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 µW) 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

- 44 V supply max. rating
- ± 15 V analog signal range
- On-resistance - $R_{DS(on)}$: 25 Ω
- Fast switching - t_{on}: 110 ns
- Ultra low power - P_D: 0.35 µW
- TTL, CMOS compatible
- Single supply capability
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free
RoHS COMPLIANT
HALOGEN FREE

APPLICATIONS

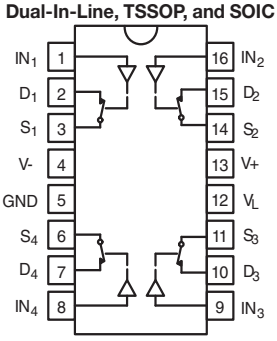
- Precision automatic test equipment
- Precision data acquisition
- Communication systems
- Battery powered systems
- Computer peripherals

BENEFITS

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

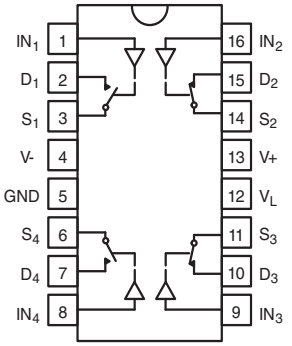
FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION

DG411, DG412
Dual-In-Line, TSSOP, and SOIC



Top View

DG413
Dual-In-Line, TSSOP, and SOIC



Top View

TRUTH TABLE		
LOGIC	DG411	DG412
0	On	Off
1	Off	On

Note

- Logic "0" ≤ 0.8 V
  Logic "1" ≥ 2.4 V

TRUTH TABLE		
LOGIC	SW_1, SW_4	SW_2, SW_3
0	Off	On
1	On	Off

Note

- Logic "0" ≤ 0.8 V
  Logic "1" ≥ 2.4 V

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ORDERING INFORMATION		
TEMP. RANGE	**PACKAGE**	**PART NUMBER**
-40 °C to +85 °C	16-pin narrow SOIC	DG411DY-E3 DG411DY-T1-E3
		DG412DY-E3 DG412DY-T1-E3
		DG413DY-E3 DG413DY-T1-E3
	16-pin TSSOP	DG411DQ-E3 DG411DQ-T1-E3
		DG412DQ-E3 DG412DQ-T1-E3
		DG413DQ-E3 DG413DQ-T1-E3

ABSOLUTE MAXIMUM RATINGS (T_A = 25 °C, unless otherwise noted)			
PARAMETER		**LIMIT**	**UNIT**
V + to V -		44	V
GND to V- GND to V -		25	
V_L		(GND - 0.3) to (V+) + 0.3	
Digital inputs [a], V_S, V_D		(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 max.)		100	
Storage temperature	(AK, AZ suffix)	-65 to +150	°C
	(DJ, DY suffix)	-65 to +125	
Power dissipation (package) [b]	16-pin narrow SOIC and TSSOP [d]	600	mW

Notes

a. Signals on S_X, D_X, or IN_X 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

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SPECIFICATIONS [a]

PARAMETER	SYMBOL	TEST CONDITIONS UNLESS SPECIFIED V + = 15 V, V - = -15 V V_L = 5 V, V_{IN} = 2.4 V, 0.8 V [f]	TEMP. [b]	TYP. [c]	A SUFFIX -55 °C TO +125 °C		D SUFFIX -40 °C TO +85 °C		UNIT
					MIN. [d]	MAX. [d]	MIN. [d]	MAX. [d]	
Analog Switch									
Analog signal range [e]	V_{ANALOG}		Full	-	- 15	15	- 15	15	V
Drain-source on-resistance	$R_{DS(on)}$	V + = 13.5 V, V - = -13.5 V, I_S = - 10 mA, V_D = ± 8.5 V	Room	25	-	35	-	35	Ω
			Full	-	-	45	-	45	
Switch off leakage current	$I_{S(off)}$	V + = 16.5, V - = -16.5 V, V_D = ± 15.5 V, V_S = ± 15.5 V	Room	± 0.1	-0.25	0.25	-0.25	0.25	nA
			Full	-	-20	20	-5	5	
	$I_{D(off)}$		Room	± 0.1	-0.25	0.25	-0.25	0.25	
			Full	-	-20	20	-5	5	
Channel on leakage current	$I_{D(on)}$	V + = 16.5 V, V - = -16.5 V, V_S = V_D = ± 15.5 V	Room	± 0.1	-0.4	0.4	-0.4	0.4	
			Full	-	-40	40	-10	10	
Digital Control									
Input current, V_{IN} low	I_{IL}	V_{IN} under test = 0.8 V	Full	0.005	-0.5	0.5	-0.5	0.5	µA
Input current, V_{IN} high	I_{IH}	V_{IN} under test = 2.4 V	Full	0.005	-0.5	0.5	-0.5	0.5	
Dynamic Characteristics									
Turn-on time	t_{on}	R_L = 300 Ω, C_L = 35 pF, V_S = ± 10 V, see Fig. 2	Room	110	-	175	-	175	ns
			Full	-	-	240	-	220	
Turn-off time	t_{off}		Room	100	-	145	-	145	
			Full	-	-	160	-	160	
Break-before-make time delay	t_D	DG413 only, V_S = 10 V, R_L = 300 Ω, C_L = 35 pF	Room	25	-	-	-	-	
Charge injection	Q	V_g = 0 V, R_g = 0 Ω, C_L = 10 nF	Room	5	-	-	-	-	pC
Off isolation [e]	OIRR	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz	Room	68	-	-	-	-	dB
Channel-to-channel crosstalk [e]	X_{TALK}		Room	85	-	-	-	-	
Source off capacitance [e]	$C_{S(off)}$	f = 1 MHz	Room	9	-	-	-	-	pF
Drain off capacitance [e]	$C_{D(off)}$		Room	9	-	-	-	-	
Channel on capacitance [e]	$C_{D(on)}$		Room	35	-	-	-	-	
Power Supplies									
Positive supply current	I+	V + = 16.5 V, V - = -16.5 V, V_{IN} = 0 V or 5 V	Room	0.0001	-	1	-	1	µA
			Full	-	-	5	-	5	
Negative supply current	I-		Room	-0.0001	-1	-	-1	-	
			Full	-	-5	-	-5	-	
Logic supply current	IL		Room	0.0001	-	1	-	1	
			Full	-	-	5	-	5	
Ground current	I_{GND}		Room	-0.0001	-1	-	-1	-	
			Full	-	-5	-	-5	-	

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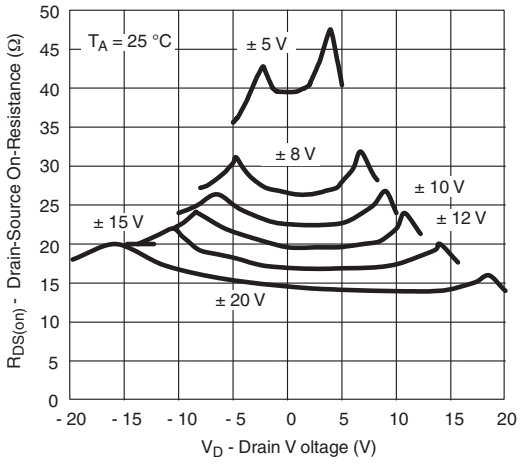
SPECIFICATIONS [a] (unipolar supplies)									
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS SPECIFIED V + = 12 V, V - = 0 V V_L = 5 V, V_{IN} = 2.4 V, 0.8 V [f]	TEMP. [b]	TYP. [c]	A SUFFIX -55 °C TO +125 °C		D SUFFIX -40 °C TO +85 °C		UNIT
					MIN. [d]	MAX. [d]	MIN. [d]	MAX. [d]	
Analog Switch									
Analog signal range [e]	V_{ANALOG}		Full	-	-	12	-	12	V
Drain-source on-resistance	$R_{DS(on)}$	V + = 10.8 V, I_S = -10 mA, V_D = 3 V, 8 V	Room	40	-	80	-	80	Ω
			Full	-	-	100	-	100	
Dynamic Characteristics									
Turn-on time	t_{on}	R_L = 300 Ω, C_L = 35 pF, V_S = 8 V, see Fig. 2	Room	175	-	250	-	250	ns
			Hot	-	-	400	-	315	
Turn-off time	t_{off}		Room	95	-	125	-	125	
			Hot	-	-	140	-	140	
Break-before-make time delay	t_D	DG413 only, V_S = 8 V, R_L = 300 Ω, C_L = 35 pF	Room	25	-	-	-	-	
Charge injection	Q	V_g = 6 V, R_g = 0 Ω, C_L = 10 nF	Room	25	-	-	-	-	pC
Power Supplies									
Positive supply current	I+	V + = 13.5 V, V_{IN} = 0 V or 5 V	Room	0.0001	-	1	-	1	µA
			Hot	-	-	5	-	5	
Negative supply current	I-		Room	-0.0001	-1	-	-1	-	
			Hot	-	-5	-	-5	-	
Logic supply current	IL		Room	0.0001	-	1	-	1	
			Hot	-	-	5	-	5	
Ground current	I_{GND}		Room	-0.0001	-1	-	-1	-	
			Hot	-	-5	-	-5	-	

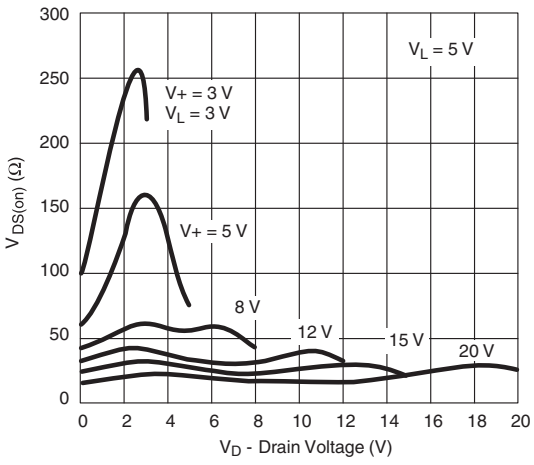
Notes
a. Refer to process option flowchart
b. Room = 25 °C, full = as determined by the operating temperature suffix
c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing
d. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this datasheet
e. Guaranteed by design, not subject to production test
f. V_{IN} = 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_D and Power Supply Voltage



On-Resistance vs. V_D and Unipolar Supply Voltage

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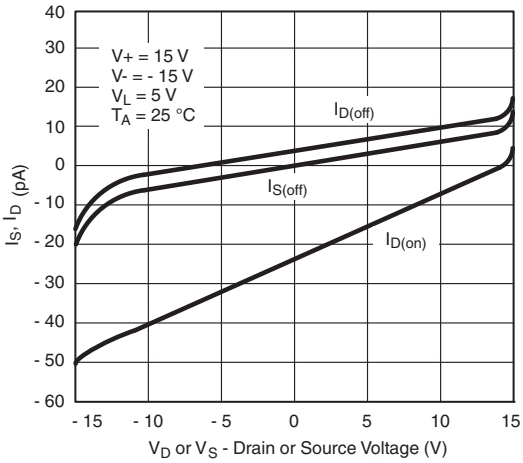
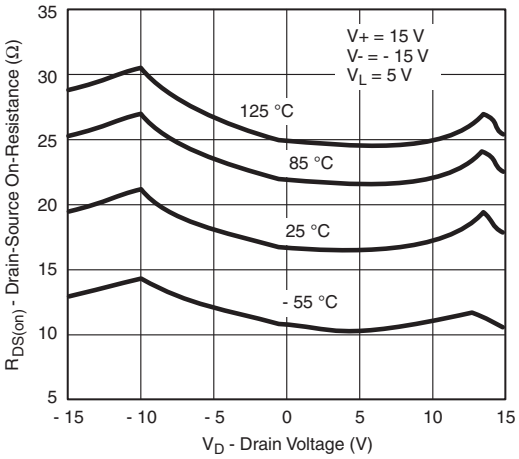
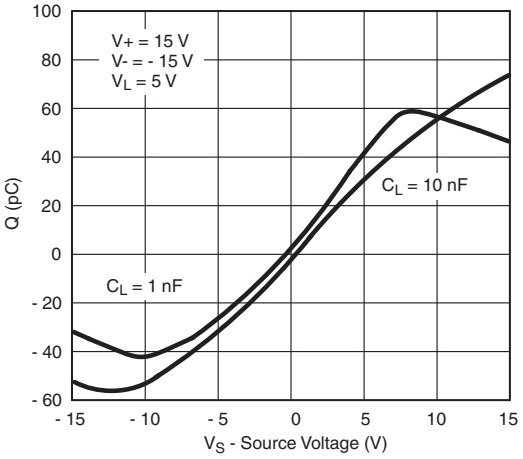
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



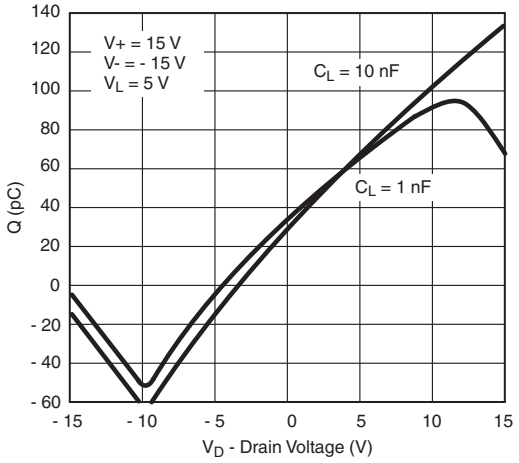
Leakage Current vs. Analog Voltage



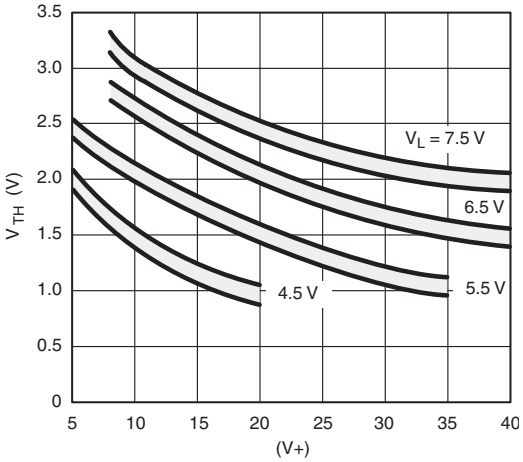
I_D, I_S Leakages vs. Temperature



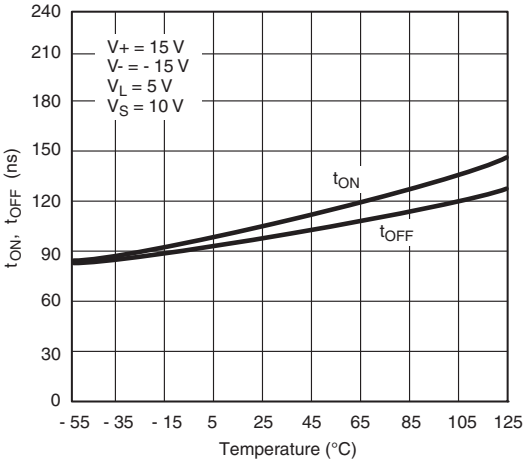
Charge Injection vs. Analog Voltage



Charge Injection vs. Analog Voltage



Input Switching Threshold vs. Supply Voltage



Switching Time vs. Temperature

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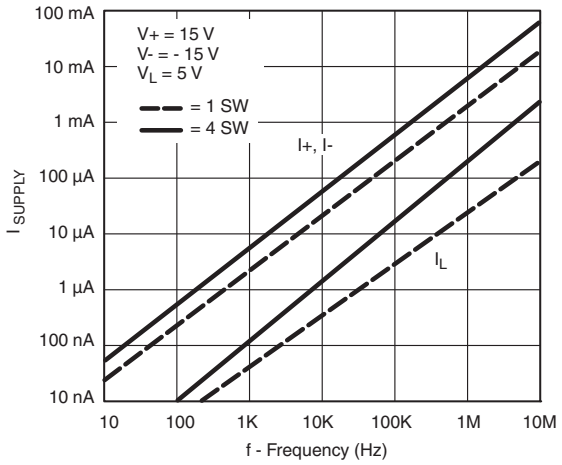
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



Supply Current vs. Input Switching Frequency

SCHEMATIC DIAGRAM (typical channel)

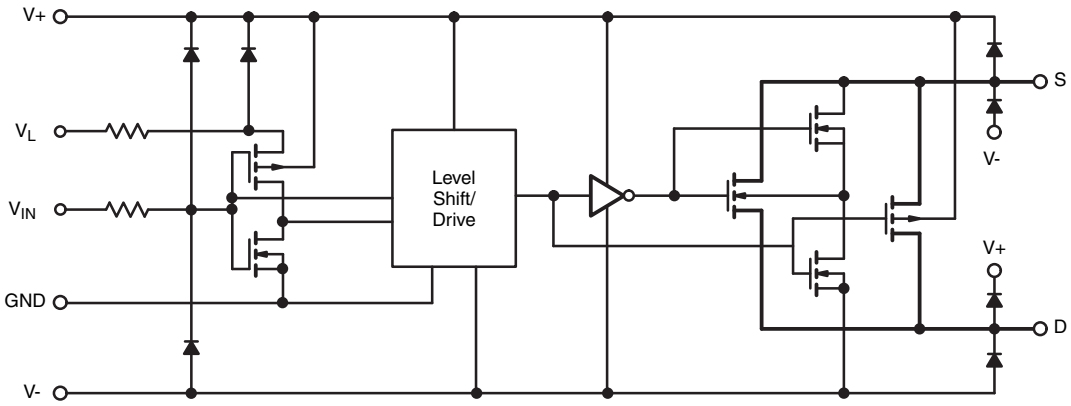
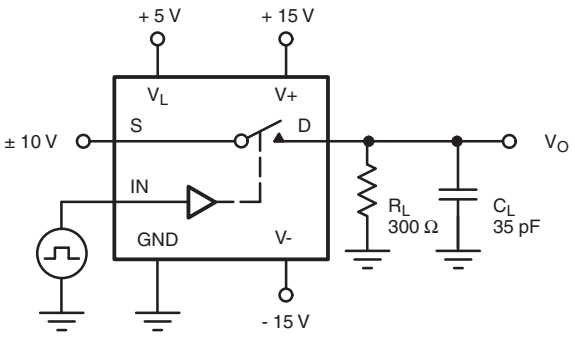


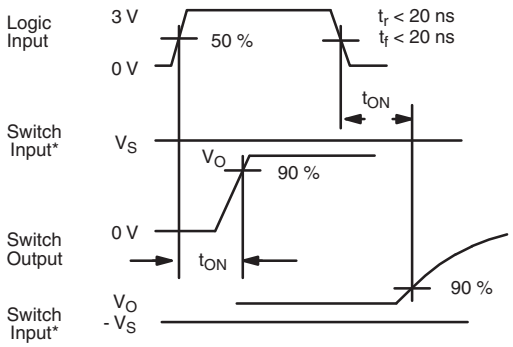
Fig. 1

TEST CIRCUITS



C_L (includes fixture and stray capacitance)

$$V_O = V_S \frac{R_L}{R_L + r_{DS(on)}}$$



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

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

Fig. 2 - Switching Time

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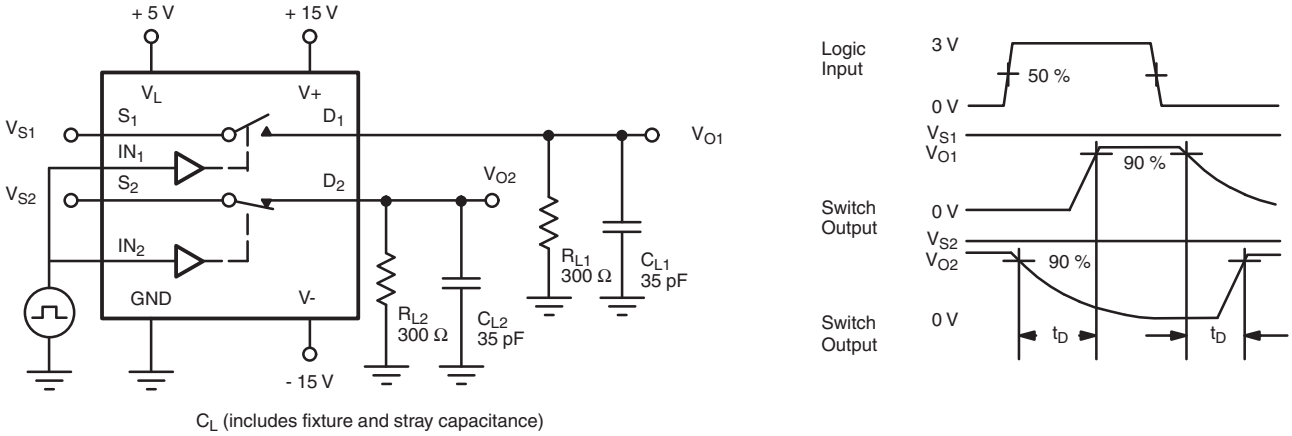
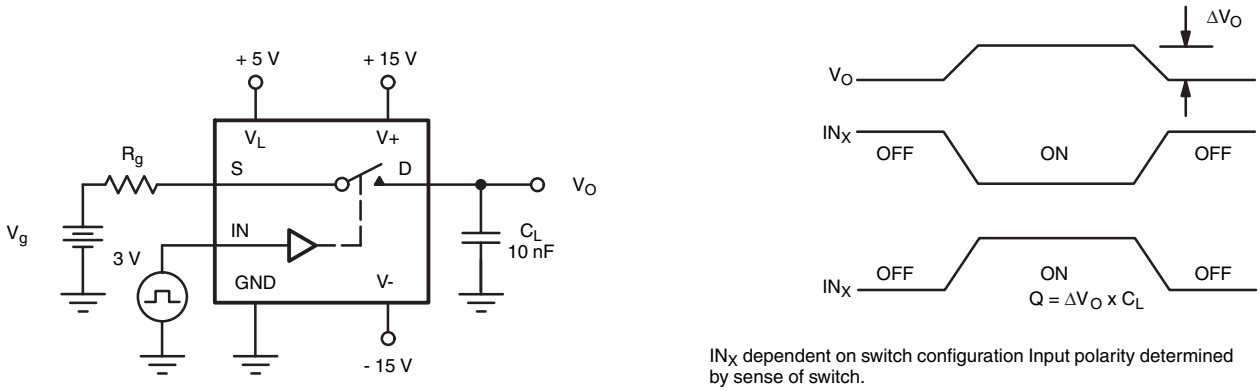
TEST CIRCUITS



C_L (includes fixture and stray capacitance)

Fig. 3 - Break-Before-Make (DG413)



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

Fig. 4 - Charge Injection

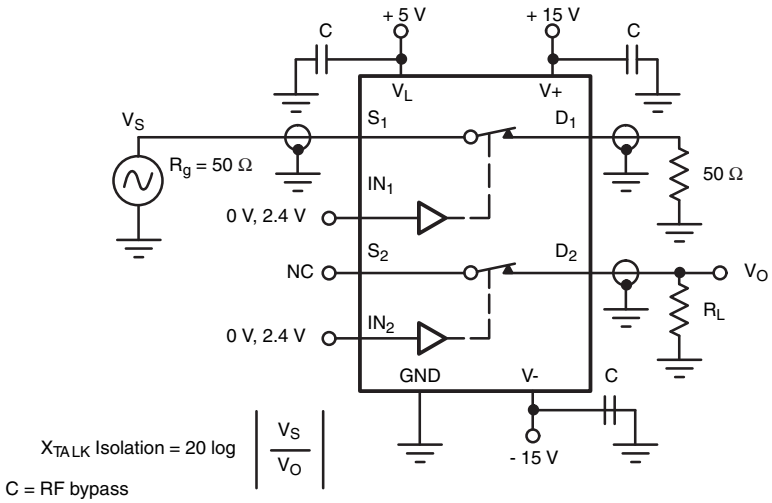


Fig. 5 - Crosstalk

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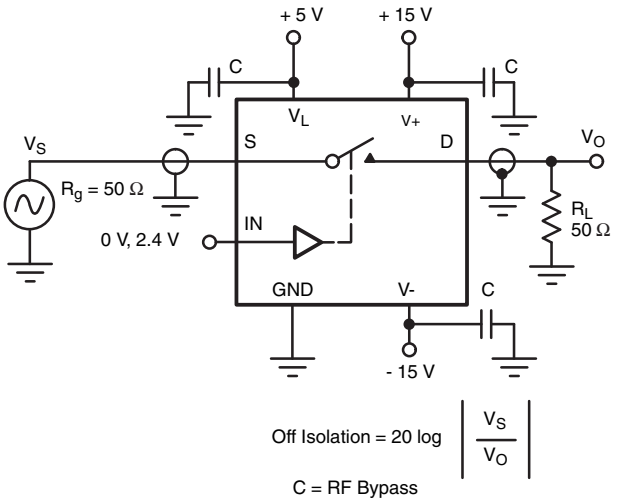

Fig. 6 - Off Isolation

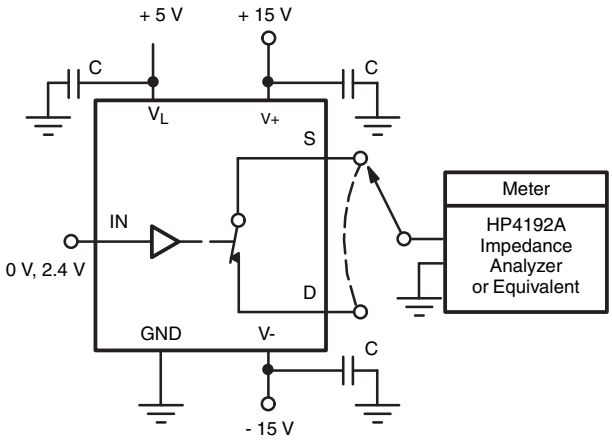

Fig. 7 - Source/Drain Capacitances

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 V_L and V- is tied to 0 V. See Input Switching Threshold vs. Supply Voltage curve for V_L versus input threshold requirements.

Summing Amplifier

When driving a high impedance, high capacitance load such as shown in Fig. 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.

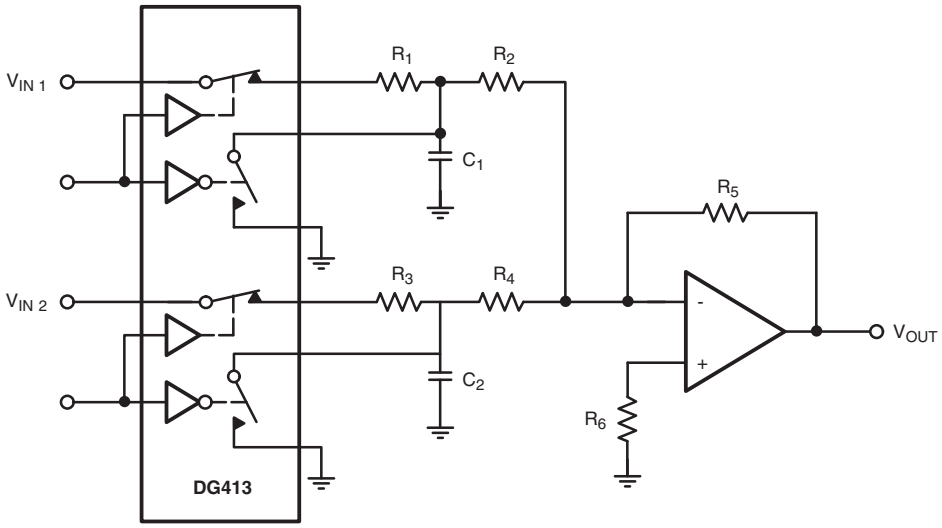

Fig. 8 - Summing Amplifier

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PRODUCT SUMMARY						
Part number	DG411	DG411	DG412	DG412	DG413	DG413
Status code	2	2	2	2	2	2
Configuration	SPST x 4, NC	SPST x 4, NC	SPST x 4, NO	SPST x 4, NO	SPST x 4, comp	SPST x 4, comp
Single supply min. (V)	5	5	5	5	5	5
Single supply max. (V)	44	44	44	44	44	44
Dual supply min. (V)	5	5	5	5	5	5
Dual supply max. (V)	22	22	22	22	22	22
On-resistance (Ω)	25	25	25	25	25	25
Charge injection (pC)	5	5	5	5	5	5
Source on capacitance (pF)	35	35	35	35	35	35
Source off capacitance (pF)	9	9	9	9	9	9
Leakage switch on typ. (nA)	0.1	0.1	0.1	0.1	0.1	0.1
Leakage switch off max. (nA)	0.25	0.25	0.25	0.25	0.25	0.25
-3 dB bandwidth (MHz)	-	-	-	-	-	-
Package	TSSOP-16	SO-16 (narrow) AS	SO-16 (narrow) AS	TSSOP-16	TSSOP-16	SO-16 (narrow) AS
Functional circuit / applications	Multi purpose, instrumentation, medical and healthcare	Multi purpose, instrumentation, medical and healthcare	Multi purpose, instrumentation, medical and healthcare	Multi purpose, instrumentation, medical and healthcare	Multi purpose, instrumentation, medical and healthcare	Multi purpose, instrumentation, medical and healthcare
Interface	Parallel	Parallel	Parallel	Parallel	Parallel	Parallel
Single supply operation	Yes	Yes	Yes	Yes	Yes	Yes
Dual supply operation	Yes	Yes	Yes	Yes	Yes	Yes
Turn on time max. (ns)	175	175	175	175	175	175
Crosstalk and off isolation	-85	-85	-85	-85	-85	-85

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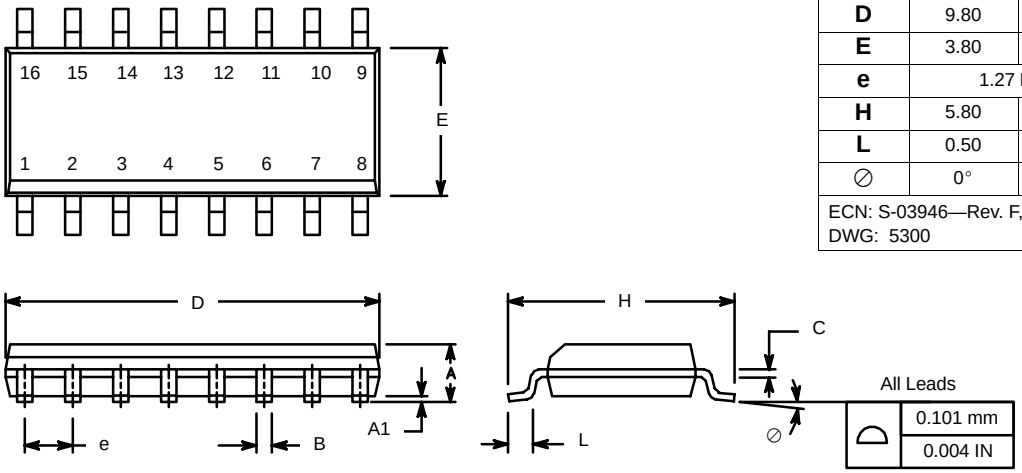
SOIC (NARROW): 16-LEAD

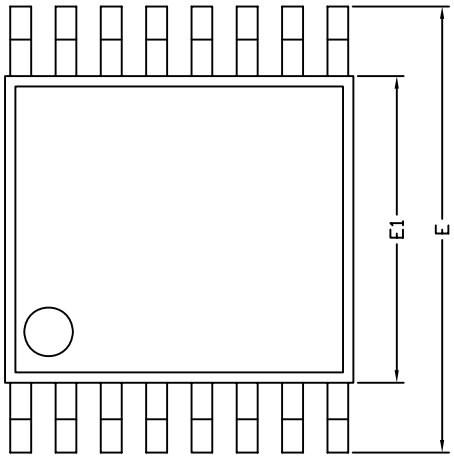
JEDEC Part Number: MS-012

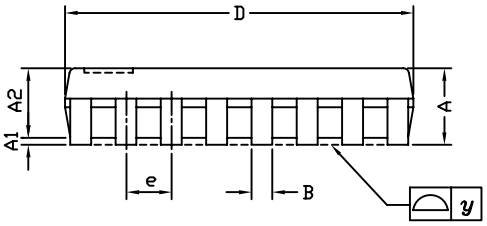


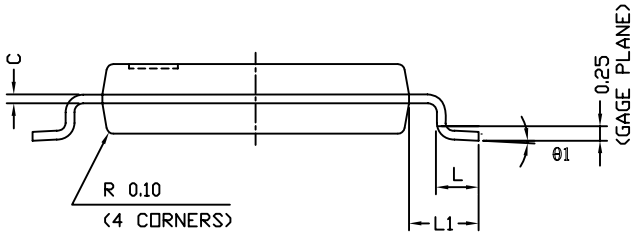
Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A_1	0.10	0.20	0.004	0.008
B	0.38	0.51	0.015	0.020
C	0.18	0.23	0.007	0.009
D	9.80	10.00	0.385	0.393
E	3.80	4.00	0.149	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
L	0.50	0.93	0.020	0.037
⊘	0°	8°	0°	8°

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

TSSOP: 16-LEAD

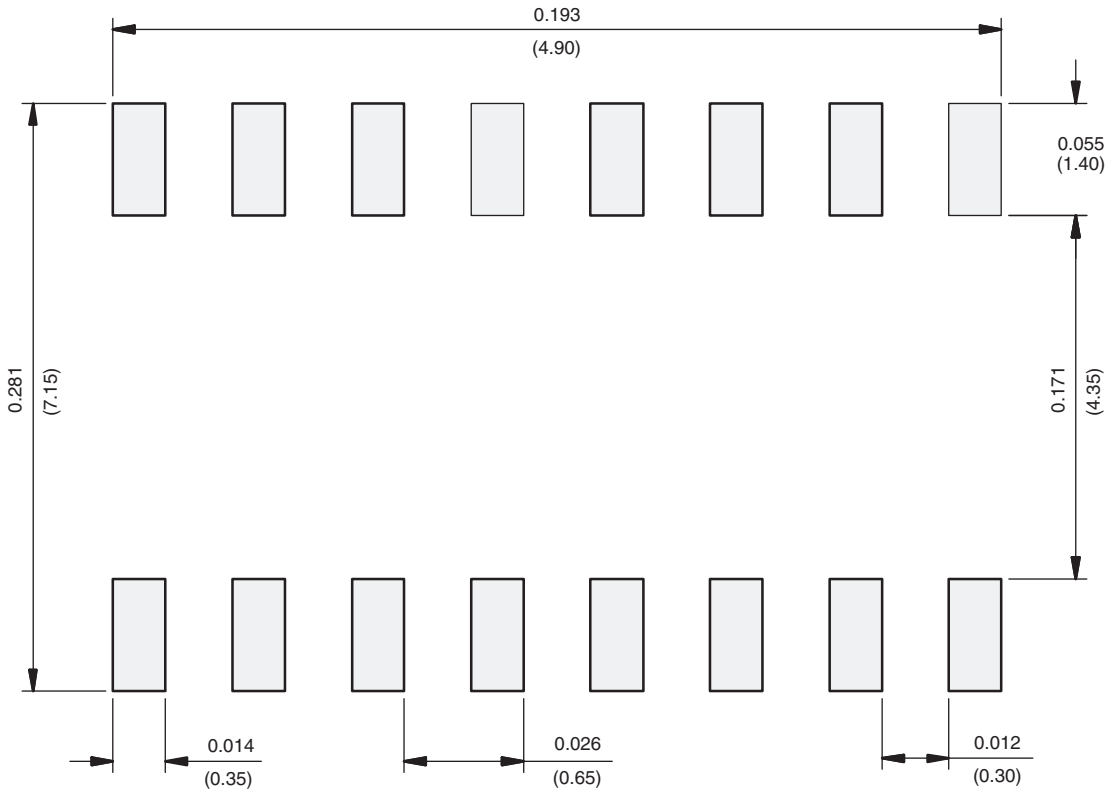






Symbols	DIMENSIONS IN MILLIMETERS		
	Min	Nom	Max
A	-	1.10	1.20
A1	0.05	0.10	0.15
A2	-	1.00	1.05
B	0.22	0.28	0.38
C	-	0.127	-
D	4.90	5.00	5.10
E	6.10	6.40	6.70
E1	4.30	4.40	4.50
e	-	0.65	-
L	0.50	0.60	0.70
L1	0.90	1.00	1.10
y	-	-	0.10
θ1	0°	3°	6°
ECN: S-61920-Rev. D, 23-Oct-06 DWG: 5624			

RECOMMENDED MINIMUM PAD FOR TSSOP-16



Recommended Minimum Pads
Dimensions in inches (mm)

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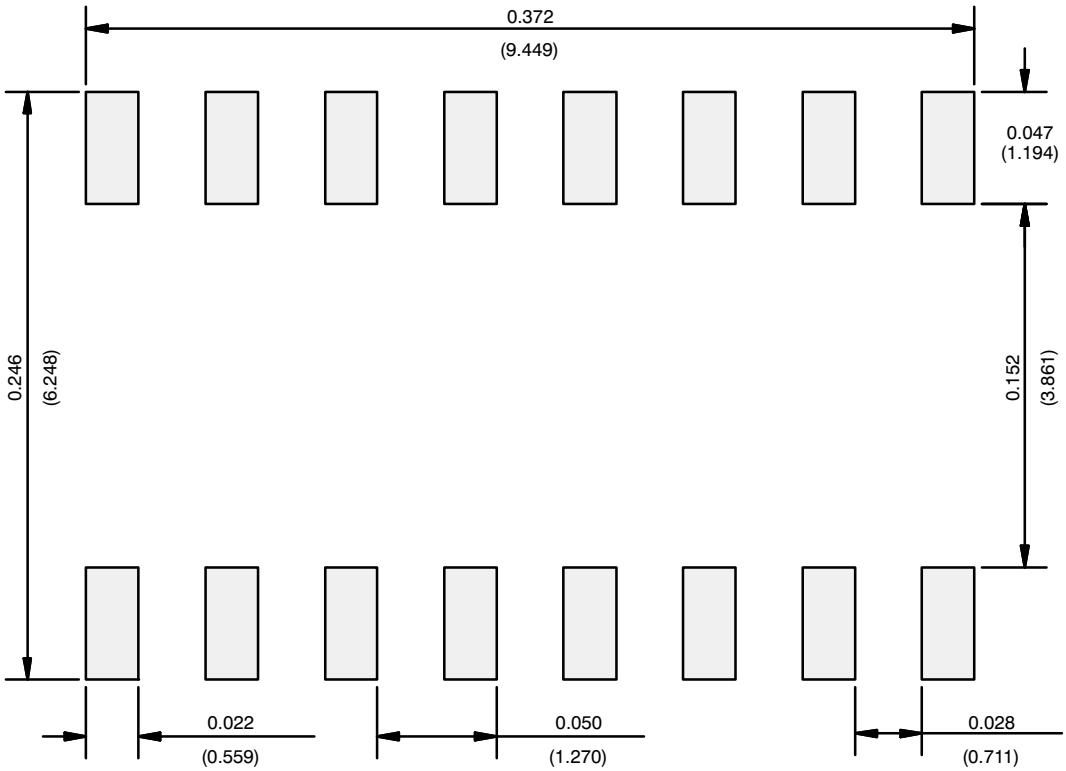
RECOMMENDED MINIMUM PADS FOR SO-16



Recommended Minimum Pads
Dimensions in Inches/(mm)

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