

# Precision 8-Ch/Dual 4-Ch Low Voltage Analog Multiplexers

## DESCRIPTION

The DG9408, DG9409 uses BiCMOS wafer fabrication technology that allows the DG9408, DG9409 to operate on single and dual supplies. Single supply voltage ranges from 3 V to 12 V while dual supply operation is recommended with  $\pm 3$  V to  $\pm 6$  V.

The DG9408 is an 8-channel single-ended analog multiplexer designed to connect one of eight inputs to a common output as determined by a 3-bit binary address ( $A_0$ ,  $A_1$ ,  $A_2$ ). The DG9409 is a dual 4-channel differential analog multiplexer designed to connect one of four differential inputs to a common dual output as determined by its 2-bit binary address ( $A_0$ ,  $A_1$ ). Break-before-make switching action to protect against momentary crosstalk between adjacent channels.

As a committed partner to the community and the environment, Vishay Siliconix manufactures this product with lead (Pb)-free device terminations. The DG9408, DG9409 are offered in a QFN package that has a nickel-palladium-gold device terminations and is represented by the lead (Pb)-free “-E4” suffix. The nickel-palladium-gold device terminations meet all the JEDEC standards for reflow and MSL ratings.

## FEATURES

- 2.7 V to 12 V single supply or  $\pm 3$  V to  $\pm 6$  V dual supply operation
- Low on-resistance -  $R_{ON}$ : 3.9  $\Omega$  typ.
- Fast switching:  $t_{ON}$  - 42 ns,  $t_{OFF}$  - 24 ns
- Break-before-make guaranteed
- Low leakage
- TTL, CMOS, LV logic (3 V) compatible
- 2000 V ESD protection (HBM)
- Material categorization: For definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**

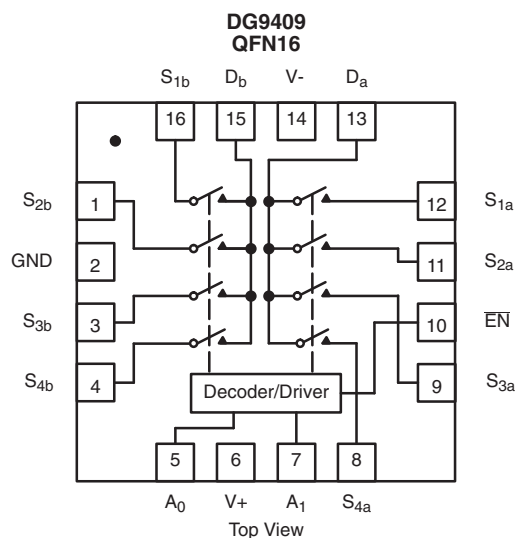
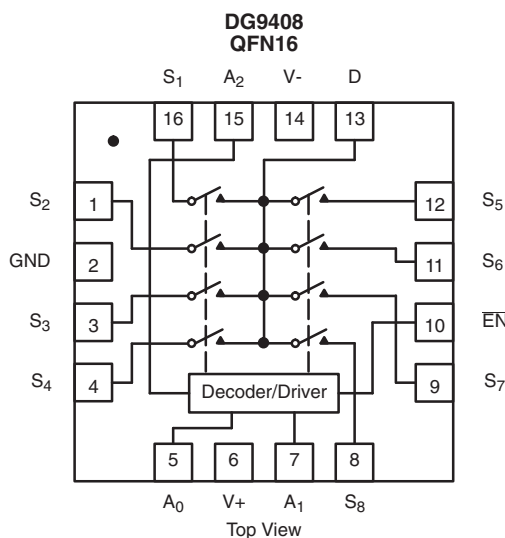
## BENEFITS

- High accuracy
- Single and dual power rail capacity
- Wide operating voltage range
- Simple logic interface

## APPLICATIONS

- Data acquisition systems
- Battery operated equipment
- Portable test equipment
- Sample and hold circuits
- Communication systems
- SDSL, DSLAM
- Audio and video signal routing

## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



## TRUTH TABLES AND ORDERING INFORMATION

TRUTH TABLE DG9408				
A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>	EN	On Switch
X	X	X	1	None
0	0	0	0	1
0	0	1	0	2
0	1	0	0	3
0	1	1	0	4
1	0	0	0	5
1	0	1	0	6
1	1	0	0	7
1	1	1	0	8

TRUTH TABLE DG9409			
A <sub>1</sub>	A <sub>0</sub>	EN	On Switch
X	X	1	None
0	0	0	1
0	1	0	2
1	0	0	3
1	1	0	4

X = Don't care

For low and high voltage levels for V<sub>AX</sub> and V<sub>EN</sub> consult "Digital Control" Parameters for Specific V+ operation. See Specifications Tables for:

Single Supply 12 V

Dual Supply V+ = 5 V, V- = - 5 V

Single Supply 5 V

Single Supply 3 V

ORDERING INFORMATION		
Temp. Range	Package	Part Number
- 40 °C to 85 °C	16-pin QFN (4 mm x 4 mm) (Variation 1)	DG9408DN-T1-E4
		DG9409DN-T1-E4

ABSOLUTE MAXIMUM RATINGS (T <sub>A</sub> = 25 °C, unless otherwise noted)			
Parameter		Limit	Unit
Voltage Referenced V+ to V-		14	V
GND		7	
Digital Inputs <sup>a</sup> , V <sub>S</sub> , V <sub>D</sub>		(V-) - 0.3 to (V+) + 0.3	
Current (Any Terminal Except S or D)		30	mA
Continuous Current, S or D		100	
Peak Current, S or D (Pulsed at 1 ms, 10 % Duty Cycle max.)		200	
Package Solder Reflow Conditions <sup>d</sup>	16-pin (4 x 4 mm) QFN	240	°C
Storage Temperature		- 65 to 150	
Power Dissipation (Package) <sup>b</sup> , (T <sub>A</sub> = 70 °C)	16-pin (4 x 4 mm) QFN <sup>c</sup>	1880	mW

Notes:

a. Signals on SX, DX or INX exceeding V+ or V- will be clamped by internal diodes. Limit forward diode current to maximum current ratings.

b. All leads soldered or welded to PC board.

c. Derate 23.5 mW/°C above 70 °C.

d. Manual soldering with soldering iron is not recommended for leadless components. The QFN is a leadless package. The end of the lead terminal is exposed copper (not plated) as a result of the singulation process in manufacturing. A solder fillet at the exposed copper lip cannot be guaranteed and is not required to ensure adequate bottom side solder interconnection.



SPECIFICATIONS (Single Supply 12 V)							
Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 12 V, ± 10 %, V- = 0 V VA, VEN = 0.8 V or 2.4 V <sup>f</sup>	Temp. <sup>b</sup>	Limits - 40 °C to 85 °C			Unit
				Min. <sup>c</sup>	Typ. <sup>d</sup>	Max. <sup>e</sup>	
Analog Switch							
Analog Signal Range <sup>e</sup>	VANALOG		Full	0		12	V
On-Resistance	RON	V+ = 10.8 V, VD = 2 V or 9 V, IS = 50 mA sequence each switch on	Room Full		4	7 7.5	Ω
RON Match Between Channels <sup>g</sup>	ΔRON	V+ = 10.8 V, VD = 2 V or 9 V, IS = 50 mA	Room			3.6	
On-Resistance Flatness <sup>i</sup>	RON Flatness		Room			8	
Switch Off Leakage Current	IS(off)	VEN = 2.4 V, VD = 11 V or 1 V, VS = 1 V or 11 V	Room Full	- 2 - 15		2 15	nA
	ID(off)		Room Full	- 2 - 15		2 15	
Channel On Leakage Current	ID(on)	VEN = 0 V, VS = VD = 1 V or 11 V	Room Full	- 2 - 15		2 15	
Digital Control							
Logic High Input Voltage	VINH		Full	2.4			V
Logic Low Input Voltage	VINL		Full			0.8	
Input Current	IIN	VAX = VEN = 2.4 V or 0.8 V	Full	- 1		1	μA
Dynamic Characteristics							
Transition Time	tTRANS	VS1 = 8 V, VS8 = 0 V, (DG9408) VS1b = 8 V, VS4b = 0 V, (DG9409) see fig. 2	Room Full		42	71 75	ns
Break-Before-Make Time	tBBM	VS(all) = VDA = 5 V see fig. 4	Room Full	2	24		
Enable Turn-On Time	tON(EN)	VAX = 0 V, VS1 = 5 V (DG9408) VAX = 0 V, VS1b = 5 V (DG9409) see fig. 3	Room Full		42	70 75	
Enable Turn-Off Time	tOFF(EN)		Room Full		24	44 46	
Charge Injection <sup>e</sup>	Q	CL = 1 nF, VGEN = 0 V, RGEN = 0 Ω	Room		29		pC
Off Isolation <sup>e, h</sup>	OIRR	f = 100 kHz, RL = 1 kΩ	Room		- 80		dB
Crosstalk <sup>e</sup>	XTALK		Room		- 85		
Source Off Capacitance <sup>e</sup>	CS(off)	f = 1 MHz, VS = 0 V, VEN = 2.4 V	DG9408	Room		21	pF
			DG9409	Room		23	
Drain Off Capacitance <sup>e</sup>	CD(off)	f = 1 MHz, VD = 0 V, VEN = 2.4 V	DG9408	Room		211	
			DG9409	Room		112	
Drain On Capacitance <sup>e</sup>	CD(on)	f = 1 MHz, VD = 0 V, VEN = 0 V	DG9408	Room		238	
			DG9409	Room		137	
Power Supplies							
Power Supply Current	I+	VEN = VA = 0 V or V+	Room			1	μA

SPECIFICATIONS (Dual Supply V+ = 5 V, V- = - 5 V)								
Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 5 V, V- = - 5 V, ± 10 % VA, VEN = 0.8 V or 2 Vf		Temp. <sup>b</sup>	Limits - 40 °C to 85 °C			Unit
					Min. <sup>c</sup>	Typ. <sup>d</sup>	Max. <sup>c</sup>	
Analog Switch								
Analog Signal Range <sup>e</sup>	VANALOG			Full	- 5		5	V
On-Resistance	RON	V+ = 4.5 V, V- = - 4.5 V, VD = ± 3.5 V, IS = 50 mA sequence each switch on		Room Full		5	8 8.5	Ω
RON Match Between Channels <sup>g</sup>	ΔRON	V+ = 4.5 V, V- = - 4.5 V, VD = ± 3.5 V, IS = 50 mA		Room			3.6	
On-Resistance Flatness <sup>i</sup>	RON Flatness			Room			8.2	
Switch Off Leakage Current <sup>a</sup>	IS(off)	V+ = 5.5 , V- = - 5.5 V VEN = 2.4 V, VD = ± 4.5 V, VS = ± 4.5 V		Room Full	- 2 - 15		2 15	nA
	ID(off)			Room Full	- 2 - 15		2 15	
Channel On Leakage Current <sup>a</sup>	ID(on)	V+ = 5.5 V, V- = - 5.5 V VEN = 0 V, VD = ± 4.5 V, VS = ± 4.5 V		Room Full	- 2 - 15		2 15	
Digital Control								
Logic High Input Voltage	VINH			Full	2			V
Logic Low Input Voltage	VINL			Full			0.8	
Input Current <sup>a</sup>	IIN	VAX = VEN = 2 V or 0.8 V		Full	- 1		1	μA
Dynamic Characteristics								
Transition Time <sup>e</sup>	tTRANS	VS1 = 3.5 V, VS8 = - 3.5 V, (DG9408) VS1b = 3.5 V, VS4b = - 3.5 V, (DG9409) see fig. 2		Room Full		68	89 94	ns
Break-Before-Make Time <sup>e</sup>	tBBM	VS(all) = VDA = 3.5 V see fig. 4		Room Full	1	16		
Enable Turn-On Time <sup>e</sup>	tON(EN)	VAX = 0 V, VS1 = 3.5 V (DG9408) VAX = 0 V, VS1b = 3.5 V (DG9409) see fig. 3		Room Full		68	88 94	
Enable Turn-Off Time <sup>e</sup>	tOFF(EN)			Room Full		58	78 81	
Source Off Capacitance <sup>e</sup>	CS(off)	f = 1 MHz, VS = 0 V, VEN = 2 V	DG9408	Room		23		pF
			DG9409	Room		23		
Drain Off Capacitance <sup>e</sup>	CD(off)	f = 1 MHz, VD = 0 V, VEN = 2 V	DG9408	Room		223		
			DG9409	Room		113		
Drain On Capacitance <sup>e</sup>	CD(on)	f = 1 MHz, VD = 0 V, VEN = 0 V	DG9408	Room		246		
			DG9409	Room		137		
Power Supplies								
Power Supply Current	I+	VEN = VA = 0 V or V+		Room			1	μA
	I-			Room	- 1			



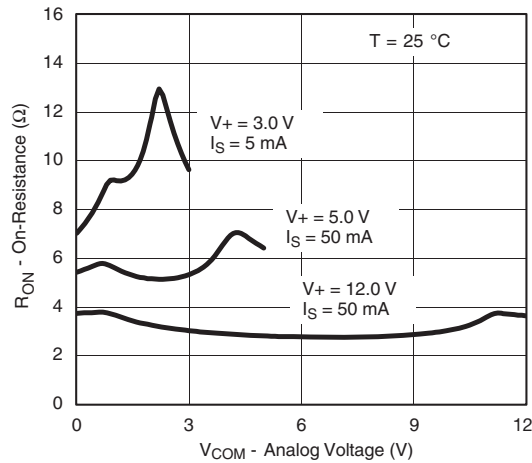
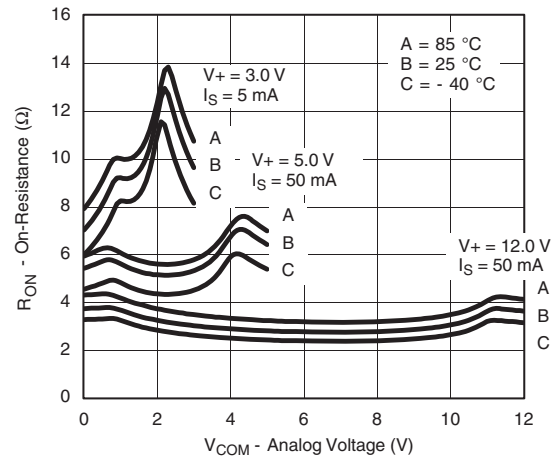
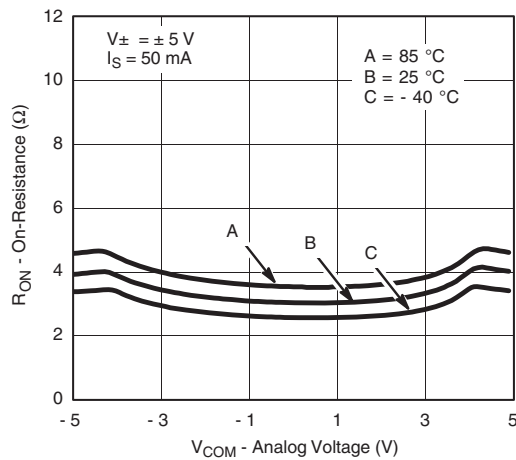
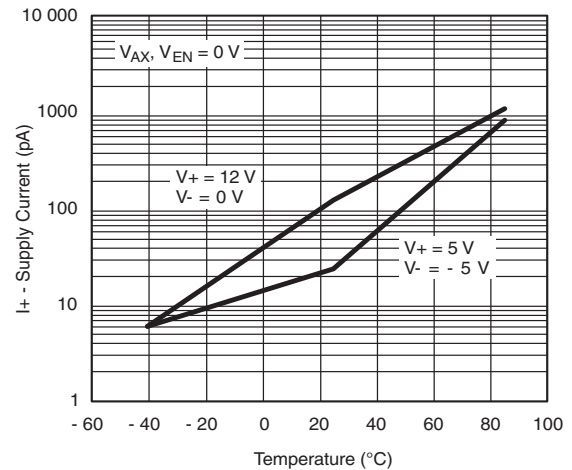
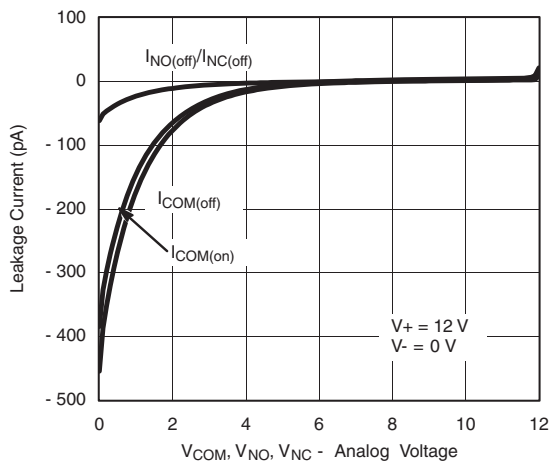
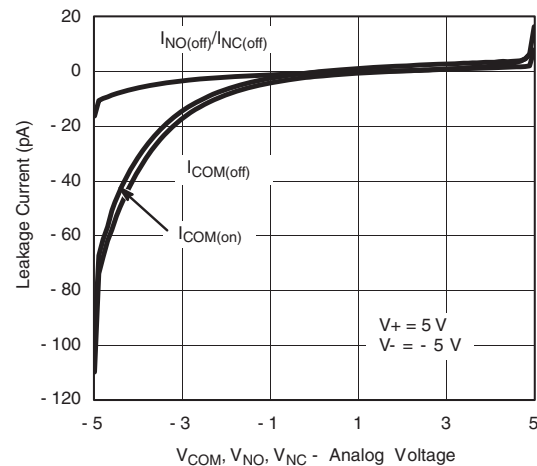
SPECIFICATIONS (Single Supply 5 V)							
Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 5 V, ± 10 %, V- = 0 V VA, VEN = 0.8 V or 2 V <sup>f</sup>	Temp. <sup>b</sup>	Limits - 40 °C to 85 °C			Unit
				Min. <sup>c</sup>	Typ. <sup>d</sup>	Max. <sup>c</sup>	
Analog Switch							
Analog Signal Range <sup>e</sup>	VANALOG		Full	0		5	V
On-Resistance	RON	V+ = 4.5 V, VD or VS = 1 V or 3.5 V, IS = 50 mA	Room Full		7	10.5 11	Ω
RON Match Between Channels <sup>g</sup>	ΔRON	V+ = 4.5 V, VD = 1 V or 3.5 V, IS = 50 mA	Room			3.6	
On-Resistance Flatness <sup>i</sup>	RON Flatness		Room			9	
Switch Off Leakage Current <sup>a</sup>	IS(off)	V+ = 5.5 V VS = 1 V or 4 V, VD = 4 V or 1 V	Room Full	- 2 - 15		2 15	nA
	ID(off)		Room Full	- 2 - 15		2 15	
Channel On Leakage Current <sup>a</sup>	ID(on)	V+ = 5.5 V VD = VS = 1 V or 4 V, sequence each switch on	Room Full	- 2 - 15		2 15	
Digital Control							
Logic High Input Voltage	VINH	V+ = 5 V	Full	2			V
Logic Low Input Voltage	VINL		Full			0.8	
Input Current <sup>a</sup>	IIN	VAX = VEN = 2 V or 0.8 V	Full	- 1		1	μA
Dynamic Characteristics							
Transition Time <sup>e</sup>	tTRANS	VS1 = 3.5 V, VS8 = 0 V, (DG9408) VS1b = 3.5 V, VS4b = 0 V, (DG9409) see fig. 2	Room Full		73	94 104	ns
Break-Before-Make Time <sup>e</sup>	tOPEN	VS(all) = VDA = 3.5 V see fig. 4	Room Full	2	29		
Enable Turn-On Time <sup>e</sup>	tON(EN)	VAX = 0 V, VS1 = 3.5 V (DG9408) VAX = 0 V, VS1b = 3.5 V (DG9409) see fig. 3	Room Full		74	94 104	
Enable Turn-Off Time <sup>e</sup>	tOFF(EN)		Room Full		38	57 61	
Charge Injection <sup>e</sup>	Q	CL = 1 nF, RGEN = 0 , VGEN = 0 V	Room		20		pC
Off Isolation <sup>e, h</sup>	OIRR	RL = 1 kΩ, f = 100 kHz	Room		- 81		dB
Crosstalk <sup>e</sup>	XTALK		Room		- 85		
Source Off Capacitance <sup>e</sup>	CS(off)	f = 1 MHz, VS = 0 V, VEN = 0 V	DG9408 Room		22		pF
			DG9409 Room		24		
Drain Off Capacitance <sup>e</sup>	CD(off)	f = 1 MHz, VD = 0 V, VEN = 2 V	DG9408 Room		223		
			DG9409 Room		113		
Drain On Capacitance <sup>e</sup>	CD(on)	f = 1 MHz, VD = 0 V, VEN = 0 V	DG9408 Room		244		
			DG9409 Room		143		
Power Supplies							
Power Supply Current	I+	VEN = VA = 0 V or V+	Room			1	μA

SPECIFICATIONS (Single Supply 3 V)								
Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 3 V, ± 10 %, V- = 0 V VEN = 0.4 V or 1.8 V <sup>f</sup>		Temp. <sup>b</sup>	Limits - 40 °C to 85 °C			Unit
					Min. <sup>c</sup>	Typ. <sup>d</sup>	Max. <sup>c</sup>	
Analog Switch								
Analog Signal Range <sup>e</sup>	VANALOG			Full	0		3	V
On-Resistance	RON	V+ = 2.7 V, VD = 0.5 V or 2.2 V, IS = 5 mA		Room Full		12	25.5 26.5	Ω
RON Match Between Channels <sup>g</sup>	ΔRON	V+ = 2.7 V, VD = 0.5 V or 2.2 V, IS = 5 mA		Room			3.6	
On- Resistance Flatness <sup>i</sup>	RON Flatness			Room			13	
Switch Off Leakage Current <sup>a</sup>	IS(off)	V+ = 3.3 V VS = 2 V or 1 V, VD = 1 or 2 V		Room Full	- 2 - 15		2 15	nA
	ID(off)			Room Full	- 2 - 15		2 15	
Channel On Leakage Current <sup>a</sup>	ID(on)	V+ = 3.3 V VD = VS = 1 V or 2 V, sequence each switch on		Room Full	- 2 - 15		2 15	
Digital Control								
Logic High Input Voltage	VINH			Full	1.8			V
Logic Low Input Voltage	VINL			Full			0.4	
Input Current <sup>a</sup>	IIN	VAX = VEN = 1.8 V or 0.4 V		Full	- 1		1	μA
Dynamic Characteristics								
Transition Time	tTRANS	VS1 = 1.5 V, VS8 = 0 V, (DG9408) VS1b = 1.5 V, VS4b = 0 V, (DG9409) see fig. 2		Room Full		140	165 182	ns
Break-Before-Make Time	tBBM	VS(all) = VDA = 1.5 V see fig. 4		Room Full	2	63		
Enable Turn-On Time	tON(EN)	VAX = 0 V, VS1 = 1.5 V (DG9408) VAX = 0 V, VS1b = 1.5 V (DG9409) see fig. 3		Room Full		140	162 178	
Enable Turn-Off Time	tOFF(EN)			Room Full		76	97 104	
Charge Injection <sup>e</sup>	Q	CL = 1 nF, RGEN = 0 , VGEN = 0 V		Room		7		pC
Off Isolation <sup>e, h</sup>	OIRR	f = 100 kHz, RL = 1 kΩ		Room		- 81		dB
Crosstalk <sup>e</sup>	XTALK			Room		- 85		
Source Off Capacitance <sup>e</sup>	CS(off)	f = 1 MHz, VS = 0 V, VEN = 1.8 V	DG9408	Room		23		pF
			DG9409	Room		25		
Drain Off Capacitance <sup>e</sup>	CD(off)	f = 1 MHz, VD = 0 V, VEN = 1.8 V	DG9408	Room		230		
			DG9409	Room		120		
Drain On Capacitance <sup>e</sup>	CD(on)	f = 1 MHz, VD = 0 V, VEN = 0 V	DG9408	Room		256		
			DG9409	Room		147		
Power Supplies								
Power Supply Current	I+	VEN = VA = 0 V or V+		Room			1	μA

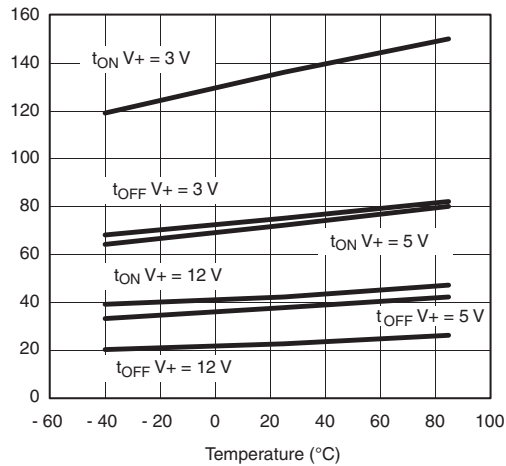
### Notes:

- Leakage parameters are guaranteed by worst case test condition and not subject to production test.
- Room = 25 °C, full = as determined by the operating temperature suffix.
- The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
- Guaranteed by design, not subject to production test.
- $V_{IN}$  = input voltage to perform proper function.
- $\Delta R_{DON} = R_{DON\text{ Max}} - R_{DON\text{ Min}}$ .
- Worst case isolation occurs on Channel 4 due to proximity to the drain pin.
- $R_{DON}$  flatness is measured as the difference between the minimum and maximum measured values across a defined Analog signal.

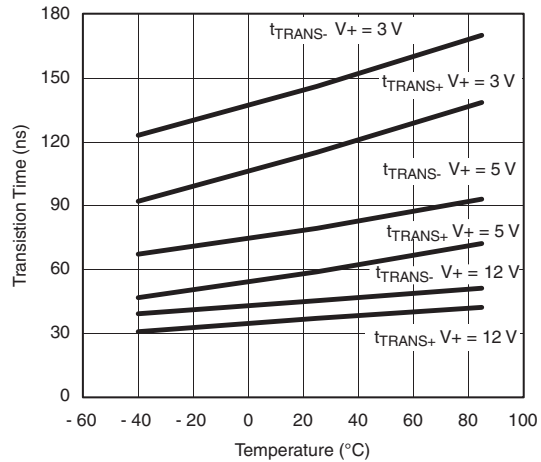
Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

 **$R_{ON}$  vs.  $V_{COM}$  and Single Supply Voltage**

 **$R_{ON}$  vs. Analog Voltage and Temperature**

 **$R_{ON}$  vs. Analog Voltage and Temperature**

**Supply Current vs. Temperature**

**Leakage Current vs. Analog Voltage**

**Leakage Current vs. Analog Voltage**

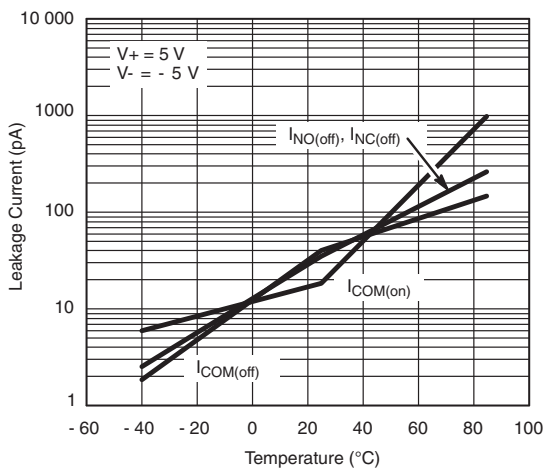
### TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



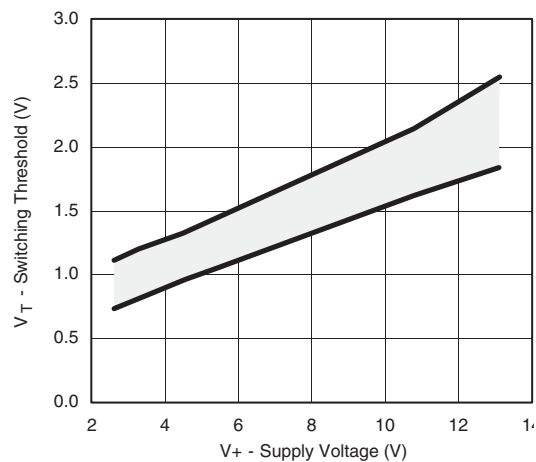
**Switching Time vs. Temperature and Single Supply Voltage**



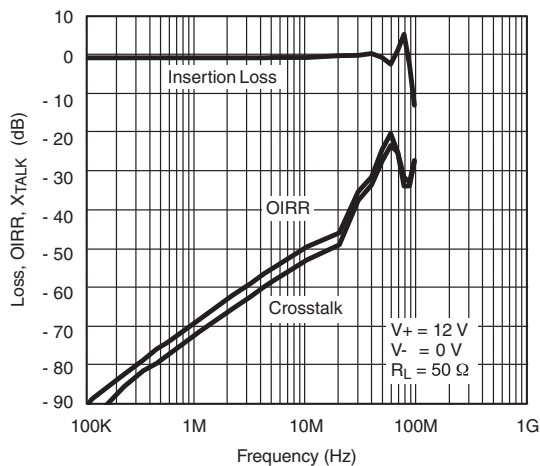
**Transition Time vs. Temperature and Single Supply Voltage**



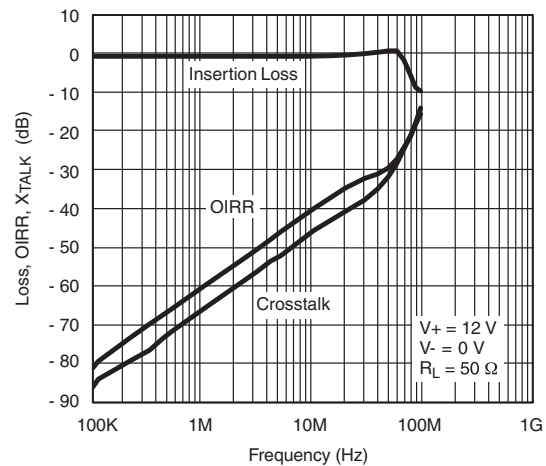
**Leakage Current vs. Temperature**



**Switching Threshold vs. Supply Voltage**

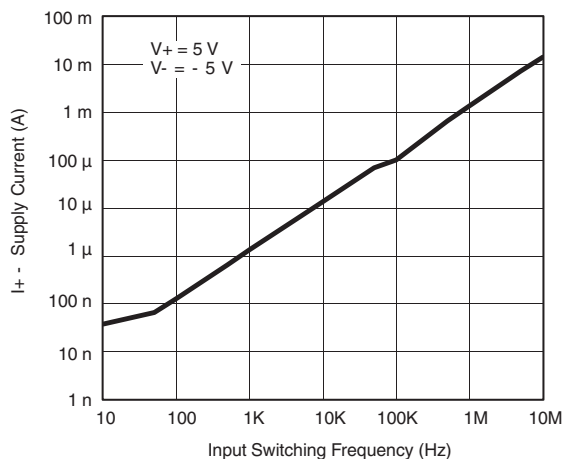
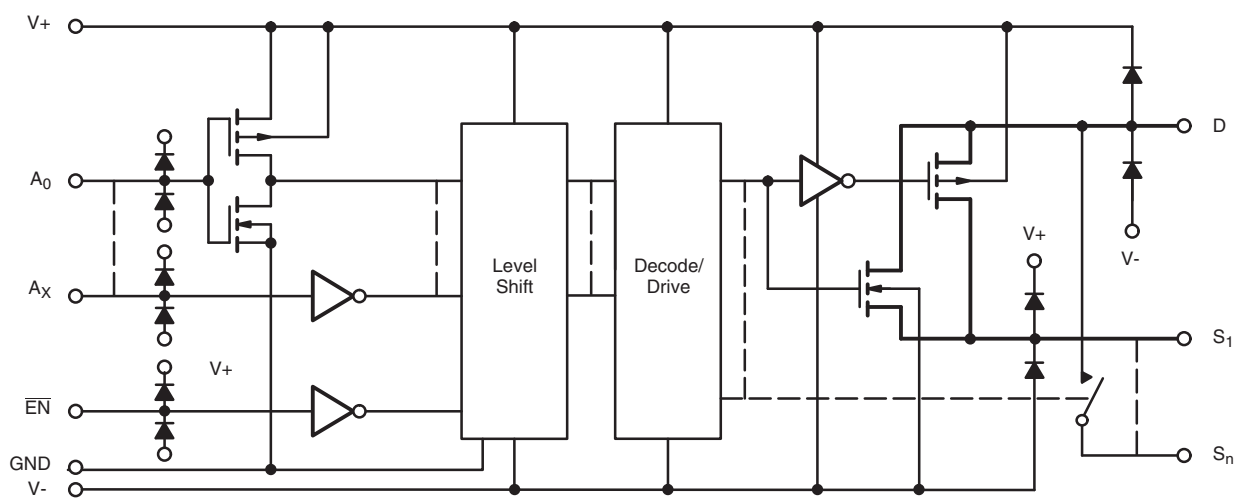


**Insertion Loss, Off Isolation and Crosstalk vs. Frequency (DG9408)**

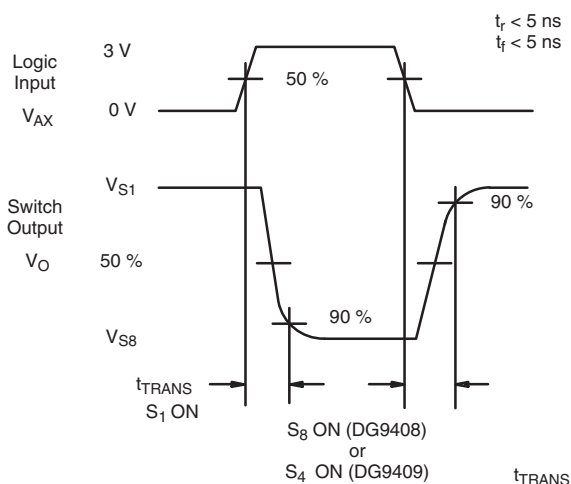
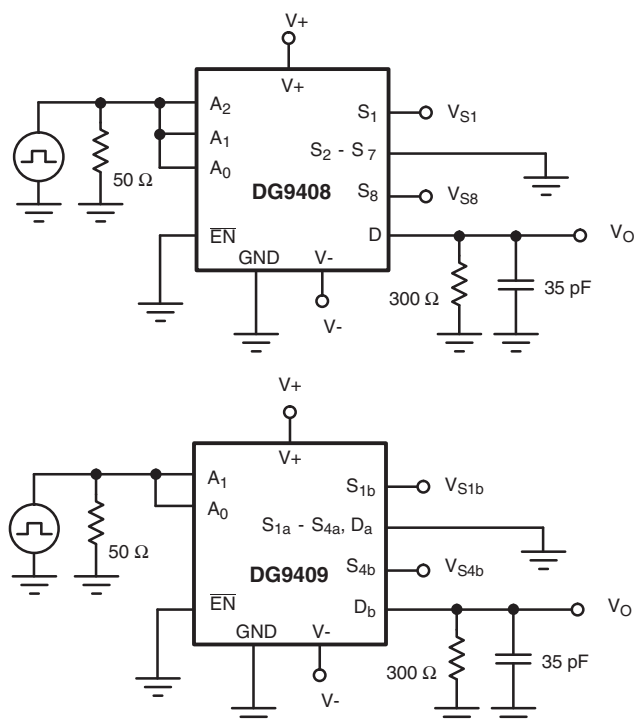


**Insertion Loss, Off Isolation and Crosstalk vs. Frequency (DG9409)**



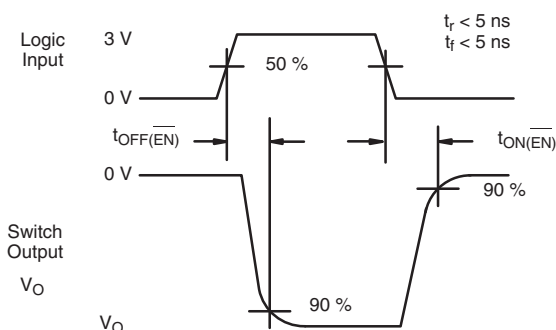
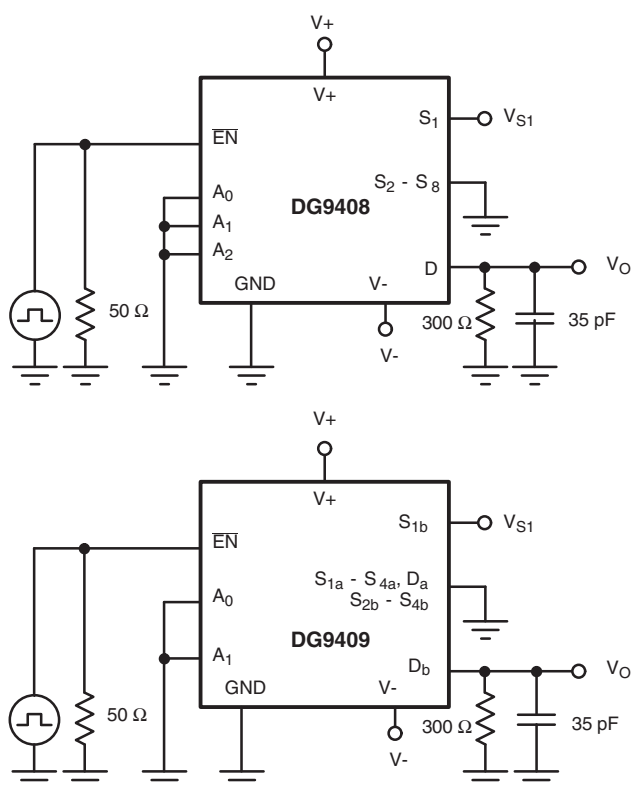
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

**Supply Current vs. Input Switching Frequency**
**SCHEMATIC DIAGRAM** (Typical Channel)

**Figure 1.**

## TEST CIRCUITS



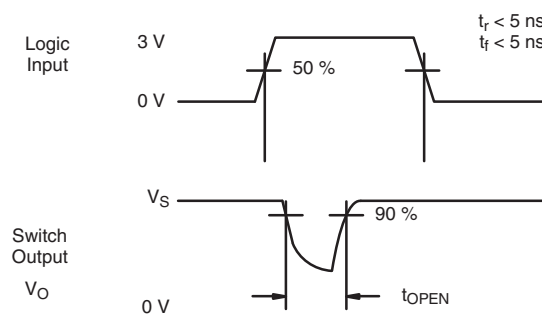
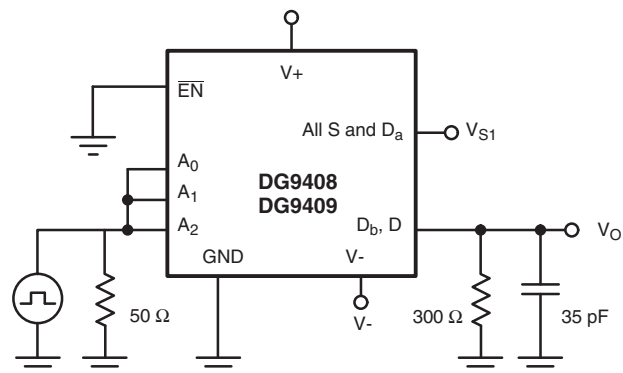
Return to Specifications:  
 Single Supply 12 V  
 Dual Supply V<sub>+</sub> = 5 V, V<sub>-</sub> = -5 V  
 Single Supply 5 V  
 Single Supply 3 V

Figure 2. Transition Time

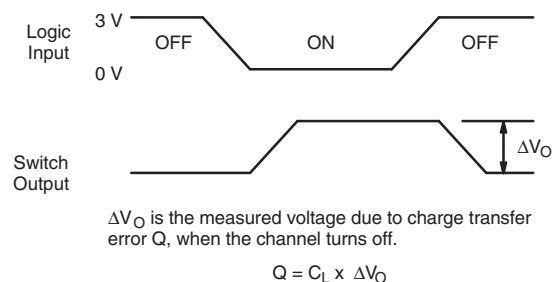
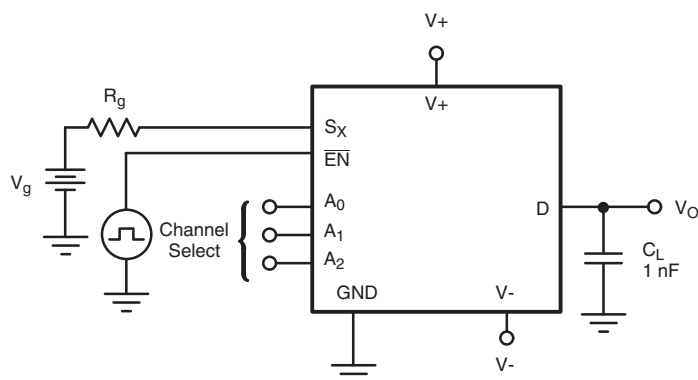
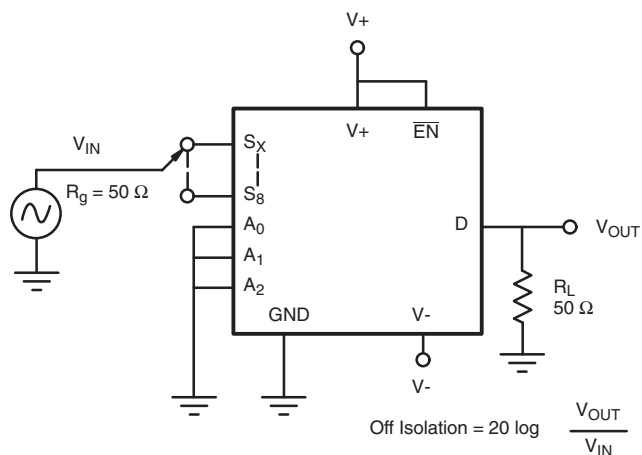


Return to Specifications:  
 Single Supply 12 V  
 Dual Supply V<sub>+</sub> = 5 V, V<sub>-</sub> = -5 V  
 Single Supply 5 V  
 Single Supply 3 V

Figure 3. Enable Switching Time

**TEST CIRCUITS**


Return to Specifications:  
 Single Supply 12 V  
 Dual Supply  $V_+ = 5\text{ V}$ ,  $V_- = -5\text{ V}$   
 Single Supply 5 V  
 Single Supply 3 V

**Figure 4. Break-Before-Make Interval**

**Figure 5. Charge Injection**

**Figure 6. Off Isolation**

## TEST CIRCUITS

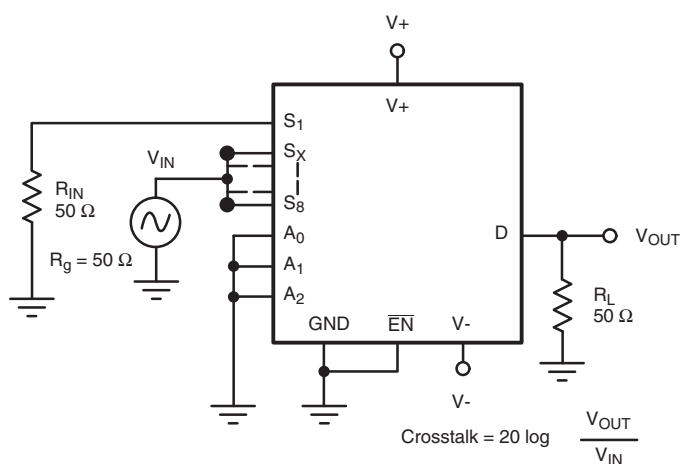


Figure 7. Crosstalk

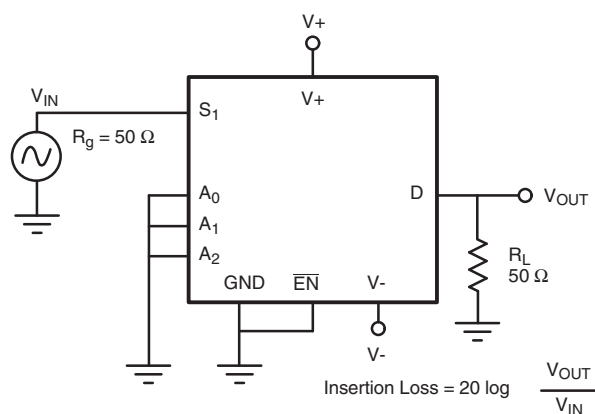


Figure 8. Insertion Loss

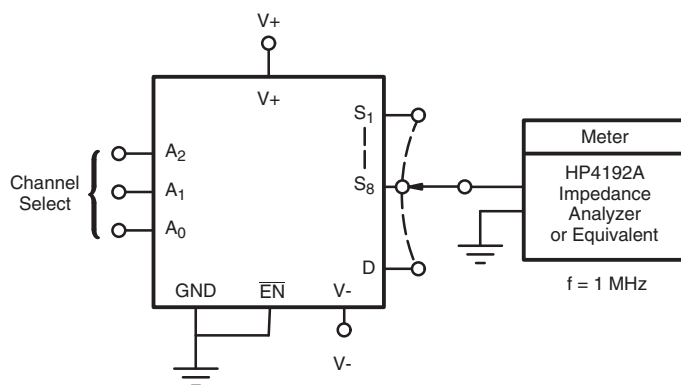
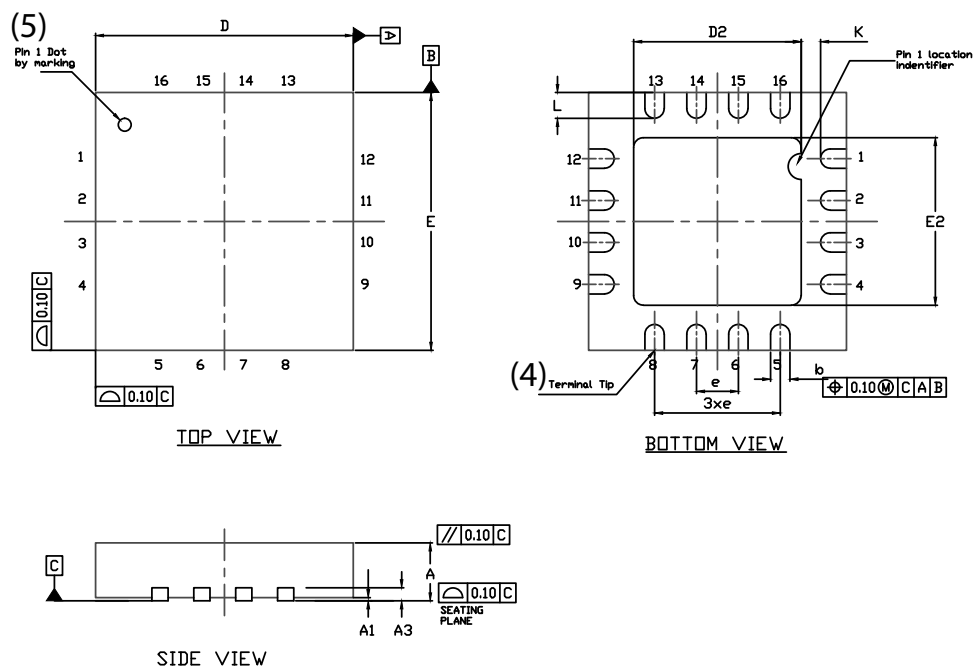


Figure 9. Source Drain Capacitance

Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see [www.vishay.com/ppg?71870](http://www.vishay.com/ppg?71870).

## QFN 4x4-16L Case Outline



DIM	VARIATION 1						VARIATION 2					
	MILLIMETERS <sup>(1)</sup>			INCHES			MILLIMETERS <sup>(1)</sup>			INCHES		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.75	0.85	0.95	0.029	0.033	0.037	0.75	0.85	0.95	0.029	0.033	0.037
A1	0	-	0.05	0	-	0.002	0	-	0.05	0	-	0.002
A3	0.20 ref.			0.008 ref.			0.20 ref.			0.008 ref.		
b	0.25	0.30	0.35	0.010	0.012	0.014	0.25	0.30	0.35	0.010	0.012	0.014
D	4.00 BSC			0.157 BSC			4.00 BSC			0.157 BSC		
D2	2.0	2.1	2.2	0.079	0.083	0.087	2.5	2.6	2.7	0.098	0.102	0.106
e	0.65 BSC			0.026 BSC			0.65 BSC			0.026 BSC		
E	4.00 BSC			0.157 BSC			4.00 BSC			0.157 BSC		
E2	2.0	2.1	2.2	0.079	0.083	0.087	2.5	2.6	2.7	0.098	0.102	0.106
K	0.20 min.			0.008 min.			0.20 min.			0.008 min.		
L	0.5	0.6	0.7	0.020	0.024	0.028	0.3	0.4	0.5	0.012	0.016	0.020
N <sup>(3)</sup>	16			16			16			16		
Nd <sup>(3)</sup>	4			4			4			4		
Ne <sup>(3)</sup>	4			4			4			4		

### Notes

- Use millimeters as the primary measurement.
- Dimensioning and tolerances conform to ASME Y14.5M. - 1994.
- N is the number of terminals. Nd and Ne is the number of terminals in each D and E site respectively.
- Dimensions b applies to plated terminal and is measured between 0.15 mm and 0.30 mm from terminal tip.
- The pin 1 identifier must be existed on the top surface of the package by using identification mark or other feature of package body.
- Package warpage max. 0.05 mm.

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