

# Precision Monolithic Quad SPST CMOS Analog Switches

## DESCRIPTION

The DG411 series of monolithic quad analog switches was designed to provide high speed, low error switching of precision analog signals. Combining low power (0.35  $\mu$ W) with high speed ( $t_{ON}$ : 110 ns), the DG411 family is ideally suited for portable and battery powered industrial and military applications.

To achieve high-voltage ratings and superior switching performance, the DG411 series was built on Vishay Siliconix's high voltage silicon gate process. An epitaxial layer prevents latchup.

Each switch conducts equally well in both directions when on, and blocks input voltages up to the supply levels when off.

The DG411, DG412 respond to opposite control logic as shown in the Truth Table. The DG413 has two normally open and two normally closed switches.

## FEATURES

- Halogen-free according to IEC 61249-2-21 Definition
- 44 V supply max. rating
- $\pm 15$  V analog signal range
- On-resistance -  $R_{DS(on)}$ : 25  $\Omega$
- Fast switching -  $t_{ON}$ : 110 ns
- Ultra low power -  $P_D$ : 0.35  $\mu$ W
- TTL, CMOS compatible
- Single supply capability
- Compliant to RoHS Directive 2002/95/EC



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

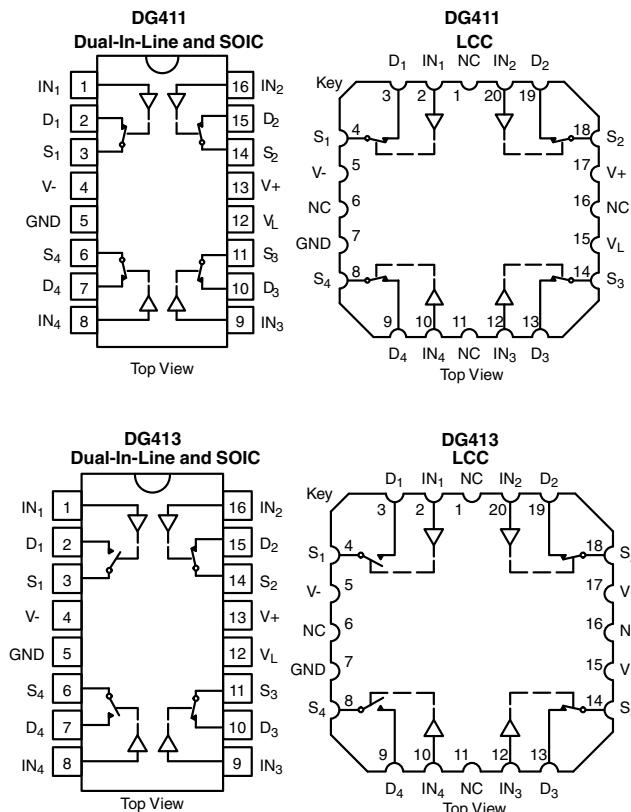
## BENEFITS

- Widest dynamic range
- Low signal errors and distortion
- Break-before-make switching action
- Simple interfacing

## APPLICATIONS

- Precision automatic test equipment
- Precision data acquisition
- Communication systems
- Battery powered systems
- Computer peripherals

## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



TRUTH TABLE		
Logic	DG411	DG412
0	ON	OFF
1	OFF	ON

Logic "0"  $\leq 0.8$  V  
Logic "1"  $\geq 2.4$  V

TRUTH TABLE		
Logic	SW <sub>1</sub> , SW <sub>4</sub>	SW <sub>2</sub> , SW <sub>3</sub>
0	OFF	ON
1	ON	OFF

Logic "0"  $\leq 0.8$  V  
Logic "1"  $\geq 2.4$  V



ORDERING INFORMATION		
Temp. Range	Package	Part Number
- 40 °C to 85 °C	16-pin plastic DIP	DG411DJ DG411DJ-E3
		DG412DJ DG412DJ-E3
		DG413DJ DG413DJ-E3
	16-pin narrow SOIC	DG411DY DG411DY-E3 DG411DY-T1 DG411DY-T1-E3
		DG412DY DG412DY-E3 DG412DY-T1 DG412DY-T1-E3
		DG413DY DG413DY-E3 DG413DY-T1 DG413DY-T1-E3
	16-pin TSSOP	DG411DQ-E3 DG411DQ-T1-E3
		DG412DQ-E3 DG412DQ-T1-E3
		DG413DQ-E3 DG413DQ-T1-E3

ABSOLUTE MAXIMUM RATINGS		
Parameter	Limit	Unit
V + to V -	44	V
GND to V -	25	
V <sub>L</sub>	(GND - 0.3) to (V+) + 0.3	
Digital Inputs <sup>a</sup> , V <sub>S</sub> , V <sub>D</sub>	(V-) -2 to (V+) + 2 or 30 mA, whichever occurs first	
Continuous Current (Any terminal)	30	mA
Peak Current, S or D (Pulsed at 1 ms, 10 % duty cycle)	100	
Storage Temperature	(AK, AZ suffix)	°C
	(DJ, DY suffix)	
Power Dissipation (Package) <sup>b</sup>	16-pin plastic DIP <sup>c</sup>	mW
	16-pin narrow SOIC <sup>d</sup>	
	16-pin CerDIP <sup>e</sup>	
	LCC-20 <sup>e</sup>	

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 welded or soldered to PC board.
- c. Derate 6 mW/°C above 25 °C.
- d. Derate 7.6 mW/°C above 75 °C.
- e. Derate 12 mW/°C above 75 °C.



SPECIFICATIONS <sup>a</sup>									
Parameter	Symbol	Test Conditions Unless Specified V <sub>+</sub> = 15 V, V <sub>-</sub> = -15 V V <sub>L</sub> = 5 V, V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup>	Temp. <sup>b</sup>	Typ. <sup>c</sup>	A Suffix - 55 °C to 125 °C		D Suffix - 40 °C to 85 °C		Unit
					Min. <sup>d</sup>	Max. <sup>d</sup>	Min. <sup>d</sup>	Max. <sup>d</sup>	
<b>Analog Switch</b>									
Analog Signal Range <sup>e</sup>	V <sub>ANALOG</sub>		Full		- 15	15	- 15	15	V
Drain-Source On-Resistance	R <sub>DS(on)</sub>	V <sub>+</sub> = 13.5 V, V <sub>-</sub> = -13.5 V I <sub>S</sub> = -10 mA, V <sub>D</sub> = ± 8.5 V	Room Full	25		35 45		35 45	Ω
Switch Off Leakage Current	I <sub>S(off)</sub>	V <sub>+</sub> = 16.5 V, V <sub>-</sub> = -16.5 V V <sub>D</sub> = ± 15.5 V, V <sub>S</sub> = ± 15.5 V	Room Full	± 0.1	- 0.25 - 20	0.25 20	- 0.25 - 5	0.25 5	nA
	I <sub>D(off)</sub>		Room Full	± 0.1	- 0.25 - 20	0.25 20	- 0.25 - 5	0.25 5	
Channel On Leakage Current	I <sub>D(on)</sub>	V <sub>+</sub> = 16.5 V, V <sub>-</sub> = -16.5 V V <sub>S</sub> = V <sub>D</sub> = ± 15.5 V	Room Full	± 0.1	- 0.4 - 40	0.4 40	- 0.4 - 10	0.4 10	
<b>Digital Control</b>									
Input Current, V <sub>IN</sub> Low	I <sub>IL</sub>	V <sub>IN</sub> under test = 0.8 V	Full	0.005	- 0.5	0.5	- 0.5	0.5	μA
Input Current, V <sub>IN</sub> High	I <sub>IH</sub>	V <sub>IN</sub> under test = 2.4 V	Full	0.005	- 0.5	0.5	- 0.5	0.5	
<b>Dynamic Characteristics</b>									
Turn-On Time	t <sub>ON</sub>	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF V <sub>S</sub> = ± 10 V, see figure 2	Room Full	110		175 240		175 220	ns
Turn-Off Time	t <sub>OFF</sub>		Room Full	100		145 160		145 160	
Break-Before-Make Time Delay	t <sub>D</sub>	DG413 only, V <sub>S</sub> = 10 V R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	25					
Charge Injection	Q	V <sub>g</sub> = 0 V, R <sub>g</sub> = 0 Ω C <sub>L</sub> = 10 nF	Room	5					pC
Off Isolation <sup>e</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room	68					dB
Channel-to-Channel Crosstalk <sup>e</sup>	X <sub>TALK</sub>		Room	85					
Source Off Capacitance <sup>e</sup>	C <sub>S(off)</sub>	f = 1 MHz	Room	9					pF
Drain Off Capacitance <sup>e</sup>	C <sub>D(off)</sub>		Room	9					
Channel On Capacitance <sup>e</sup>	C <sub>D(on)</sub>		Room	35					
<b>Power Supplies</b>									
Positive Supply Current	I <sub>+</sub>	V <sub>+</sub> = 16.5 V, V <sub>-</sub> = -16.5 V V <sub>IN</sub> = 0 V or 5 V	Room Full	0.0001		1 5		1 5	μA
Negative Supply Current	I <sub>-</sub>		Room Full	- 0.0001	- 1 - 5		- 1 - 5		
Logic Supply Current	I <sub>L</sub>		Room Full	0.0001		1 5		1 5	
Ground Current	I <sub>GND</sub>		Room Full	- 0.0001	- 1 - 5		- 1 - 5		



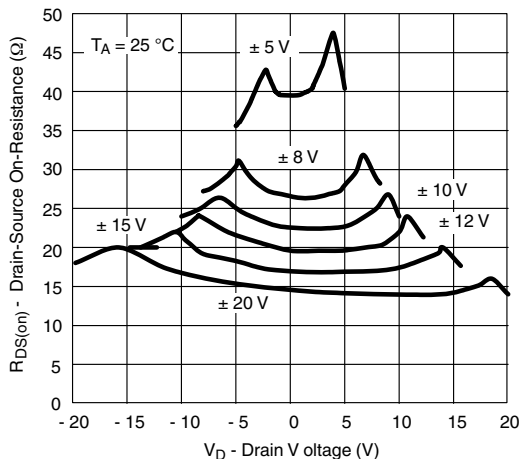
SPECIFICATIONS <sup>a</sup> (for Unipolar Supplies)									
Parameter	Symbol	Test Conditions Unless Specified V <sub>+</sub> = 12 V, V <sub>-</sub> = 0 V V <sub>L</sub> = 5 V, V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup>	Temp. <sup>b</sup>	Typ. <sup>c</sup>	A Suffix - 55 °C to 125 °C		D Suffix - 40 °C to 85 °C		Unit
					Min. <sup>d</sup>	Max. <sup>d</sup>	Min. <sup>d</sup>	Max. <sup>d</sup>	
<b>Analog Switch</b>									
Analog Signal Range <sup>e</sup>	V <sub>ANALOG</sub>		Full			12		12	V
Drain-Source On-Resistance	R <sub>DS(on)</sub>	V <sub>+</sub> = 10.8 V, I <sub>S</sub> = - 10 mA, V <sub>D</sub> = 3 V, 8 V	Room Full	40		80 100		80 100	Ω
<b>Dynamic Characteristics</b>									
Turn-On Time	t <sub>ON</sub>	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF V <sub>S</sub> = 8 V, see figure 2	Room Hot	175		250 400		250 315	ns
Turn-Off Time	t <sub>OFF</sub>		Room Hot	95		125 140		125 140	
Break-Before-Make Time Delay	t <sub>D</sub>	DG413 only, V <sub>S</sub> = 8 V R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	25					
Charge Injection	Q	V <sub>g</sub> = 6 V, R <sub>g</sub> = 0 Ω, C <sub>L</sub> = 10 nF	Room	25					pC
<b>Power Supplies</b>									
Positive Supply Current	I <sub>+</sub>	V <sub>+</sub> = 13.5 V, V <sub>IN</sub> = 0 V or 5 V	Room Hot	0.0001		1 5		1 5	μA
Negative Supply Current	I <sub>-</sub>		Room Hot	- 0.0001	- 1 - 5		- 1 - 5		
Logic Supply Current	I <sub>L</sub>		Room Hot	0.0001		1 5		1 5	
Ground Current	I <sub>GND</sub>		Room Hot	- 0.0001	- 1 - 5		- 5		

Notes:

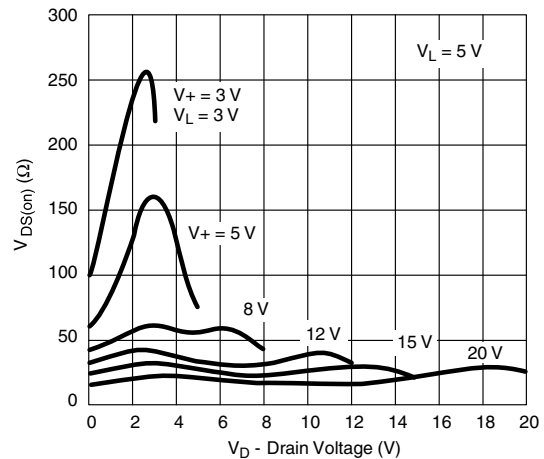
- a. Refer to process option flowchart.
- b. Room = 25 °C, Full = as determined by the operating temperature suffix.
- c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
- d. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- e. Guaranteed by design, not subject to production test.
- f. V<sub>IN</sub> = input voltage to perform proper function.

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)

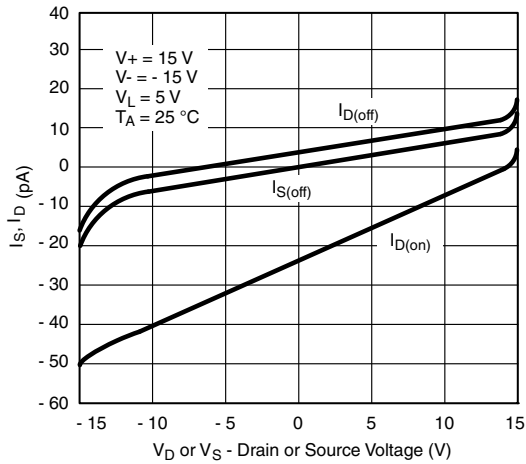


On-Resistance vs. V<sub>D</sub> and Power Supply Voltage

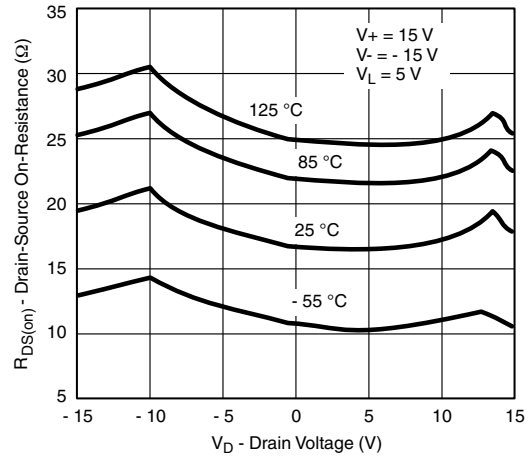


On-Resistance vs. V<sub>D</sub> and Unipolar Supply Voltage

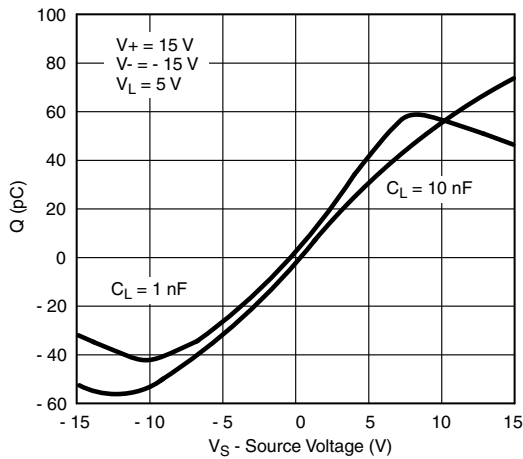
## TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



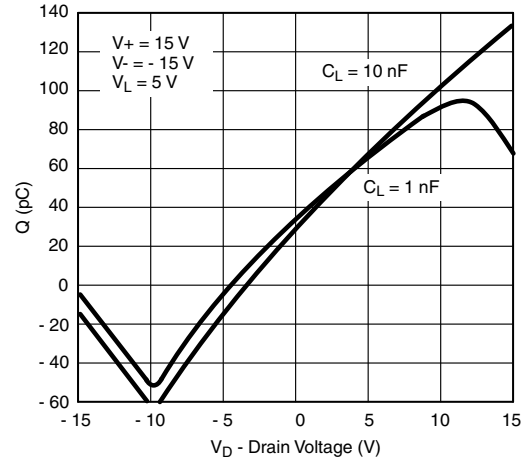
**Leakage Current vs. Analog Voltage**



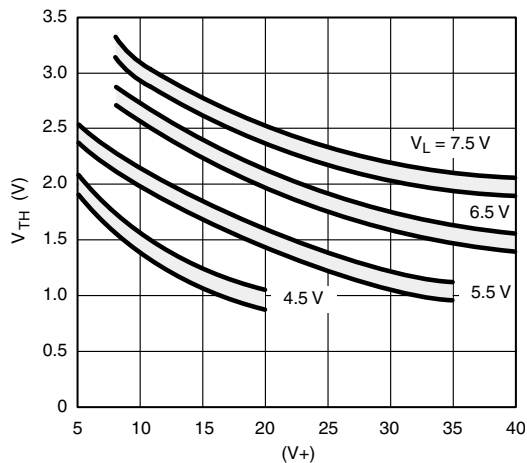
**$I_D, I_S$  Leakages vs. Temperature**



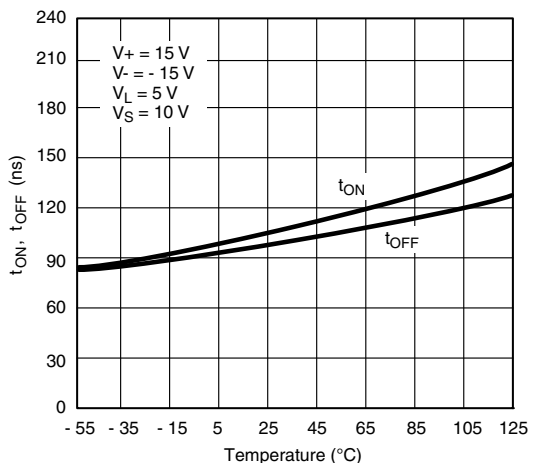
**Charge Injection vs. Analog Voltage**



**Charge Injection vs. Analog Voltage**

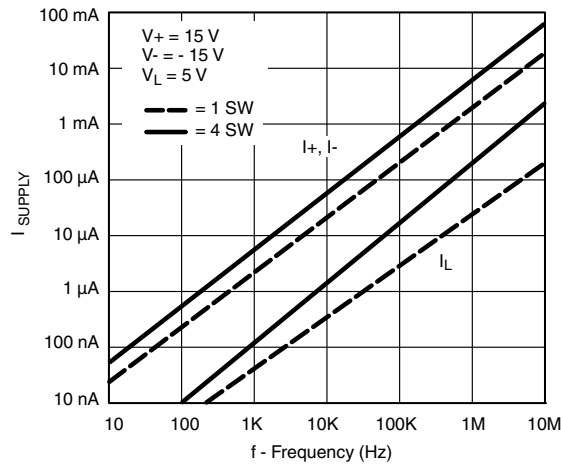


**Input Switching Threshold vs. Supply Voltage**



**Switching Time vs. Temperature**

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



Supply Current vs. Input Switching Frequency

## SCHEMATIC DIAGRAM (Typical Channel)

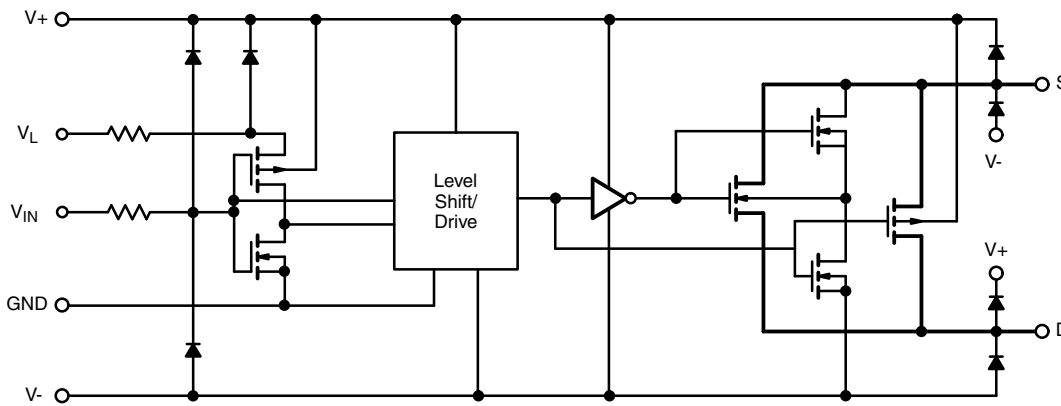
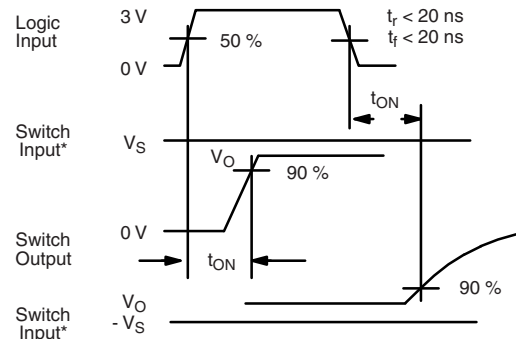
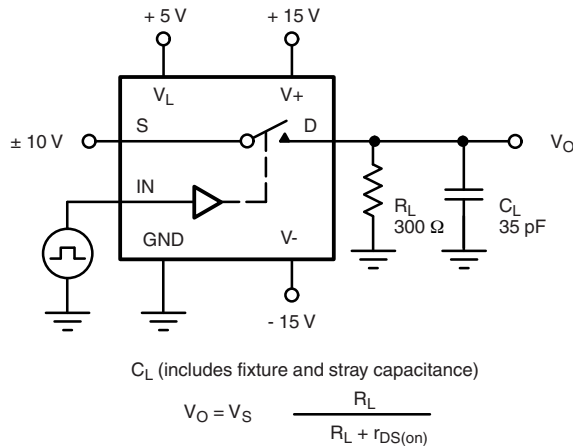


Figure 1.

## TEST CIRCUITS



\*  $V_S = 10\text{ V}$  for  $t_{ON}$ ,  $V_S = -10\text{ V}$  for  $t_{OFF}$

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

Figure 2. Switching Time





Figure 6. Off Isolation

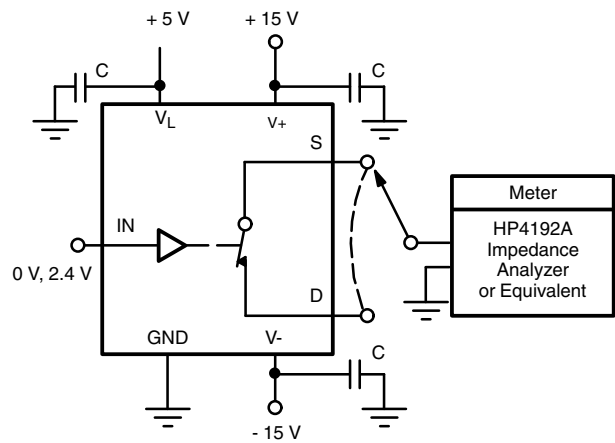


Figure 7. Source/Drain Capacitances

## APPLICATIONS

### Single Supply Operation:

The DG411, DG412, DG413 can be operated with unipolar supplies from 5 V to 44 V. These devices are characterized and tested for unipolar supply operation at 12 V to facilitate the majority of applications. In single supply operation, V+ is tied to VL and V- is tied to 0 V. See Input Switching Threshold vs. Supply Voltage curve for VL versus input threshold requirements.

### Summing Amplifier

When driving a high impedance, high capacitance load such as shown in figure 8, where the inputs to the summing amplifier have some noise filtering, it is necessary to have shunt switches for rapid discharge of the filter capacitor, thus preventing offsets from occurring at the output.

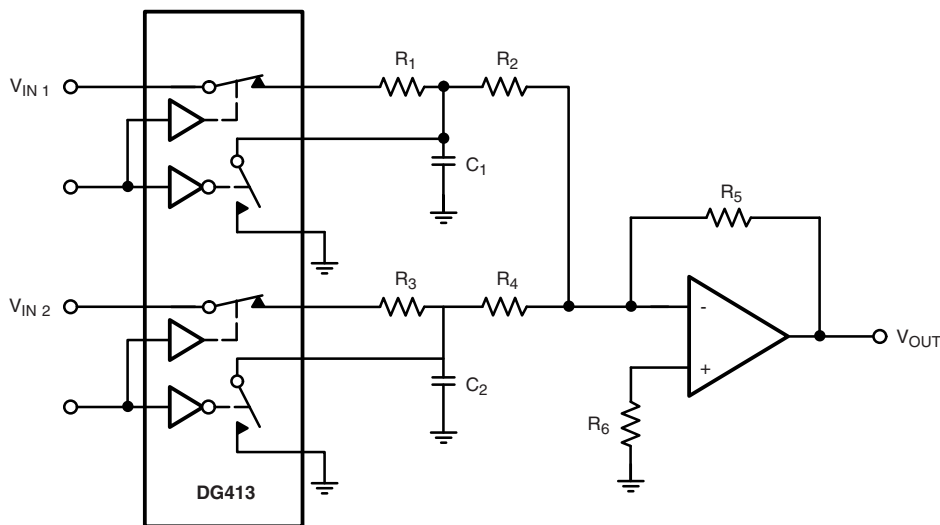


Figure 8. Summing Amplifier

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**SOIC (NARROW): 16-LEAD**  
JEDEC Part Number: MS-012



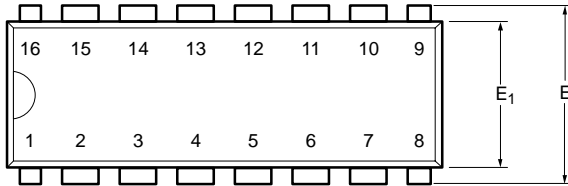
Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A <sub>1</sub>	0.10	0.20	0.004	0.008
B	0.38	0.51	0.015	0.020
C	0.18	0.23	0.007	0.009
D	9.80	10.00	0.385	0.393
E	3.80	4.00	0.149	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
L	0.50	0.93	0.020	0.037
∅	0°	8°	0°	8°

ECN: S-03946—Rev. F, 09-Jul-01  
DWG: 5300





**PDIP: 16-LEAD**



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
<b>A</b>	3.81	5.08	0.150	0.200
<b>A<sub>1</sub></b>	0.38	1.27	0.015	0.050
<b>B</b>	0.38	0.51	0.015	0.020
<b>B<sub>1</sub></b>	0.89	1.65	0.035	0.065
<b>C</b>	0.20	0.30	0.008	0.012
<b>D</b>	18.93	21.33	0.745	0.840
<b>E</b>	7.62	8.26	0.300	0.325
<b>E<sub>1</sub></b>	5.59	7.11	0.220	0.280
<b>e<sub>1</sub></b>	2.29	2.79	0.090	0.110
<b>e<sub>A</sub></b>	7.37	7.87	0.290	0.310
<b>L</b>	2.79	3.81	0.110	0.150
<b>Q<sub>1</sub></b>	1.27	2.03	0.050	0.080
<b>S</b>	0.38	1.52	.015	0.060

ECN: S-03946—Rev. D, 09-Jul-01  
DWG: 5482





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