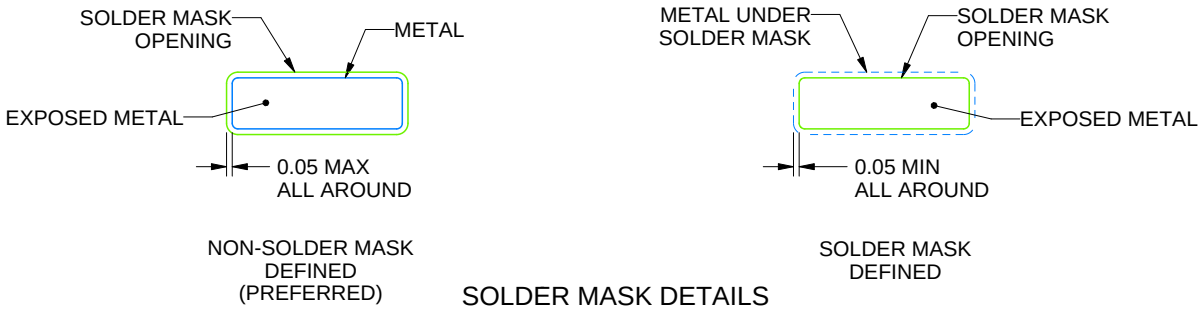


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X

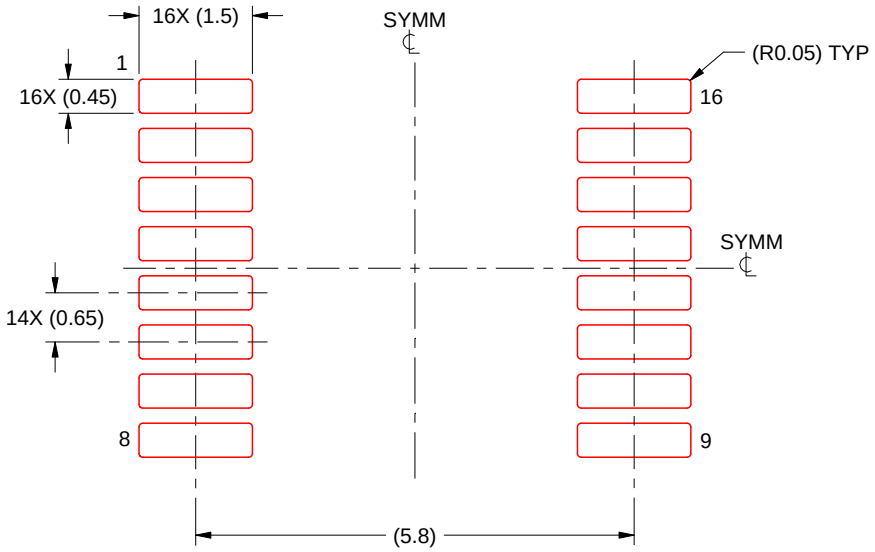


SOLDER MASK DETAILS

4220204/A 02/2017

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220204/A 02/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265