

## Single 4 x 1 and Dual 2 x 1 Multiplexers

### DESCRIPTION

The DG9414, a single 4 to 1 multiplexer, and the DG9415, a dual 2 x 1 multiplexer, are monolithic CMOS analog devices designed for high performance low voltage operation. Combining low power, high speed, low on-resistance and small physical size, the DG9414 and DG9415 are ideal for portable and battery powered applications requiring high performance and efficient use of board space.

Both the DG9414 and DG9415 are built on Vishay Siliconix's low voltage BCD-15 process. Minimum ESD protection, per Method 3015.7, is 2000 V. An epitaxial layer prevents latchup. Break-before-make is guaranteed for DG9415.

### FEATURES

- Low voltage operation (+ 2.7 V to + 12 V)
- Low on-resistance -  $R_{DS(on)}$ : 14  $\Omega$
- Low power consumption
- TTL compatible
- ESD protection > 2000 V (method 3015.7)
- Available in TSSOP-10 (aka MSOP-10)
- **Compliant to RoHS Directive 2002/95/EC**


**RoHS**  
COMPLIANT

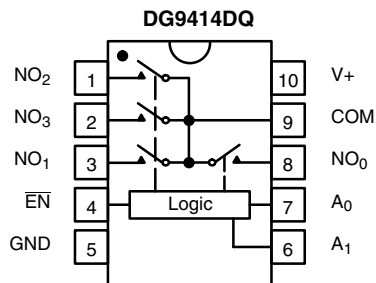
### BENEFITS

- High accuracy
- Simple logic interface
- Reduce board space

### APPLICATIONS

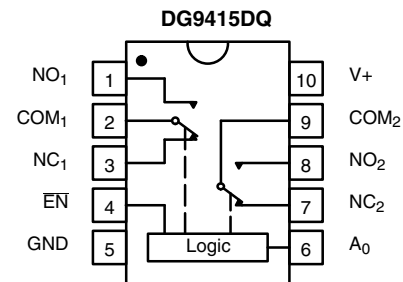
- Battery operated systems
- Portable test equipment
- Sample and hold circuits
- Cellular phones
- Communication systems
- Networking equipment

### FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



$\overline{EN}$	$A_1$	$A_0$	On Switch
1	X	X	None
0	0	0	$NO_0$
0	0	1	$NO_1$
0	1	0	$NO_2$
0	1	1	$NO_3$

X = Do not care



$\overline{EN}$	$A_0$	On Switch
1	X	None
0	0	$NC_1$ $NC_2$
0	1	$NO_1$ $NO_2$

X = Do not care

### ORDERING INFORMATION

Temp Range	Package	Part Number
- 40 °C to 85 °C	MSOP-10	DG9414DQ-T1-E3
		DG9415DQ-T1-E3



ABSOLUTE MAXIMUM RATINGS		
Parameter	Limit	Unit
Reference V+ to GND	- 0.3 to + 13	V
IN, COM, NC, NO <sup>a</sup>	- 0.3 to (V+ + 0.3)	
Continuous Current (Any terminal)	± 20	mA
Peak Current (Pulsed at 1 ms, 10 % duty cycle)	± 40	
ESD (Method 3015.7)	> 2000	V
Storage Temperature (D Suffix)	- 65 to 150	°C

Notes:

- a. Signals on S<sub>x</sub>, D<sub>x</sub> or IN<sub>x</sub> 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.

SPECIFICATIONS (V+ = 3 V)							
Parameter	Symbol	Test Conditions Otherwise Unless Specified V+ = 3 V, ± 10 %, V <sub>IN</sub> = 0.4 V or 2.4 V <sup>e</sup>	Temp. <sup>a</sup>	Limits - 40 °C to 85 °C			Unit
				Min. <sup>c</sup>	Typ. <sup>b</sup>	Max. <sup>c</sup>	
<b>Analog Switch</b>							
Analog Signal Range <sup>d</sup>	V <sub>ANALOG</sub>		Full	0		V+	V
On-Resistance	R <sub>ON</sub>	V+ = 2.7 V, V <sub>COM</sub> = 1 V/1.5 V/2 V I <sub>NO</sub> or I <sub>NC</sub> = 5 mA	Room Full		63	97 101	Ω
R <sub>ON</sub> Match <sup>d</sup>	ΔR <sub>ON</sub>		Room		3	11	
R <sub>ON</sub> Flatness <sup>d,f</sup>	R <sub>ON</sub> Flatness		Room		14	33	
NO or NC Off Leakage Current <sup>g</sup>	I <sub>NO/NC(off)</sub>	V+ = 3.3, V <sub>NO</sub> or V <sub>NC</sub> = 0.3 V/3 V V <sub>COM</sub> = 3 V/0.3 V	Room Full	- 1 - 10		1 10	nA
COM Off Leakage Current <sup>g</sup>	I <sub>COM(off)</sub>		Room Full	- 1 - 10		1 10	
Channel-On Leakage Current <sup>g</sup>	I <sub>COM(on)</sub>	V+ = 3.3 V V <sub>COM</sub> = V <sub>NO</sub> or V <sub>NC</sub> = 0.3 V/3 V	Room Full	- 1 - 10		1 10	
<b>Digital Control</b>							
Input Current <sup>g</sup>	I <sub>INL</sub> or I <sub>INH</sub>	V <sub>IN</sub> = 0 or V+	Full	- 1		1	μA
Input High Voltage <sup>d</sup>	V <sub>INH</sub>		Full	1.6			V
Input Low Voltage <sup>d</sup>	V <sub>INL</sub>		Full			0.4	
<b>Dynamic Characteristics</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>NO</sub> or V <sub>NC</sub> = 1.5 V	Room Full		102	125 142	ns
Turn-Off Time	t <sub>OFF</sub>		Room Full		45	68 75	
Break-Before-Make Time	t <sub>D</sub>		Room	7	78		
Transition Time	t <sub>trans</sub>	V <sub>NO</sub> = 1.5 V/0 V, V <sub>NC</sub> = 0 V/1.5 V	Room Full		81	128 144	
Charge Injection <sup>d</sup>	Q <sub>INJ</sub>	C <sub>L</sub> = 1 nF, V <sub>gen</sub> = 0 V, R <sub>gen</sub> = 0 Ω	Room		3		pC
Off-Isolation	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room		- 58		dB
Channel-to-Channel Crosstalk (DG9415)	X <sub>TALK</sub>	R <sub>L</sub> = 50 Ω, f = 1 MHz	Room		- 64		
NO, NC Off Capacitance	C <sub>NO(off)</sub> , C <sub>NC(off)</sub>	f = 1 MHz	DG9414	Room		11	pF
			DG9415	Room		10	
COM Off Capacitance	C <sub>COM(off)</sub>		DG9414	Room		26	
			DG9415	Room		13	
COM On Capacitance	C <sub>COM(on)</sub>		DG9414	Room		43	
			DG9415	Room		25	
<b>Power Supply</b>							
Power Supply Range	V+			2.7		3.3	V
Power Supply Current <sup>h</sup>	I+	V+ = 3.3 V, V <sub>IN</sub> = 0 V or 3.3 V	Full			1	μA



SPECIFICATIONS (V <sub>+</sub> = 5 V)							
Parameter	Symbol	Test Conditions Otherwise Unless Specified V <sub>+</sub> = 5 V, ± 10 %, V <sub>IN</sub> = 0.8 V or 2.4 V <sup>e</sup>	Temp. <sup>a</sup>	Limits - 40 °C to 85 °C			Unit
				Min. <sup>c</sup>	Typ. <sup>b</sup>	Max. <sup>c</sup>	
<b>Analog Switch</b>							
Analog Signal Range <sup>d</sup>	V <sub>ANALOG</sub>		Full	0		V <sub>+</sub>	V
On-Resistance	R <sub>ON</sub>	V <sub>+</sub> = 4.5 V, V <sub>COM</sub> = 1.5 V/2.5 V/3.5 V I <sub>NO</sub> or I <sub>NC</sub> = 10 mA	Room		33	56	Ω
R <sub>ON</sub> Match	ΔR <sub>ON</sub>		Room		2	10	
R <sub>ON</sub> Flatness <sup>f</sup>	R <sub>ON</sub> Flatness		Room		10	20	
NO or NC Off Leakage Current <sup>g</sup>	I <sub>NO/NC(off)</sub>	V <sub>+</sub> = 5.5 V, V <sub>NO</sub> or V <sub>NC</sub> = 1 V/4.5 V V <sub>COM</sub> = 4.5 V/1 V	Room	- 1		1	nA
COM Off Leakage Current <sup>g</sup>	I <sub>COM(off)</sub>		Room	- 1		1	
Channel-On Leakage Current <sup>g</sup>	I <sub>COM(on)</sub>	V <sub>+</sub> = 5.5 V V <sub>COM</sub> = V <sub>NO</sub> or V <sub>NC</sub> = 1 V/4.5 V	Room	- 1		1	
<b>Digital Control</b>							
Input Current <sup>h</sup>	I <sub>INL</sub> or I <sub>INH</sub>	V <sub>IN</sub> = 0 or V <sub>+</sub>	Full	- 1		1	μA
Input High Voltage <sup>d</sup>	V <sub>INH</sub>		Full	1.8			V
Input Low Voltage <sup>d</sup>	V <sub>INL</sub>		Full			0.6	
<b>Dynamic Characteristics</b>							
Turn-On Time <sup>h</sup>	t <sub>ON</sub>	V <sub>NO</sub> or V <sub>NC</sub> = 3 V	Room		56	77	ns
Turn-Off Time <sup>h</sup>	t <sub>OFF</sub>		Room		25	46	
Break-Before-Make Timet <sup>h</sup>	t <sub>D</sub>		Room	7	34		
Transition Time	t <sub>trans</sub>	V <sub>NO</sub> = 3 V/ 0 V, V <sub>NC</sub> = 0 V/3 V	Room		47	77	dB
Off-Isolation	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room		- 58		
Channel-to-Channel Crosstalk (DG9415)	X <sub>TALK</sub>	R <sub>L</sub> = 50 Ω, f = 1 MHz	Room		- 64		
Charge Injection <sup>d</sup>	Q <sub>INJ</sub>	C <sub>L</sub> = 1 nF, V <sub>gen</sub> = 0 V, R <sub>gen</sub> = 0 Ω	Room		6		pC
NO, NC Off Capacitance	C <sub>NO(off)</sub> , C <sub>NC(off)</sub>	f = 1 MHz	DG9414	Room	11		pF
			DG9415	Room	10		
COM Off Capacitance	C <sub>COM(off)</sub>		DG9414	Room	25		
			DG9415	Room	13		
COM On Capacitance	C <sub>COM(on)</sub>		DG9414	Room	42		
			DG9415	Room	24		
<b>Power Supply</b>							
Power Supply Range	V <sub>+</sub>			4.5		5.5	V
Power Supply Current <sup>h</sup>	I <sub>+</sub>	V <sub>+</sub> = 5.5 V, V <sub>IN</sub> = 0 V or 5.5 V	Full			1	μA

Notes:

- a. Room = 25 °C, Full = as determined by the operating suffix.
- b. Typical values are for design aid only, not guaranteed nor subject to production testing.
- c. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this datasheet.
- d. Guarantee by design, nor subjected to production test.
- e. V<sub>IN</sub> = input voltage to perform proper function.
- f. Difference of min and max values.
- g. Guaranteed by 12 V leakage testing, not production tested.
- h. Guaranteed by worst case test conditions and not subject to test.

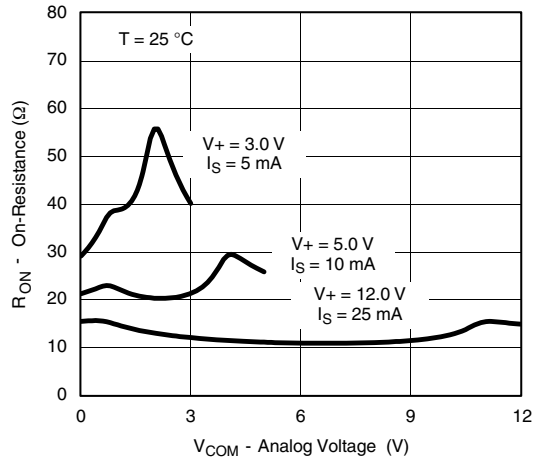
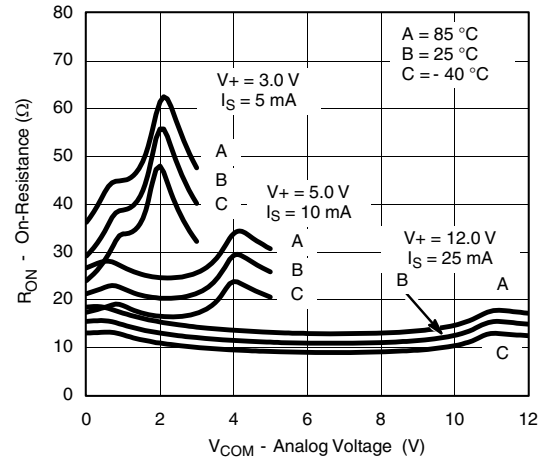
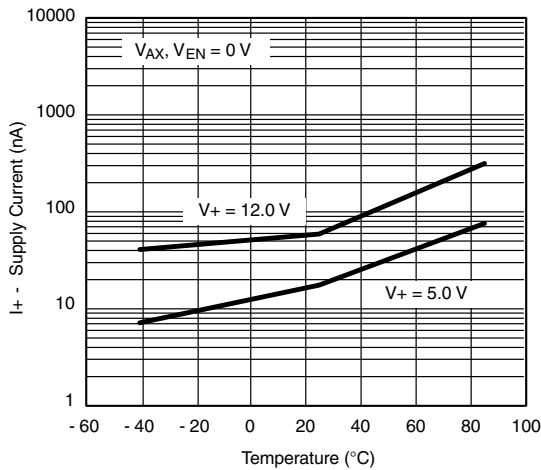
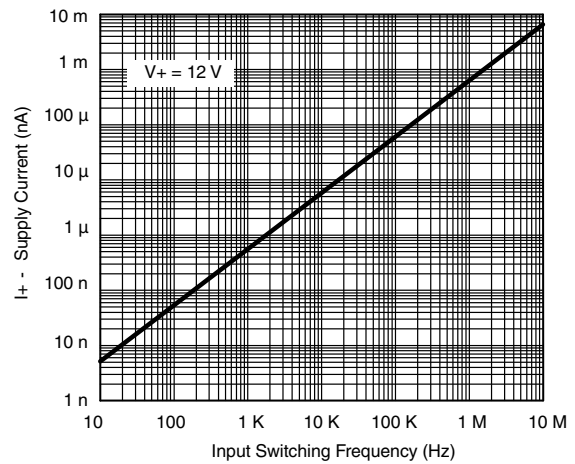
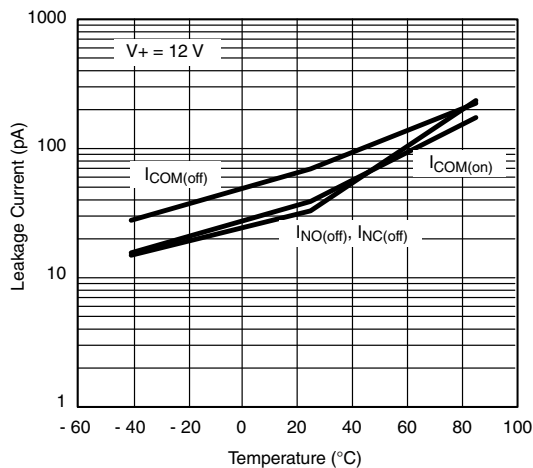
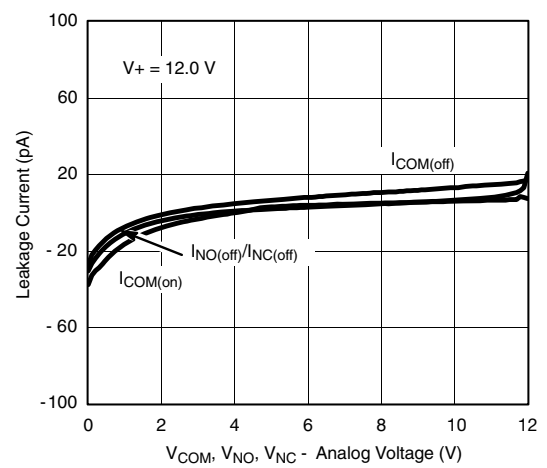


SPECIFICATIONS ( $V_+ = 12\text{ V}$ )									
Parameter	Symbol	Test Conditions Unless Specified $V_+ = 12\text{ V}$ , $V_{IN} = 0.8\text{ V}$ or $2.4\text{ V}^e$	Temp. <sup>a</sup>	Limits - 40 °C to 85 °C			Unit		
				Min. <sup>c</sup>	Typ. <sup>b</sup>	Max. <sup>c</sup>			
<b>Analog Switch</b>									
Analog Signal Range <sup>d</sup>	$V_{ANALOG}$		Full	0		12	V		
$R_{ON}$ Match	$\Delta R_{ON}$		Room		1	9	Ω		
$R_{ON}$ Flatness <sup>d,f</sup>	$R_{ON}$ Flatness		Room		1	10			
On-Resistance	$R_{ON}$	$V_+ = 10.8\text{ V}$ , $I_{NO}$ , $I_{NC} = 25\text{ mA}$ $V_{COM} = 2/9\text{ V}$	Room Full		14	17 19			
Switch Off Leakage Current	$I_{NO(off)}$ $I_{NC(off)}$	$V_{COM} = 1/11\text{ V}$ $V_{NO}$ , $V_{NC} = 11/1\text{ V}$	Room Full	- 1 - 10		1 10	nA		
	$I_{COM(off)}$		Room Full	- 1 - 10		1 10			
Channel On Leakage Current	$I_{COM(on)}$	$V_{NO}$ , $V_{NC} = V_{COM} = 11/1\text{ V}$	Room Full	- 1 - 10		1 10			
<b>Digital Control</b>									
Input Current	$I_{INL}$ or $I_{INH}$	$V_{IN} = 0$ or $V_+$	Full	- 1		1	μA		
Input High Voltage <sup>d</sup>	$V_{INH}$		Full	2.4			V		
Input Low Voltage <sup>d</sup>	$V_{INL}$		Full			0.8			
<b>Dynamic Characteristics</b>									
Turn-On Time <sup>h</sup>	$t_{ON}$	$R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ $V_{NO}$ , $V_{NC} = 5\text{ V}$ See Figure 2	Room Full		33	55 59	ns		
Turn-Off Time <sup>h</sup>	$t_{OFF}$		Room Full		17	40 41			
Break-Before-Make Time Delay <sup>h</sup>	$t_D$	DG419L Only, $V_{NC}$ , $V_{NO} = 5\text{ V}$ $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$	Room	2	24				
Transition Time	$t_{trans}$	$V_{NO} = 5\text{ V}/0\text{ V}$ , $V_{NC} = 0\text{ V}/5\text{ V}$	Room Full		29	56 59			
Charge Injection <sup>d</sup>	$Q_{INJ}$	$V_g = 0\text{ V}$ , $R_g = 0\ \Omega$ , $C_L = 1\text{ nF}$	Room		13		pC		
Off Isolation <sup>d</sup>	OIRR	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ $f = 1\text{ MHz}$	Room		- 58		dB		
Channel-to-Channel Crosstalk <sup>d</sup>	$X_{TALK}$		Room		- 64				
NO, NC Off Capacitance <sup>d</sup>	$C_{NO(off)}$ , $C_{NC(off)}$	$V_{IN} = 0$ or $V_+$ , $f = 1\text{ MHz}$	DG9414	Room		10	pF		
			DG9415	Room		10			
COM Off Capacitance	$C_{COM(off)}$		DG9414	Room		24			
			DG9415	Room		13			
COM On Capacitance <sup>d</sup>	$C_{COM(on)}$		DG9414	Room		40			
			DG9415	Room		23			
<b>Power Supplies</b>									
Positive Supply Current	I+		$V_{IN} = 0\text{ V}$ or $12\text{ V}$	Full				1	μA

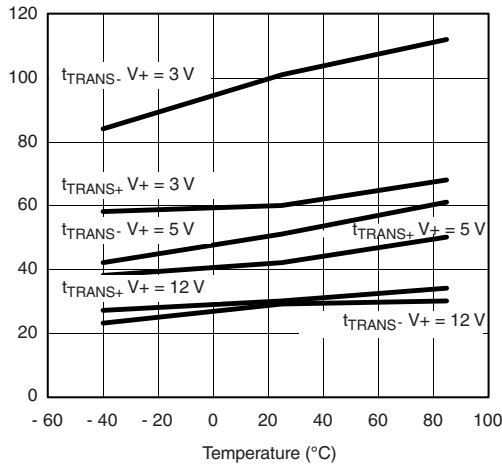
Notes:

- a. Room = 25 °C, Full = as determined by the operating suffix.
- b. Typical values are for design aid only, not guaranteed nor subject to production testing.
- c. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this datasheet.
- d. Guarantee by design, nor subjected to production test.
- e.  $V_{IN}$  = input voltage to perform proper function.
- f. Difference of min and max values.
- g. Guaranteed by 12 V leakage testing, not production tested.
- h. Guaranteed by worst case test conditions and not subject to test.

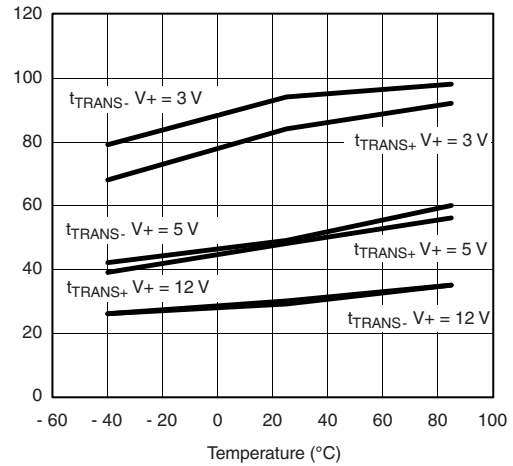
Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure 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 Supply Voltage**

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

**Supply Current vs. Temperature**

**Supply Current vs. Input Switching Frequency**

**Leakage Current vs. Temperature**

**Leakage vs. Analog Voltage**

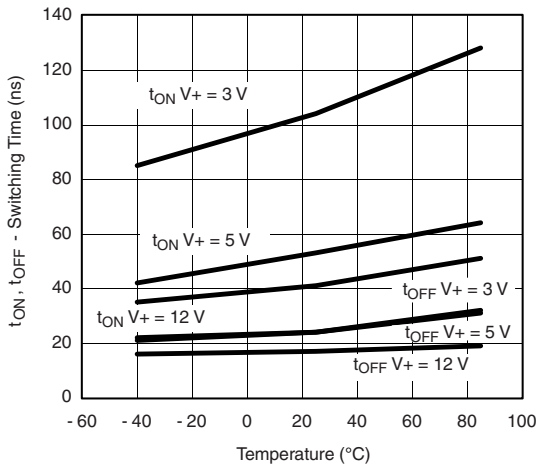
### TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



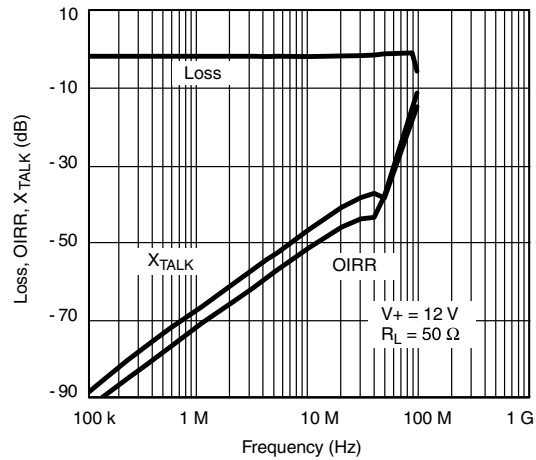
Transistion Time vs. Temperature (DG9414)



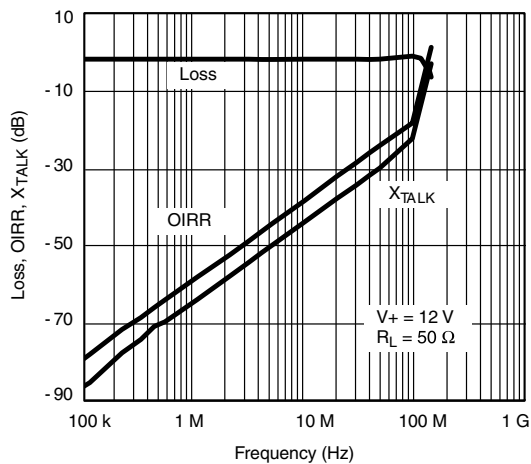
Transistion Time vs. Temperature (DG9415)



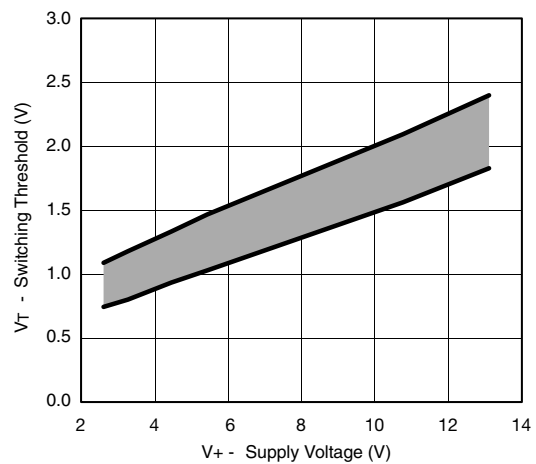
Switching Time vs. Temperature



Insertion Loss, Off-Isolation Crosstalk vs. Frequency (DG9414)

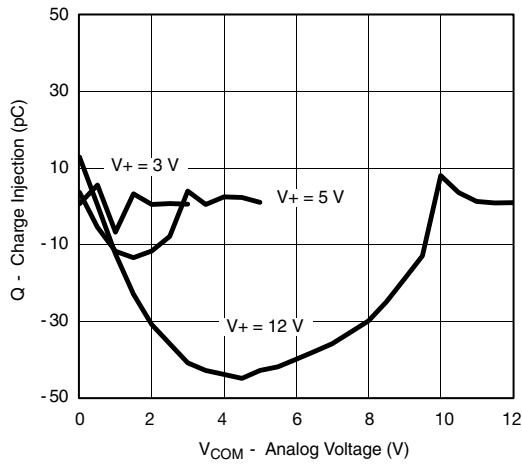


Insertion Loss, Off-Isolation Crosstalk vs. Frequency (DG9415)

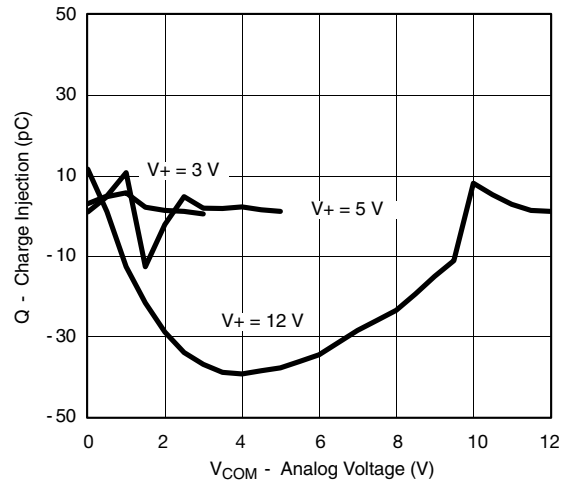


Switching Threshold vs. Supply Voltage

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

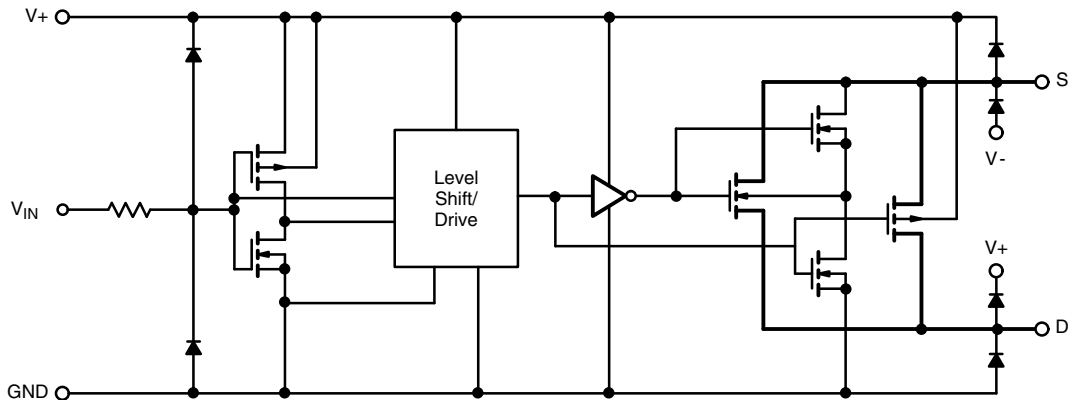


**Charge Injection vs. Analog Voltage (DG9414)**



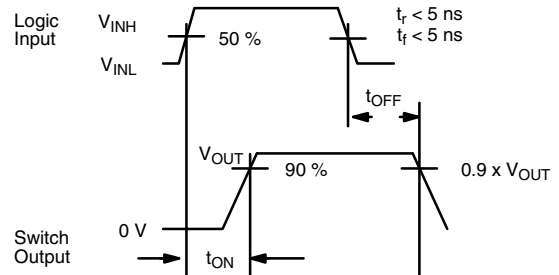
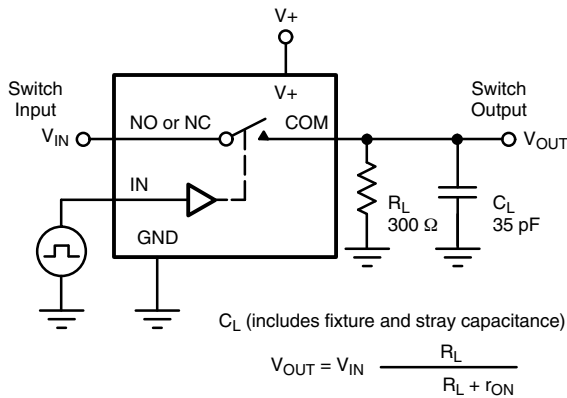
**Charge Injection vs. Analog Voltage (DG9415)**

**SCHEMATIC DIAGRAM** (Typical Channel)



**Figure 1.**

**TEST CIRCUITS**



Note: Logic input waveform is inverted for switches that have the opposite logic sense control

**Figure 2. Switching Time**

## TEST CIRCUITS

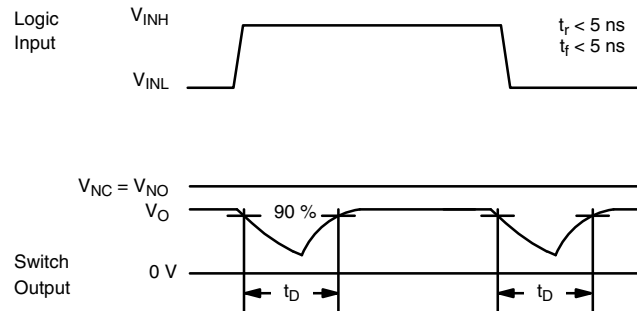
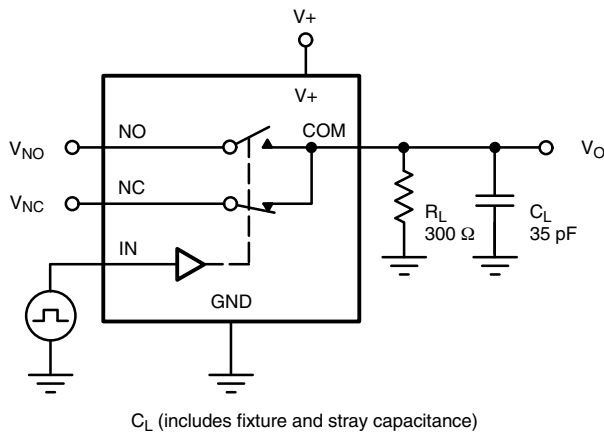


Figure 3. Break-Before-Make

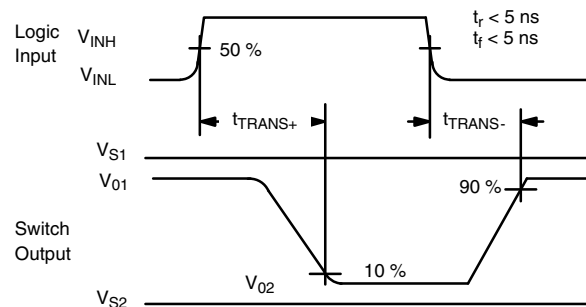
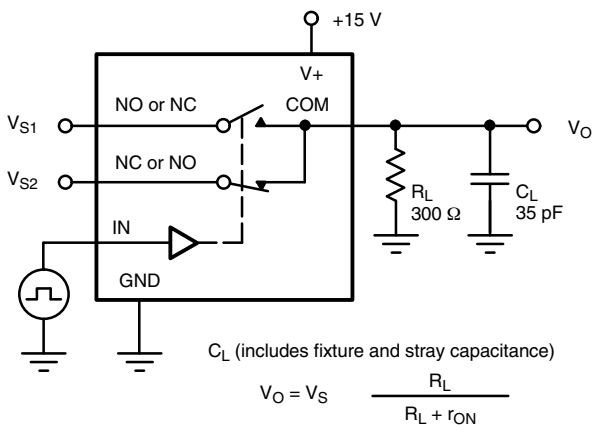
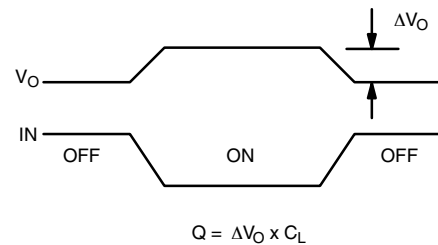
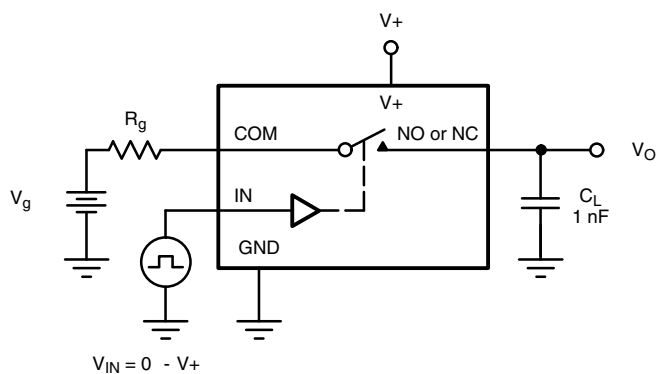


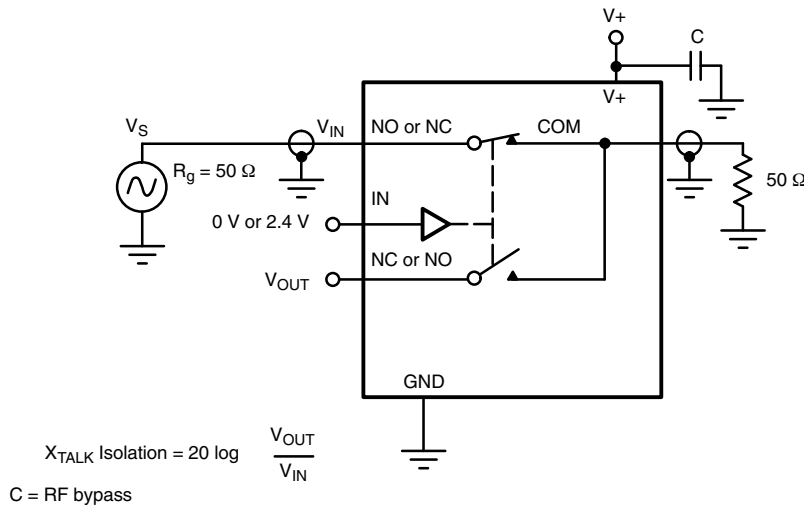
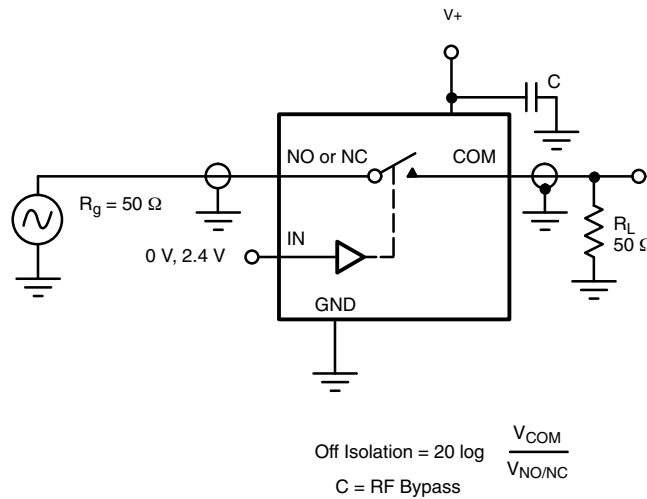
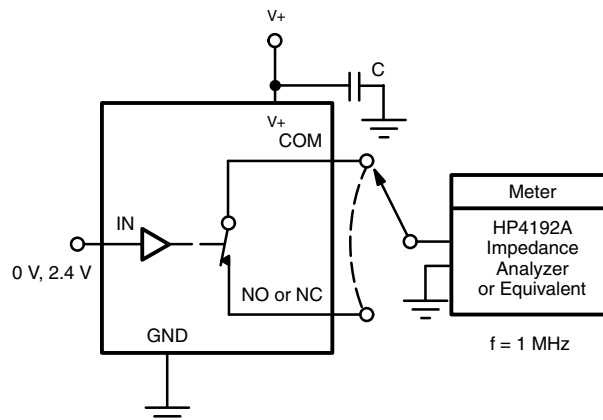
Figure 4. Transition Time



IN dependent on switch configuration Input polarity determined by sense of switch.

Figure 5. Charge Injection



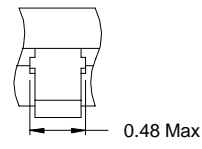
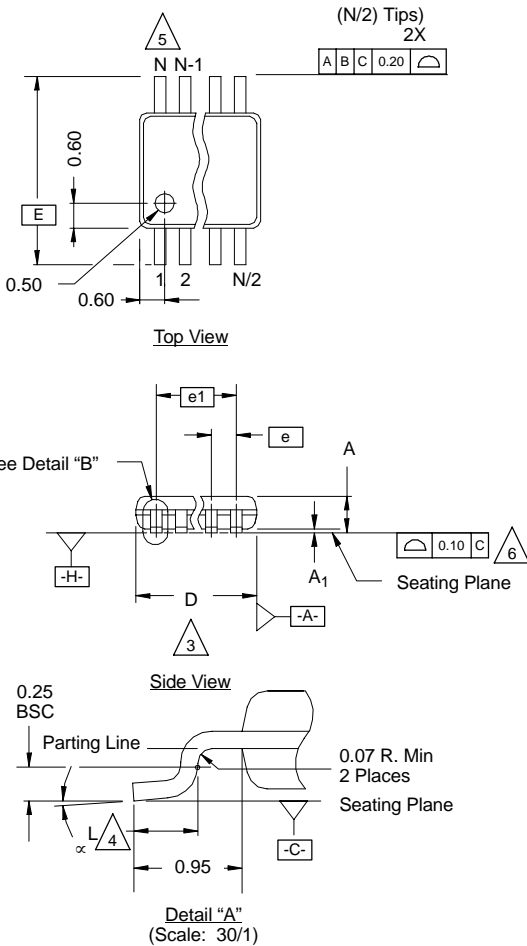
**TEST CIRCUITS**

**Figure 6. Crosstalk**

**Figure 7. Off Isolation**

**Figure 8. Source/Drain Capacitances**

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?71766](http://www.vishay.com/ppg?71766).

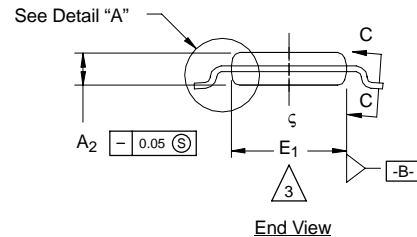
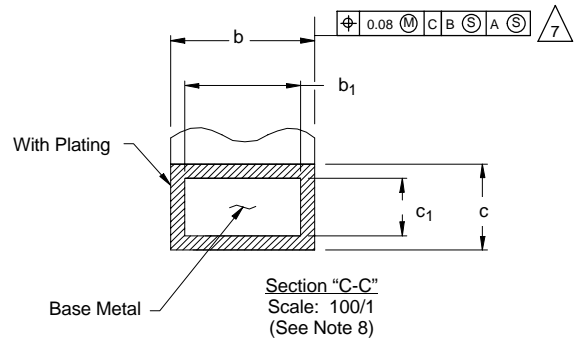


**MSOP: 10-LEADS**

JEDEC Part Number: MO-187, (Variation AA and BA)



Detail "B"  
(Scale: 30/1)  
Dambar Protrusion



NOTES:

- Die thickness allowable is  $0.203 \pm 0.0127$ .
- Dimensioning and tolerances per ANSI.Y14.5M-1994.
- Dimensions "D" and "E<sub>1</sub>" do not include mold flash or protrusions, and are measured at Datum plane [-H-], mold flash or protrusions shall not exceed 0.15 mm per side.
- Dimension is the length of terminal for soldering to a substrate.
- Terminal positions are shown for reference only.
- Formed leads shall be planar with respect to one another within 0.10 mm at seating plane.
- The lead width dimension does not include Dambar protrusion. Allowable Dambar protrusion shall be 0.08 mm total in excess of the lead width dimension at maximum material condition. Dambar cannot be located on the lower radius or the lead foot. Minimum space between protrusions and an adjacent lead to be 0.14 mm. See detail "B" and Section "C-C".
- Section "C-C" to be determined at 0.10 mm to 0.25 mm from the lead tip.
- Controlling dimension: millimeters.
- This part is compliant with JEDEC registration MO-187, variation AA and BA.
- Datums [-A-] and [-B-] to be determined Datum plane [-H-].
- Exposed pad area in bottom side is the same as teh leadframe pad size.

**N = 10L**

Dim	MILLIMETERS			Note
	Min	Nom	Max	
A	-	-	1.10	
A <sub>1</sub>	0.05	0.10	0.15	
A <sub>2</sub>	0.75	0.85	0.95	
b	0.17	-	0.27	8
b <sub>1</sub>	0.17	0.20	0.23	8
c	0.13	-	0.23	
c <sub>1</sub>	0.13	0.15	0.18	
D	3.00 BSC			3
E	4.90 BSC			
E <sub>1</sub>	2.90	3.00	3.10	3
e	0.50 BSC			
e <sub>1</sub>	2.00 BSC			
L	0.40	0.55	0.70	4
N	10			5
α	0°	4°	6°	
ECN: T-02080—Rev. C, 15-Jul-02 DWG: 5867				



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