

June 1994

## Monolithic Quad SPST CMOS Analog Switches

### Features

- This Circuit is Processed in Accordance to MIL-STD-883 and is Fully Conformant Under the Provisions of Paragraph 1.2.1.
- ON-Resistance  $<35\Omega$  Max
- Low Power Consumption ( $P_D <35\mu W$ )
- Fast Switching Action
  - $t_{ON} <175ns$
  - $t_{OFF} <145ns$
- Low Charge Injection
- Upgrade from DG211/DG212
- TTL, CMOS Compatible
- Single or Split Supply Operation

### Applications

- Audio Switching
- Battery Operated Systems
- Data Acquisition
- Hi-Rel Systems
- Sample and Hold Circuits
- Communication Systems
- Automatic Test Equipment

### Description

The DG411/883 series monolithic CMOS analog switches are drop-in replacements for the popular DG211 and DG212 series devices. They include four independent single pole throw (SPST) analog switches, and TTL and CMOS compatible digital inputs.

These switches feature lower analog ON resistance ( $<35\Omega$ ) and faster switch time ( $t_{ON} <175ns$ ) compared to the DG211 or DG212. Charge injection has been reduced, simplifying sample and hold applications.

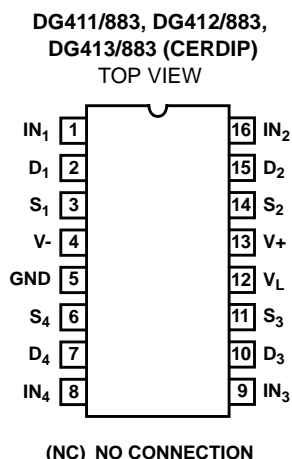
The improvements in the DG411/883 series are made possible by using a high voltage silicon-gate process. An epitaxial layer prevents the latch-up associated with older CMOS technologies. The 44V maximum voltage range permits controlling 40V<sub>P-P</sub> signals. Power supplies may be single-ended from +5V to +34V, or split from  $\pm 5V$  to  $\pm 20V$ .

The four switches are bilateral, equally matched for AC or bidirectional signals. The ON resistance variation with analog signals is quite low over a  $\pm 15V$  analog input range. The switches in the DG411/883 and DG412/883 are identical, differing only in the polarity of the selection logic. Two of the switches in the DG413/883 (#1 and #4) use the logic of the DG211 and DG411/883 (i.e. a logic "0" turns the switch ON) and the other two switches use DG212 and DG412/883 positive logic. This permits independent control of turn-on and turn-off times for SPDT configurations, permitting "break-before-make" or "make-before-break" operation with a minimum of external logic.

### Ordering Information

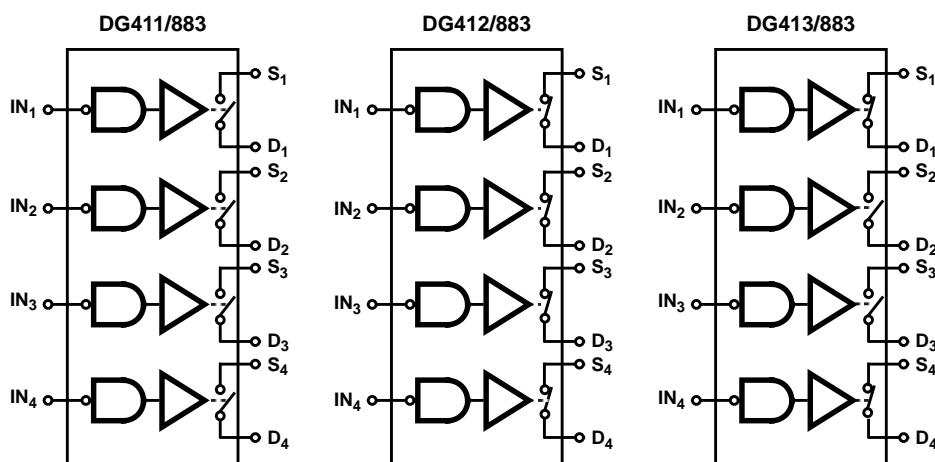
PART NUMBER	TEMP. RANGE	PACKAGE
DG411AK/883	-55°C to +125°C	16 Lead CerDIP
DG412AK/883	-55°C to +125°C	16 Lead CerDIP
DG413AK/883	-55°C to +125°C	16 Lead CerDIP

### Pinout



### Functional Diagrams

Four SPST Switches per Package Switches Shown for Logic "1" Input



**DG411/883, DG412/883, DG413/883**

**Pin Description**

PIN	SYMBOL	DESCRIPTION
1	IN <sub>1</sub>	Logic Control for Switch 1
2	D <sub>1</sub>	Drain (Output) Terminal for Switch 1
3	S <sub>1</sub>	Source (Input) Terminal for Switch 1
4	V-	Negative Power Supply Terminal
5	GND	Ground Terminal (Logic Common)
6	S <sub>4</sub>	Source (Input) Terminal for Switch 4
7	D <sub>4</sub>	Drain (Output) Terminal for Switch 4
8	IN <sub>4</sub>	Logic Control for Switch 4
9	IN <sub>3</sub>	Logic Control for Switch 3
10	D <sub>3</sub>	Drain (Output) Terminal for Switch 3
11	S <sub>3</sub>	Source (Input) Terminal for Switch 3
12	V <sub>L</sub>	Logic Reference Voltage
13	V+	Positive Power Supply Terminal (Substrate)
14	S <sub>2</sub>	Source (Input) Terminal for Switch 2
15	D <sub>2</sub>	Drain (Output) Terminal for Switch 2
16	IN <sub>2</sub>	Logic Control for Switch 2

**TRUTH TABLE**

LOGIC	DG411/ 883	DG412/ 883	DG413/883	
	SWITCH	SWITCH	SWITCH 1, 4	SWITCH 2, 3
0	ON	OFF	OFF	ON
1	OFF	ON	ON	OFF

NOTE: Logic "0" ≤0.8V. Logic "1" ≥2.4V.

# Specifications DG411/883, DG412/883, DG413/883

## Absolute Maximum Ratings

V+ to V-	44V
GND to V-	25V
V <sub>L</sub> (Note 2)	(GND -0.3V) to (V+) +0.3V
Digital Inputs, V <sub>S</sub> , V <sub>D</sub> (Note 2)	(V-) -2V to (V+) + 2V or 30mA, Whichever Occurs First
Continuous Current (Any Terminal)	30mA
Current, S or D (Pulsed 1ms, 10% Duty Cycle)	100mA
Storage Temperature Range (A Suffix)	-65°C to +125°C
Lead Temperature (Soldering 10s)	+300°C

## Thermal Information

Thermal Resistance (Note 3)	$\theta_{JA}$	$\theta_{JC}$
CerDIP Package	85°C/W	24°C/W
Junction Temperature	+175°C	
Operating Temperature (A Suffix)	-55°C to +125°C	

*CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.*

## Operating Conditions

Operating Voltage Range	±20V Max	Input High Voltage	2.4V Min
Operating Temperature Range	-55°C to +125°C	Input Rise and Fall Time	≤20ns
Input Low Voltage	0.8V Max		

**TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS**

Device Tested at: V+ = +15V, V- = -15V, V<sub>L</sub> = 5V, GND = 0V, Unless Otherwise Specified

PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS		UNITS		
					MIN	MAX			
Drain-to-Source ON Resistance DG411/883 DG412/883 DG413/883	R <sub>DS(ON)</sub>	V+ = +13.5V, V- = -13.5V, I <sub>S</sub> = -10mA, V <sub>D</sub> = ±8.5V	1, 3	+25°C, -55°C	0	35	Ω		
				+125°C	0	45	Ω		
			2	+25°C, -55°C	0	35	Ω		
				+125°C	0	45	Ω		
			V <sub>IN</sub> = 2.4V	1, 3	+25°C, -55°C	0	35	Ω	
				2	+125°C	0	45	Ω	
		DG411/883 DG412/883 DG413/883	V+ = +10.8V, V- = -0V, I <sub>S</sub> = -10mA, V <sub>D</sub> = 3.0V and 8.0V	1, 3	+25°C, -55°C	0	80	Ω	
					+125°C	0	100	Ω	
				2	+25°C, -55°C	0	80	Ω	
					+125°C	0	100	Ω	
				V <sub>IN</sub> = 0.8V or 2.4V (Note 1)	1, 3	+25°C, -55°C	0	80	Ω
					2	+125°C	0	100	Ω
Source OFF Leakage Current DG411/883 DG412/883 DG413/883	I <sub>S(OFF)</sub>	V+ = 16.5V, V- = -16.5V, V <sub>D</sub> = -15.5V, V <sub>S</sub> = 15.5V	1	+25°C	-0.25	+0.25	nA		
				2, 3	+125°C, -55°C	-20	+20	nA	
			2, 3	+25°C	-0.25	+0.25	nA		
				+125°C, -55°C	-20	+20	nA		
			1	+25°C	-0.25	+0.25	nA		
				2, 3	+125°C, -55°C	-20	+20	nA	
			V <sub>IN</sub> = 0.8V or 2.4V (Note 1)	1	+25°C	-0.25	+0.25	nA	
				2, 3	+125°C, -55°C	-20	+20	nA	
			DG411/883 DG412/883 DG413/883	V+ = 16.5V, V- = -16.5V, V <sub>D</sub> = 15.5V, V <sub>S</sub> = -15.5V	1	+25°C	-0.25	+0.25	nA
						2, 3	+125°C, -55°C	-20	+20
					2, 3	+25°C	-0.25	+0.25	nA
						+125°C, -55°C	-20	+20	nA
		1			+25°C	-0.25	+0.25	nA	
					2, 3	+125°C, -55°C	-20	+20	nA
		V <sub>IN</sub> = 0.8V or 2.4V (Note 1)	1	+25°C	-0.25	+0.25	nA		
			2, 3	+125°C, -55°C	-20	+20	nA		

## Specifications DG411/883, DG412/883, DG413/883

**TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)**

Device Tested at:  $V_+ = +15V$ ,  $V_- = -15V$ ,  $V_L = 5V$ ,  $GND = 0V$ , Unless Otherwise Specified

PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS		UNITS		
					MIN	MAX			
Drain OFF Leakage Current DG411/883 DG412/883 DG413/883 DG411/883 DG412/883 DG413/883	$I_{D(OFF)}$	$V_+ = 16.5V$ , $V_- = -16.5V$ , $V_D = -15.5V$ , $V_S = 15.5V$	$V_{IN} = 2.4V$	1	+25°C	-0.25	+0.25	nA	
				2, 3	+125°C, -55°C	-20	+20	nA	
			$V_{IN} = 0.8V$	1	+25°C	-0.25	+0.25	nA	
				2, 3	+125°C, -55°C	-20	+20	nA	
			$V_{IN} = 0.8V$ or 2.4V (Note 1)	1	+25°C	-0.25	+0.25	nA	
				2, 3	+125°C, -55°C	-20	+20	nA	
		$V_+ = 16.5V$ , $V_- = -16.5V$ , $V_D = 15.5V$ , $V_S = -15.5V$	$V_{IN} = 2.4V$	1	+25°C	-0.25	+0.25	nA	
				2, 3	+125°C, -55°C	-20	+20	nA	
			$V_{IN} = 0.8V$	1	+25°C	-0.25	+0.25	nA	
				2, 3	+125°C, -55°C	-20	+20	nA	
			$V_{IN} = 0.8V$ or 2.4V (Note 1)	1	+25°C	-0.25	+0.25	nA	
				2, 3	+125°C, -55°C	-20	+20	nA	
Channel ON Leakage Current DG411/883 DG412/883 DG413/883	$I_{D(ON)} + I_{S(ON)}$	$V_+ = 16.5V$ , $V_- = -16.5V$ , $V_S = V_D = \pm 15.5V$	$V_{IN} = 0.8V$	1	+25°C	-0.4	+0.4	nA	
				2, 3	+125°C, -55°C	-40	+40	nA	
			$V_{IN} = 2.4V$	1	+25°C	-0.4	+0.4	nA	
				2, 3	+125°C, -55°C	-40	+40	nA	
		$V_{IN} = 0.8V$ or 2.4V (Note 1)	1	+25°C	-0.4	+0.4	nA		
			2, 3	+125°C, -55°C	-40	+40	nA		
		Input Current with $V_{IN}$ Low	$I_{IL}$	Input Under Test = 0.8V, All Others = 2.4V	1, 2, 3	+25°C, +125°C, -55°C	-0.5	+0.5	$\mu A$
		Input Current with $V_{IN}$ High	$I_{IH}$	Input Under Test = 2.4V, All Others = 0.8V	1, 2, 3	+25°C, +125°C, -55°C	-0.5	+0.5	$\mu A$
Positive Supply Current	$I_+$	$V_+ = 16.5V$ , $V_- = -16.5V$ , $V_{IN} = 0V$ or 5.0V	1	+25°C	-	+1.0	$\mu A$		
			2, 3	+125°C, -55°C	-	+5.0	$\mu A$		
		$V_+ = 13.2V$ , $V_- = 0V$ , $V_{IN} = 0V$ or 5.0V $V_L = 5.25V$	1	+25°C	-	+1.0	$\mu A$		
			2, 3	+125°C, -55°C	-	+5.0	$\mu A$		
Negative Supply Current	$I_-$	$V_+ = 16.5V$ , $V_- = -16.5V$ , $V_{IN} = 0V$ or 5.0V	1	+25°C	-1.0	-	$\mu A$		
			2, 3	+125°C, -55°C	-5.0	-	$\mu A$		
		$V_+ = 13.2V$ , $V_- = 0V$ , $V_{IN} = 0V$ or 5.0V $V_L = 5.25V$	1	+25°C	-1.0	-	$\mu A$		
			2, 3	+125°C, -55°C	-5.0	-	$\mu A$		
Logic Supply Current	$I_L$	$V_+ = 16.5V$ , $V_- = -16.5V$ , $V_{IN} = 0V$ or 5.0V	1	+25°C	-	+1.0	$\mu A$		
			2, 3	+125°C, -55°C	-	+5.0	$\mu A$		
		$V_+ = 13.2V$ , $V_- = 0V$ , $V_{IN} = 0V$ or 5.0V $V_L = 5.25V$	1	+25°C	-	+1.0	$\mu A$		
			2, 3	+125°C, -55°C	-	+5.0	$\mu A$		
Ground Current	$I_{GND}$	$V_+ = 16.5V$ , $V_- = -16.5V$ , $V_{IN} = 0V$ or 5.0V	1	+25°C	-1.0	-	$\mu A$		
			2, 3	+125°C, -55°C	-5.0	-	$\mu A$		
		$V_+ = 13.2V$ , $V_- = 0V$ , $V_{IN} = 0V$ or 5.0V $V_L = 5.25V$	1	+25°C	-1.0	-	$\mu A$		
			2, 3	+125°C, -55°C	-5.0	-	$\mu A$		

## Specifications DG411/883, DG412/883, DG413/883

**TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS**

Device Tested at:  $V_+ = +15V$ ,  $V_- = -15V$ ,  $V_L = 5V$ ,  $GND = 0V$ , Unless Otherwise Specified

PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Turn ON Time	$t_{ON}$	$C_L = 35pF$ , $V_S = \pm 10V$ , $R_L = 300\Omega$	9, 11	+25°C, -55°C	0	175	ns
			10	+125°C	0	240	ns
		$V_+ = 12V$ , $V_- = 0V$ , $C_L = 35pF$ , $V_S = +8V$ , $R_L = 300\Omega$	9, 11	+25°C, -55°C	0	250	ns
			10	+125°C	0	400	ns
Turn OFF Time	$t_{OFF}$	$C_L = 35pF$ , $V_S = \pm 10V$ , $R_L = 300\Omega$	9, 11	+25°C, -55°C	0	145	ns
			10	+125°C	0	160	ns
		$V_+ = 12V$ , $V_- = 0V$ , $C_L = 35pF$ , $V_S = +8V$ , $R_L = 300\Omega$	9, 11	+25°C, -55°C	0	125	ns
			10	+125°C	0	140	ns

**TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS (NOTE 1)**

Device Tested at:  $V_+ = +15V$ ,  $V_- = -15V$ ,  $V_L = 5V$ ,  $GND = 0V$ , Unless Otherwise Specified

PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Charge Injection	Q	See Figure 2, $V_G = 0V$ , $R_G = 0\Omega$ , $T_A = +25^\circ C$ , $C_L = 10nF$	9	+25°C	-100	+100	pC
				+25°C			pC
		See Figure 2, $V_G = 6V$ , $R_G = 0\Omega$ , $T_A = +25^\circ C$ $C_L = 10nF$ , $V_+ = 12V$ , $V_- = 0V$	9	+25°C	-100	+100	pC
				+25°C			pC

**NOTES:**

- $V_{IN}$  = Input Voltage to Perform Proper Function.
- 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.
- All leads soldered or welded to PC board.
- Parameters listed in Table 3 are controlled via design or process and are not directly tested at final production. These parameters are lab characterized upon initial design release or upon design changes. These parameters are guaranteed by characterization based upon data from multiple production runs which reflect lot to lot and within lot variation.

**TABLE 4. ELECTRICAL TEST REQUIREMENTS**

MIL-STD-883 TEST REQUIREMENTS	SUBGROUPS (SEE TABLES 1 AND 2)
Interim Electrical Parameters (Pre Burn-In)	1
Final Electrical Test Parameters	1 (Note 1), 2, 3, 9, 10, 11
Group A Test Requirements	1, 2, 3, 9, 10, 11
Groups C and D Endpoints	1

**NOTE:**

- PDA applies to Subgroup 1 only.

**Die Characteristics**

**DIE DIMENSIONS:**

2760 $\mu$ m x 1780 $\mu$ m x 485  $\pm$  25 $\mu$ m

**METALLIZATION:**

Type: SiAl

Thickness: 12k $\text{\AA}$   $\pm$  1k $\text{\AA}$

**GLASSIVATION:**

Type: Nitride

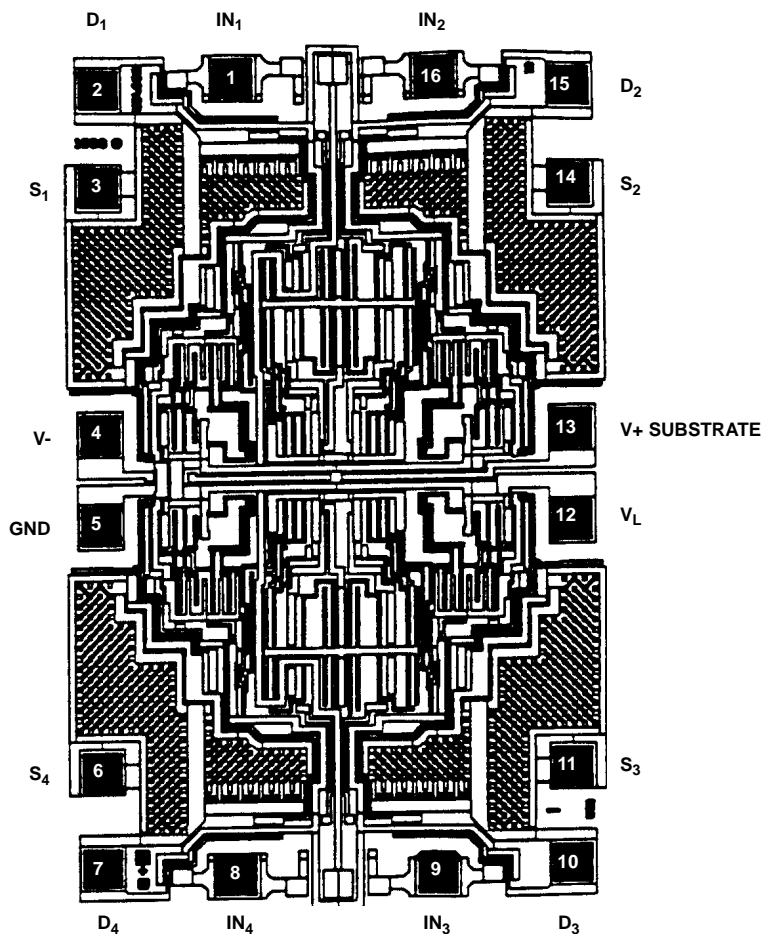
Thickness: 8k $\text{\AA}$   $\pm$  1k $\text{\AA}$

**WORST CASE CURRENT DENSITY:**

1.5 x 10<sup>5</sup>A/cm<sup>2</sup>

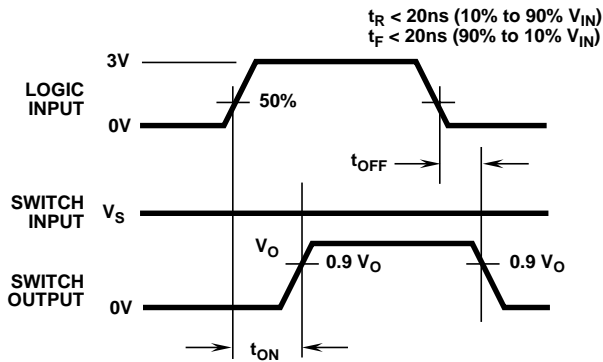
**Metallization Mask Layout**

DG411/883, DG412/883, DG413/883



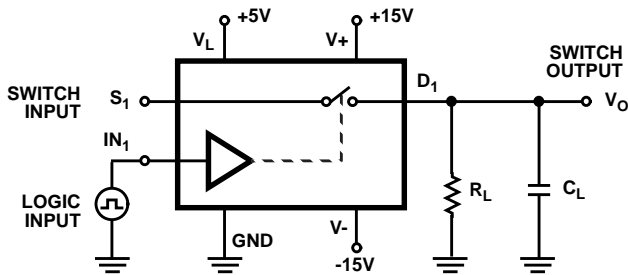
**Test Circuits**

$V_O$  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.

FIGURE 1A.



Repeat test for all IN and S.  
For load conditions, see Specifications  $C_L$  (includes fixture and stray capacitance)

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

FIGURE 1B.

FIGURE 1. SWITCHING TIME

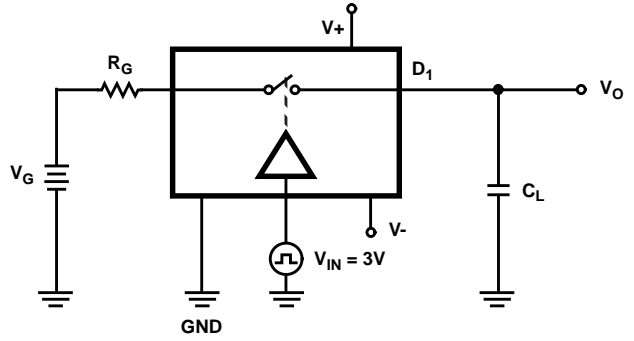
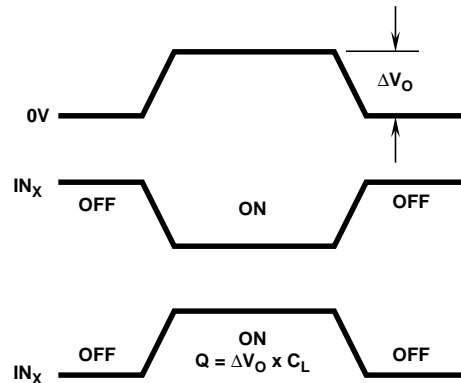


FIGURE 2A.



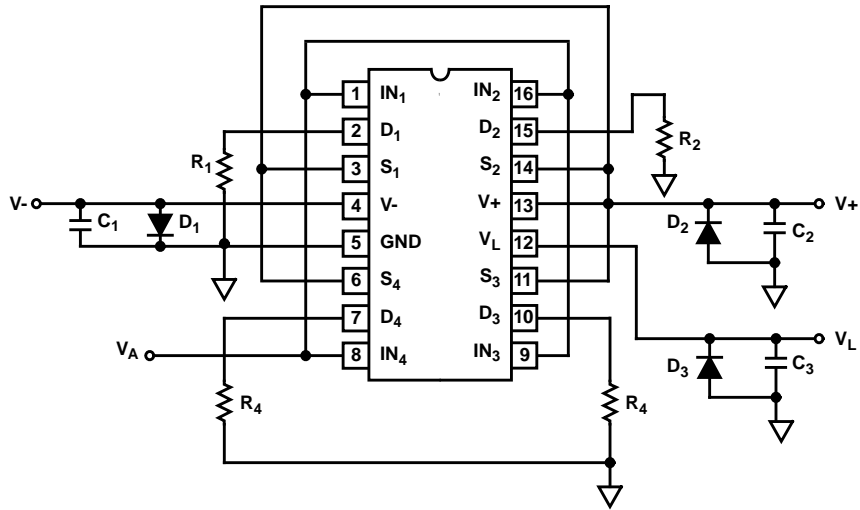
$IN_x$  dependent on switch configuration input polarity determined by sense of switch.

FIGURE 2B.

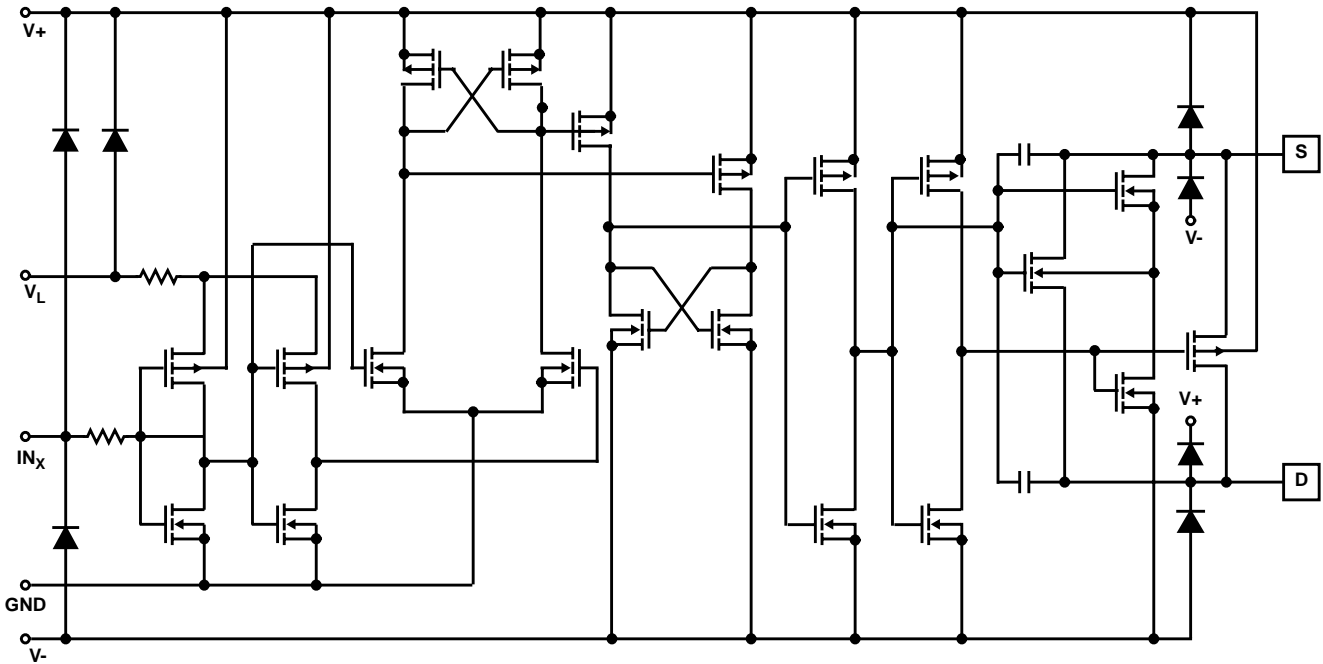
FIGURE 2. CHARGE INJECTION

**Burn-In Circuit**

DG411/883, DG412/883, DG413/883 CERAMIC DIP



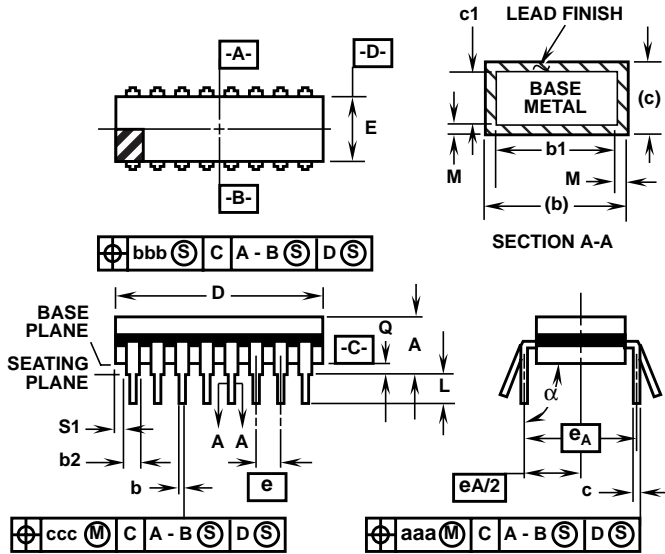
**Typical Schematic Diagram (Typical Channel)**





**Ceramic Dual-In-Line Frit Seal Packages (CerDIP)**

**F16.3 MIL-STD-1835 GDIP1-T16 (D-2, CONFIGURATION A)  
16 LEAD CERAMIC DUAL-IN-LINE FRIT SEAL PACKAGE**



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.200	-	5.08	-
b	0.014	0.026	0.36	0.66	2
b1	0.014	0.023	0.36	0.58	3
b2	0.045	0.065	1.14	1.65	-
b3	0.023	0.045	0.58	1.14	4
c	0.008	0.018	0.20	0.46	2
c1	0.008	0.015	0.20	0.38	3
D	-	0.840	-	21.34	5
E	0.220	0.310	5.59	7.87	5
e	0.100 BSC		2.54 BSC		-
eA	0.300 BSC		7.62 BSC		-
eA/2	0.150 BSC		3.81 BSC		-
L	0.125	0.200	3.18	5.08	-
Q	0.015	0.060	0.38	1.52	6
S1	0.005	-	0.13	-	7
alpha	90°	105°	90°	105°	-
aaa	-	0.015	-	0.38	-
bbb	-	0.030	-	0.76	-
ccc	-	0.010	-	0.25	-
M	-	0.0015	-	0.038	2, 3
N	16		16		8

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**NOTES:**

1. Index area: A notch or a pin one identification mark shall be located adjacent to pin one and shall be located within the shaded area shown. The manufacturer's identification shall not be used as a pin one identification mark.
2. The maximum limits of lead dimensions b and c or M shall be measured at the centroid of the finished lead surfaces, when solder dip or tin plate lead finish is applied.
3. Dimensions b1 and c1 apply to lead base metal only. Dimension M applies to lead plating and finish thickness.
4. Corner leads (1, N, N/2, and N/2+1) may be configured with a partial lead paddle. For this configuration dimension b3 replaces dimension b2.
5. This dimension allows for off-center lid, meniscus, and glass overrun.
6. Dimension Q shall be measured from the seating plane to the base plane.
7. Measure dimension S1 at all four corners.
8. N is the maximum number of terminal positions.
9. Dimensioning and tolerancing per ANSI Y14.5M - 1982.
10. Controlling dimension: INCH.

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## DESIGN INFORMATION

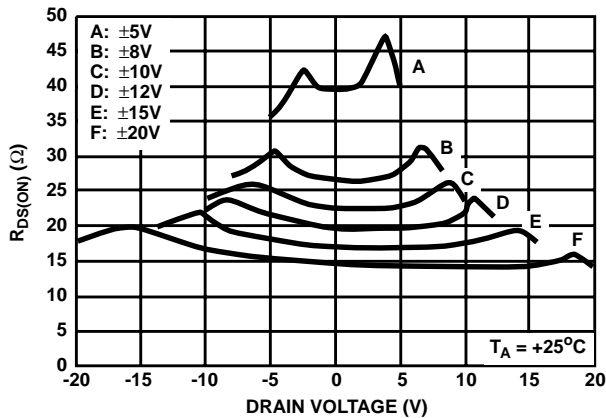
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## Monolithic Quad SPST CMOS Analog Switches

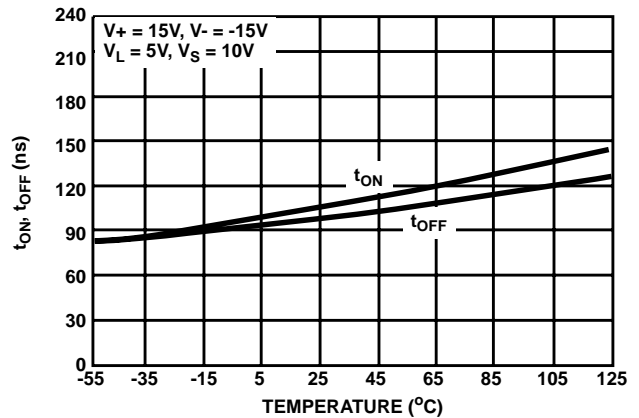
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### Typical Performance Curves

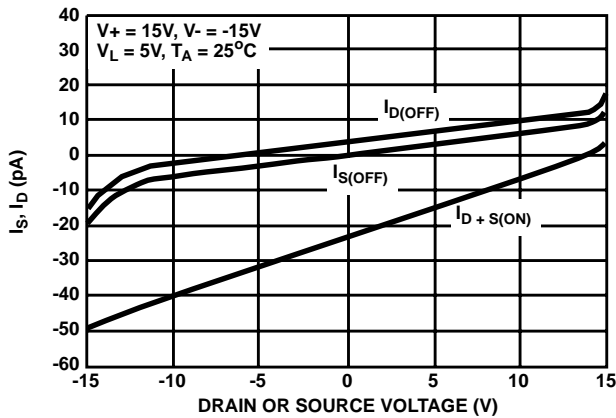
**ON-RESISTANCE vs  $V_D$  AND POWER SUPPLY VOLTAGE**



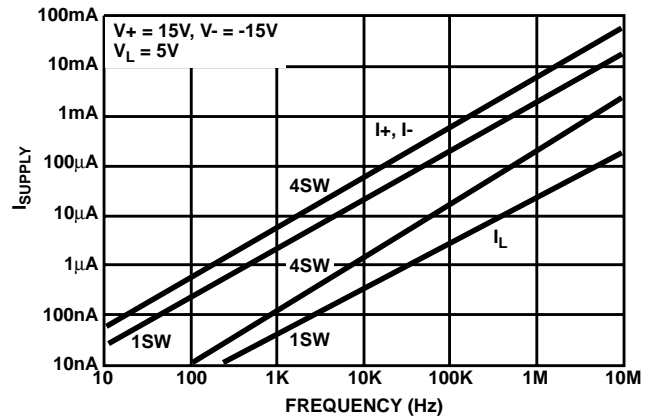
**SWITCHING TIME vs TEMPERATURE**



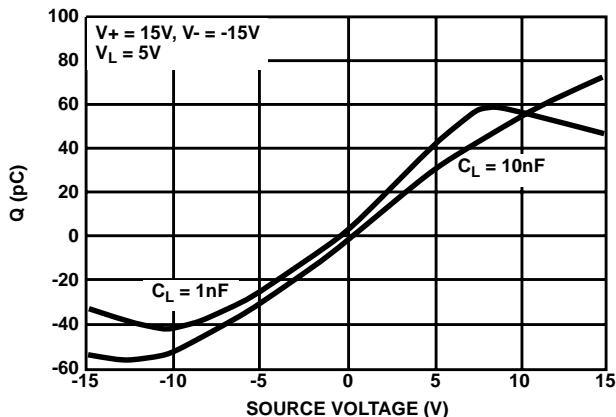
**LEAKAGE CURRENT vs ANALOG VOLTAGE**



**SUPPLY CURRENT vs INPUT SWITCHING FREQUENCY**



**CHARGE INJECTION vs ANALOG VOLTAGE ( $V_D$ )**



**CHARGE INJECTION vs ANALOG VOLTAGE ( $V_S$ )**

