DG411/412/413

Precision Monolithic Quad SPST CMOS Analog Switches

Siliconix incorporated

403-143

FEATURES

- ±15 Volt Input Range
- ON Resistance < 35 Ω
- Fast Switching Action
  t_{ON} < 175 ns
  t_{OFF} < 145 ns
- Ultra Low Power Requirements (P_D < 35 μW)
- TTL, CMOS Compatible
- ESDS Protection > ±4000 V

BENEFITS

- Widest Dynamic Range
- Low Signal Errors and Distortion
- Break-Before-Make Switching Action
- Simple Interfacing

APPLICATIONS

- High Performance Audio and Video Switching
- Precision Automatic Test Equipment
- Precision Data Acquisition
- Sample and Hold Circuits
- Communication Systems
- Battery Operated Systems

DESCRIPTION

The DG411 series of monolithic quad analog switches was designed to provide high speed, low error switching of precision analog, audio and video signals. Combining low power (< 35 μW) with high speed (t_{ON} < 175 ns), the DG411 family is ideally suited for portable and battery powered industrial and military applications.

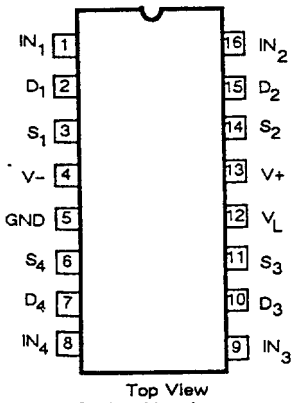
To achieve high-voltage ratings and superior switching performance, the DG411 series was built on Siliconix's high voltage silicon gate process. An epitaxial layer prevents latchup.

Each switch conducts equally well in both directions when ON, and blocks up to 30 volts peak-to-peak when OFF. ON resistance is very flat over the full ±15 V analog range, rivaling JFET performance without the inherent dynamic range limitation.

The three devices in this series are differentiated by the type of switch action as shown in the functional block diagrams. Package options include the 16-pin CerDIP, plastic and small outline (SO) packages. Performance grades include both the industrial, D suffix (-40 to 85°C), and the military, A suffix (-55 to 125°C) temperature ranges.

PIN CONFIGURATIONS

Dual-In-Line Package

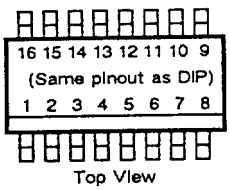


Top View

Order Numbers:

CerDIP: DG411AK
DG411AK/883
Plastic: DG411DJ

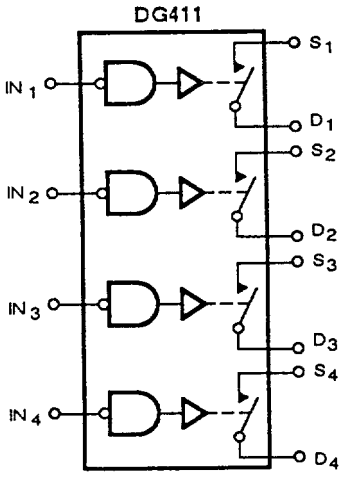
SO Package



Top View

Order Number:
DG411DY

FUNCTIONAL BLOCK DIAGRAM



DG411
Four SPST Switches per Package
Truth Table*

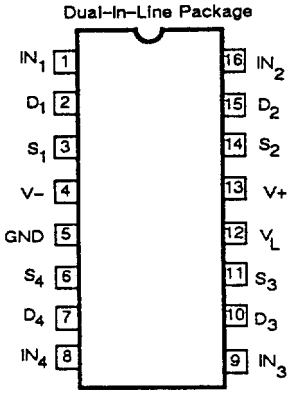
LOGIC	SWITCH
0	ON
1	OFF

Logic "0" ≤ 0.8 V
Logic "1" ≥ 2.4 V

*Switches shown for logic "1" input.

PIN CONFIGURATIONS

Dual-In-Line Package

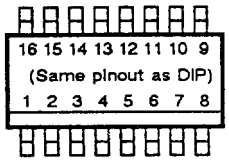


Top View

Order Numbers:

CerDIP: DG412AK
DG412AK/883
Plastic: DG412DJ

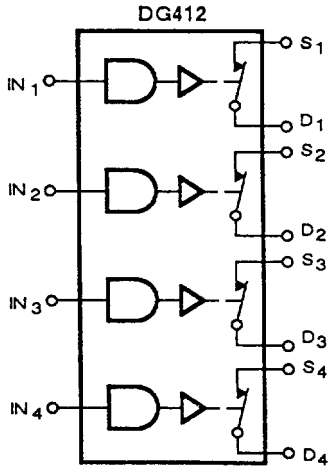
SO Package



Top View

Order Number:
DG412DY

DG412



DG412

Four SPST Switches per Package

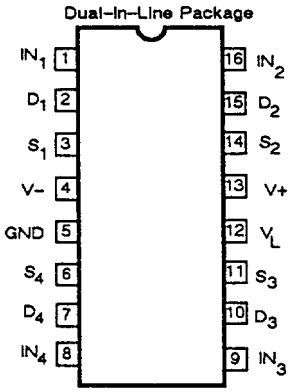
Truth Table*

LOGIC	SWITCH
0	OFF
1	ON

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

*Switches shown for logic "1" input.

Dual-In-Line Package

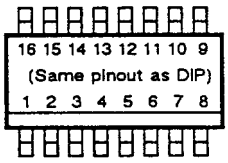


Top View

Order Numbers:

CerDIP: DG413AK
DG413AK/883
Plastic: DG413DJ

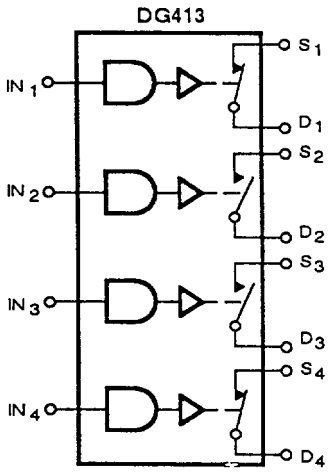
SO Package



Top View

Order Number:
DG413DY

DG413



DG413

Four SPST Switches per Package

Truth Table*

LOGIC	SWITCH 1, 4	SWITCH 2, 3
0	OFF	ON
1	ON	OFF

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

*Switches shown for logic "1" input.

5

ABSOLUTE MAXIMUM RATINGS

V+ to V- ..... 44 V

GND to V- ..... 25 V

V_L ..... (GND -0.3 V) to 44 V

Digital Inputs, V_S, V_D[1] ..... (V-) -2 V to (V+) +2 V
or 30 mA, whichever occurs first

Continuous Current (Any Terminal) ..... 30 mA

Current, S or D (Pulsed 1 ms, 10% Duty Cycle) . 100 mA

Storage Temperature (A Suffix) ..... -65 to 150°C
(D Suffix) ..... -65 to 125°C

Operating Temperature (A Suffix) ..... -55 to 125°C
(D Suffix) ..... -40 to 85°C

Power Dissipation (Package)*
16-Pin Plastic DIP** ..... 470 mW
16-Pin CerDIP*** ..... 900 mW
16-Pin SO**** ..... 600 mW

* All leads welded or soldered to PC board.
** Derate 6 mW /°C above 25°C.
*** Derate 12 mW /°C above 75°C.
**** Derate 7.6 mW/°C above 75°C.

1 Signals on Sx, Dx, or INx exceeding V+ or V- will be clamped by internal diodes. Limit forward diode current to maximum current ratings.

Siliconix incorporated

ELECTRICAL CHARACTERISTICS [a]

PARAMETER	SYMBOL	Test Conditions Unless Otherwise Specified: V+ = 15 V, V- = -15 V, V_L = 5 V, GND = 0 V, V_{IN} = 2.4 V, 0.8 V [e]		LIMITS 1=25°C 2=125,85°C 3=-55,-40°C TEMP	TYP [d]	A SUFFIX -55 to 125°C MIN [b]	A SUFFIX -55 to 125°C MAX [b]	D SUFFIX -40 to 85°C MIN [b]	D SUFFIX -40 to 85°C MAX [b]	UNIT
SWITCH										
Analog Signal Range [c]	V_{ANALOG}					-15	15	-15	15	V
Drain-Source ON Resistance	$r_{DS(ON)}$	I_S = -10 mA, V_D = ± 8.5 V, V+ = 13.5 V, V- = -13.5 V		1,3 2	25		35 45		35 45	Ω
Switch OFF Leakage Current	$I_{S(OFF)}$	V+ = 16.5 V, V- = -16.5 V	V_D = -15.5 V, V_S = 15.5 V	1,3 2	-0.1	-0.25 -20	0.25 20	-0.25 -20	0.25 20	nA
	$I_{D(OFF)}$		V_D = 15.5 V, V_S = -15.5 V	1,3 2	-0.1	-0.25 -20	0.25 20	-0.25 -20	0.25 20	
Channel ON Leakage Current	$I_{D(ON)}$ + $I_{S(ON)}$		V_S = V_D = ±15.5 V	1,3 2	-0.1	-0.4 -40	0.4 40	-0.4 -40	0.4 40	
INPUT										
Input Current with V_{IN} LOW	I_{IL}	V_{IN} Under Test = 0.8 V, All Other = 2.4 V		1,2,3	.005	-0.5	0.5	-0.5	0.5	µA
Input Current with V_{IN} HIGH	I_{IH}	V_{IN} Under Test = 2.4 V, All Other = 0.8 V		1,2,3	.005	-0.5	0.5	-0.5	0.5	
DYNAMIC										
Turn-ON Time	t_{ON}	R_L = 300Ω, C_L = 35 pF, See Switching Time Test Circuit, V_S = ±10 V		1,3	110		175		175	ns
Turn-OFF Time	t_{OFF}			1,3	100		145		145	
Break-Before-Make Time Delay	t_D	DG413 Only, R_L = 300Ω, C_L = 35 pF		1	25	10		10		
Charge Injection	Q	V_{gen} = 0 V, R_{gen} = 0Ω, C_L = 10 nF		1	5					pC
OFF Isolation [c]		R_L = 50Ω, C_L = 5 pF, f = 1 MHz		1	68					dB
Crosstalk [c] (Channel-to-Channel)		Any Other Channel Switches, R_L = 50Ω, C_L = 5 pF, f = 1 MHz		1	85					
Source OFF Capacitance [c]	$C_{S(OFF)}$	f = 1 MHz		1	9					pF
Drain OFF Capacitance [c]	$C_{D(OFF)}$			1	9					
Drain and Source ON [c] Capacitance	$C_{D(ON)}$ + $C_{S(ON)}$			1	18					

ELECTRICAL CHARACTERISTICS [a]

PARAMETER	SYMBOL	Test Conditions Unless Otherwise Specified: V+ = 15 V, V- = -15 V, V_L = 5 V, GND = 0 V, V_{IN} = 2.4 V, 0.8 V [e]	LIMITS 1=25°C 2=125,85°C 3=-55,-40°C		A SUFFIX -55 to 125°C		D SUFFIX -40 to 85°C		UNIT
			TEMP	TYP [d]	MIN [b]	MAX [b]	MIN [b]	MAX [b]	
SUPPLY									
Positive Supply Current	I+	V+ = 16.5 V, V- = -16.5 V, V_{IN} = 0 or 5 V	1 2	.0001		1 5		1 5	µA
Negative Supply Current	I-		1 2	-.0001	-1 -5		-1 -5		
Logic Supply Current	I_L		1 2	-.0001		1 5		1 5	
Ground Current	I_{GND}		1 2	-.0001	-1 -5		-1 -5		

ELECTRICAL CHARACTERISTICS [a] (UNIPOLAR SUPPLY)

PARAMETER	SYMBOL	Test Conditions Unless Otherwise Specified: V+ = 12 V, V- = 0 V, V_L = 5 V, GND = 0 V, V_{IN} = 2.4 V, 0.8 V [e]	LIMITS 1=25°C 2=125,85°C 3=-55,-40°C		A SUFFIX -55 to 125°C		D SUFFIX -40 to 85°C		UNIT
			TEMP	TYP [d]	MIN [b]	MAX [b]	MIN [b]	MAX [b]	
SWITCH									
Analog Signal Range [c]	V_{ANALOG}				0	12	0	12	V
Drain-Source ON Resistance	$r_{DS(ON)}$	I_S = -10 mA, V_D = 3.8 V, V+ = 10.8 V	1,3 2	40		80 100		80 100	Ω
DYNAMIC									
Turn-ON Time	t_{ON}	R_L = 300Ω, C_L = 35 pF, See Switching Time Test Circuit, V_S = 8 V	1,3	175		250		250	ns
Turn-OFF Time	t_{OFF}		1,3	95		125		125	
Break-Before-Make Time Delay	t_D	DG413 Only, R_L = 300Ω, C_L = 35 pF	1	25	10		10		
Charge Injection	Q	V_{gen} = 0 V, R_{gen} = 0Ω, C_L = 10 nF	1	25					pC
SUPPLY									
Positive Supply Current	I+	V_{IN} = 0 or 5 V; V+ = 13.2 V	1 2	.0001		1 5		1 5	µA
Negative Supply Current	I-		1 2	-.0001	-1 -5		-1 -5		
Logic Supply Current	I_L	V_L = 5.25 V	1 2	-.0001		1 5		1 5	
Ground Current	I_{GND}		1 2	-.0001	-1 -5		-1 -5		

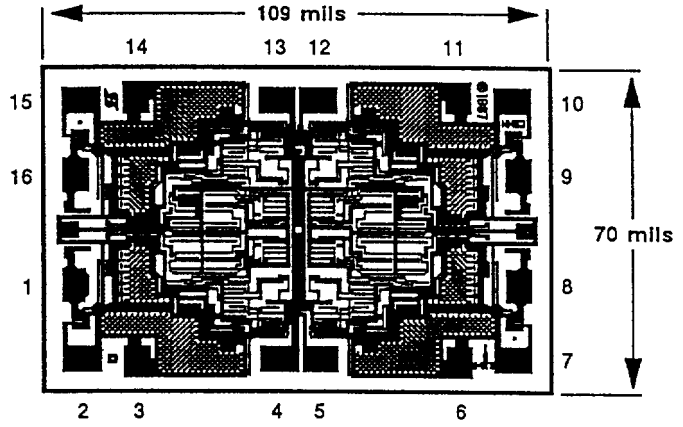
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ELECTRICAL CHARACTERISTICS [a]

NOTES:
a. Refer to PROCESS OPTION FLOWCHART for additional information.
b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
c. Guaranteed by design, not subject to production test.
d. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
e. V_{IN} = input voltage to perform proper function.

DIE TOPOGRAPHY

DG411/412/413



20X

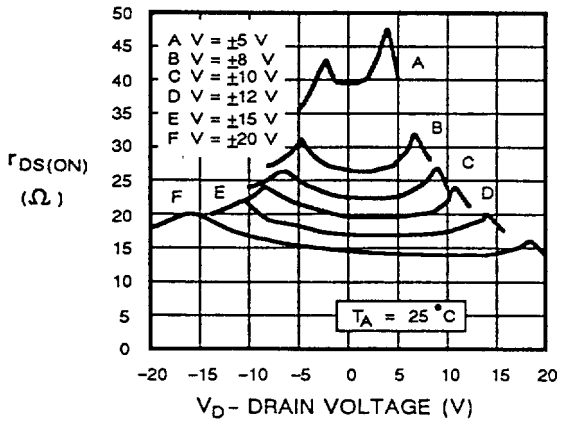
Pad No.	Function
1	IN_1
2	D_1
3	S_1
4	V-
5	GND
6	S_4
7	D_4
8	IN_4
9	IN_3
10	D_3
11	S_3
12	V_L
13	V+ (Substrate)
14	S_2
15	D_2
16	IN_2

CSHN-A, B, C

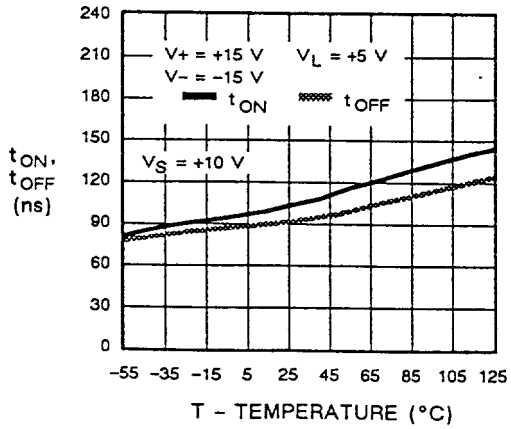
8 Capacitors 36 P-Channel Enhancement MOSFETs 8 Diodes
5 Resistors 44 N-Channel Enhancement MOSFETs

TYPICAL CHARACTERISTICS

ON-Resistance vs. V_D and Power Supply Voltage

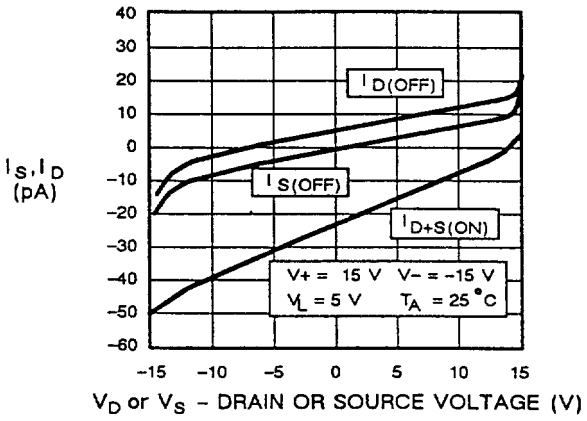


Switching Time vs. Temperature

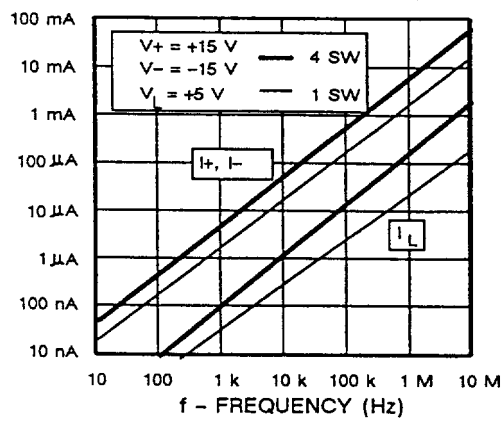


TYPICAL CHARACTERISTICS (Cont'd)

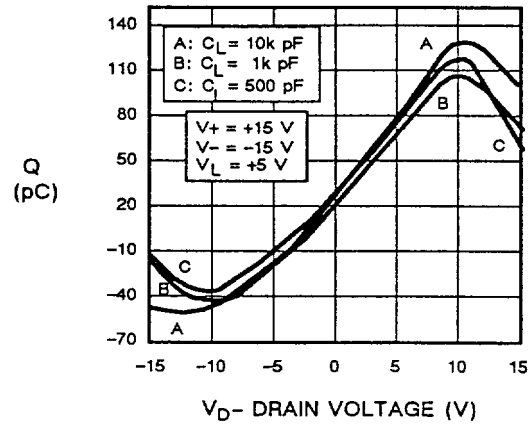
Leakage Current vs. Analog Voltage



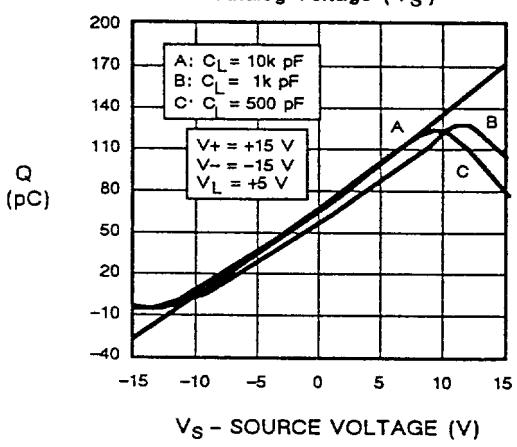
Supply Current vs. Input Switching Frequency



Charge Injection vs. Analog Voltage (V_D)

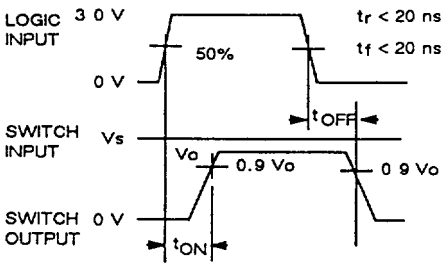


Charge Injection vs. Analog Voltage (V_S)

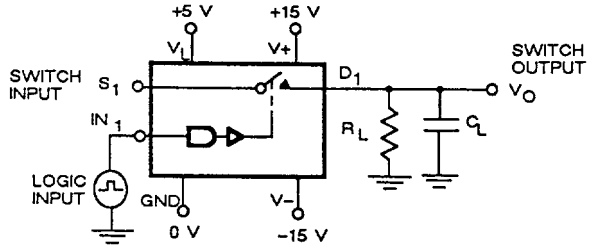


SWITCHING TIME TEST CIRCUIT

V_O is the steady state output with the switch ON. Feedthrough via switch capacitance may result in spikes at the leading and trailing edge of the output waveform.



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

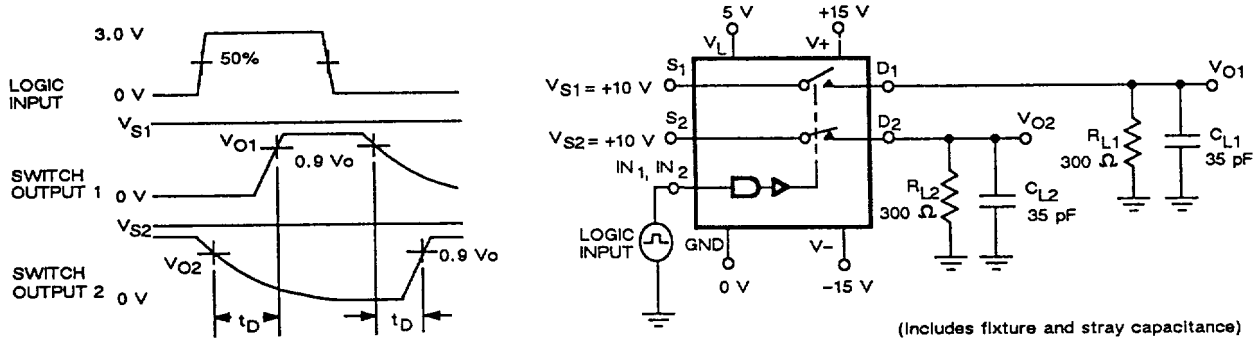


Repeat test for all IN and S.

For load conditions, See Electrical Characteristics
C_L (includes fixture and stray capacitance)

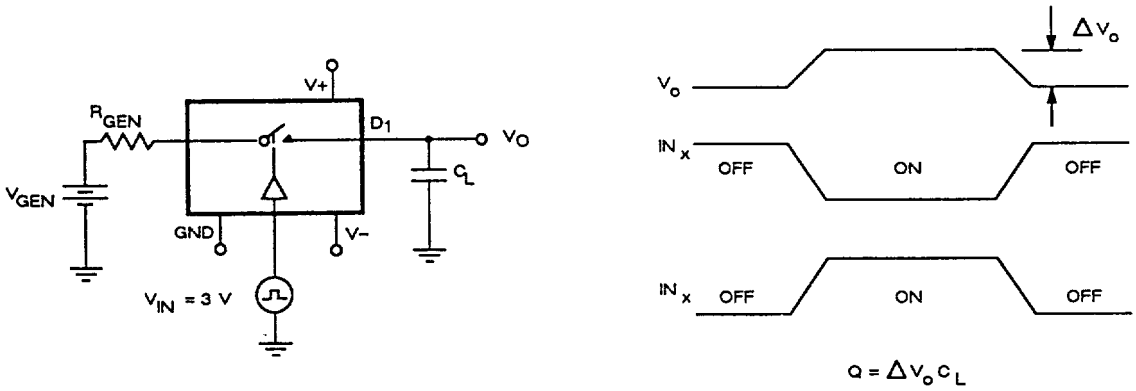
$$V_o = V_S \frac{R_L}{R_L + R_{DS(ON)}}$$

BREAK-BEFORE-MAKE TIME TEST CIRCUIT



(Includes fixture and stray capacitance)

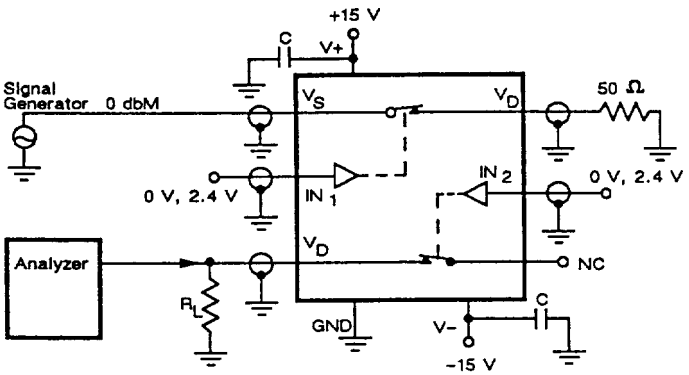
CHARGE INJECTION TEST CIRCUIT



$$Q = \Delta V_o C_L$$

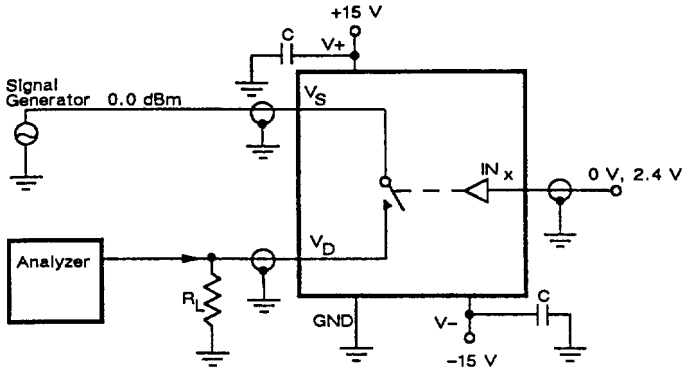
IN_x dependent on switch configuration
Input polarity determined by sense of switch

CROSSTALK TEST CIRCUIT



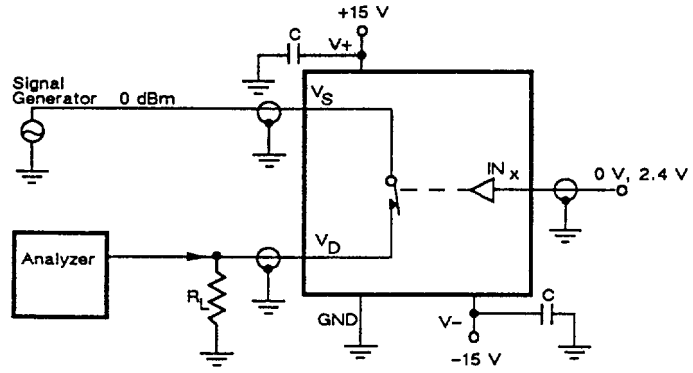
FREQUENCY TESTED	SIGNAL GENERATOR	ANALYZER
100 Hz to 13 MHz	HP3330B Automatic Synthesizer	HP3571A Tracking Spectrum Analyzer

OFF ISOLATION TEST CIRCUIT



FREQUENCY TESTED	SIGNAL GENERATOR	ANALYZER
100 Hz to 13 MHz	HP3330B Automatic Synthesizer	HP3571A Tracking Spectrum Analyzer

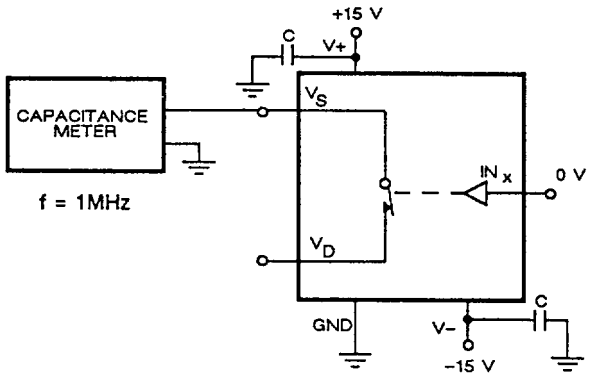
INSERTION LOSS TEST CIRCUIT



FREQUENCY TESTED	SIGNAL GENERATOR	ANALYZER
100 Hz to 13 MHz	HP3330B Automatic Synthesizer	HP3571A Tracking Spectrum Analyzer

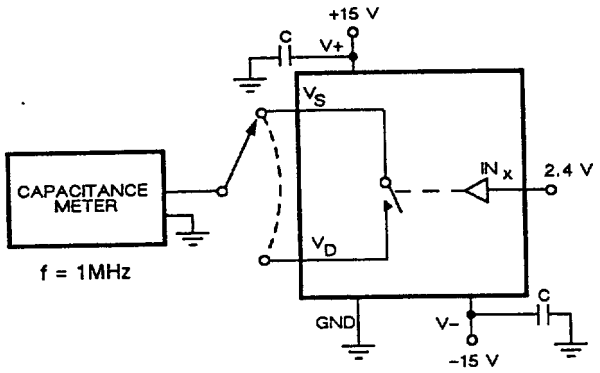
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SOURCE/DRAIN ON CAPACITANCE



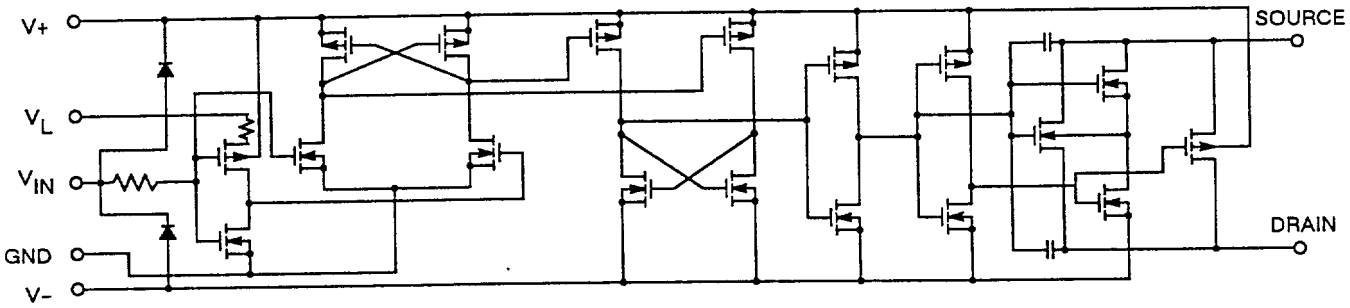
METER
BOONTON 72BD Capacitance Meter or equivalent

SOURCE/DRAIN OFF CAPACITANCE

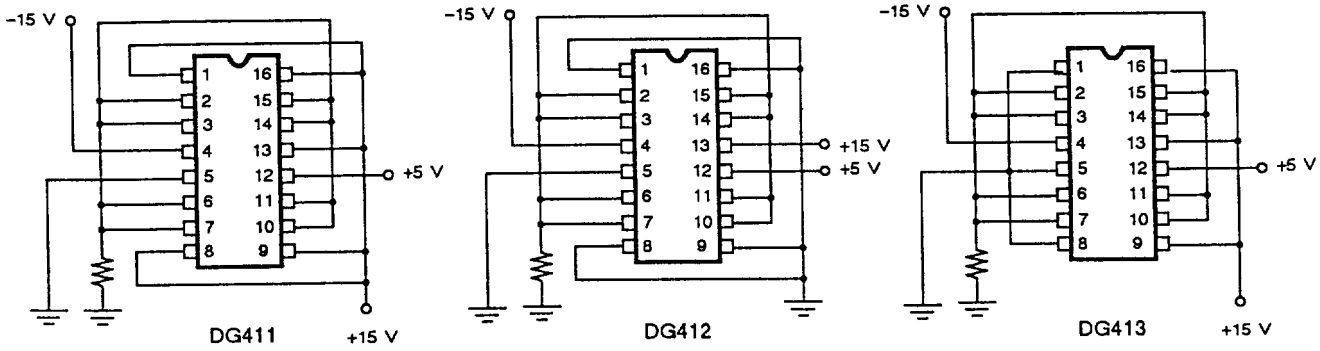


METER
BOONTON 72BD Capacitance Meter or equivalent

SCHEMATIC DIAGRAM (Typical Channel)



BURN-IN CIRCUITS



Note: All resistors are 10 kΩ unless otherwise specified.

PIN DESCRIPTION

SYMBOL	DESCRIPTION
S	Analog Channel Input or Output
D	Analog Channel Output or Input
IN	Logic Control input
V+	Positive Supply Voltage
V–	Negative Supply Voltage
GND	Digital Ground
V_L	Logic Supply Voltage

APPLICATIONS

Single Supply Operation:

The DG411/412/413 are characterized and tested for single supply operation at 12 volts. Although these devices can be operated with single supplies from 7.5 up to 22 V, 12 volts was selected as the test voltage because a majority of the applications use 12 volts. To function properly 12 volts is tied to pin 13 and 0 volts is tied to pin 4. Note: Pin 12 still requires 5 volts for proper TTL compatible switching.

Fast Sample and Hold:

The bulk of errors in sample and hold circuits attributed to analog switches come from two parameters – leakage currents and charge injection. Both parameters cause completely different errors to take place. Leakage currents discharge the holding capacitor (C_H) with time causing droop, while charge injection causes a dc offset to occur. The DG411/412/413's very low leakage current (250 pA) and charge injection (5 pC) specifications enhance sample and hold (Figure 1) accuracy.

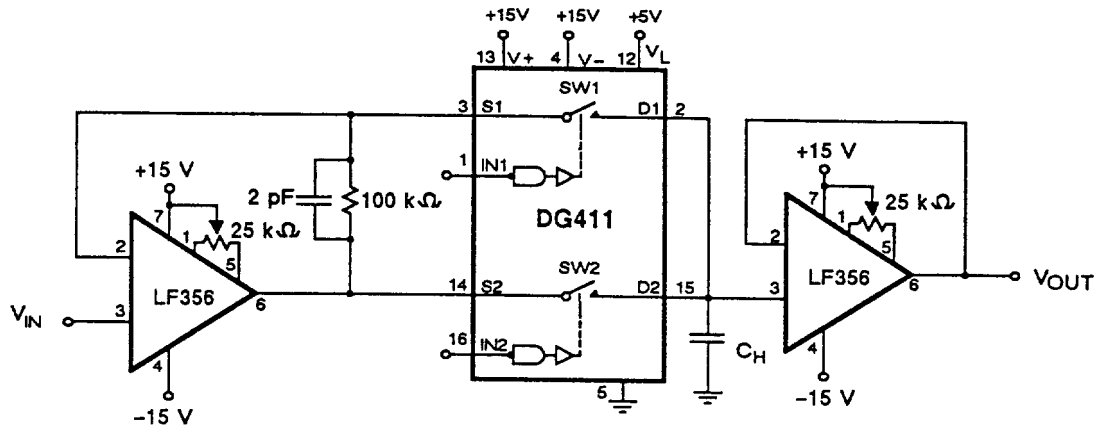


Figure 1. Fast, Accurate Sample and Hold

Summing Amplifier

When driving a high impedance, high capacitance load such as shown in Figure 2, 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 occuring at the output.

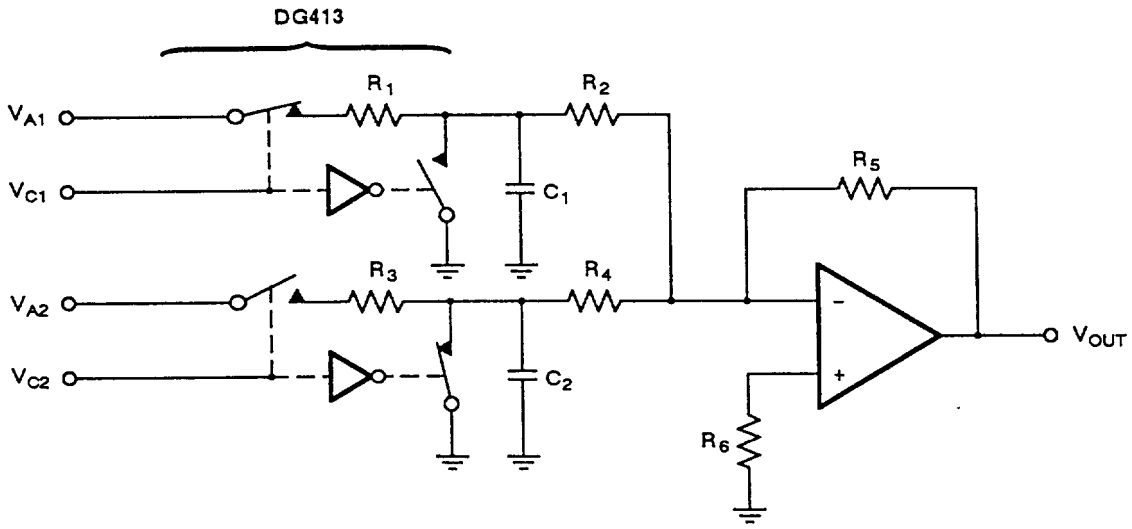


Figure 2. Summing Amplifier