19-4729; Rev 3; 6/99

MAXIM

Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

General Description

Maxim's redesigned DG406 and DG407 CMOS analog multiplexers now feature guaranteed matching between channels (8Ω max) and flatness over the specified signal range (9Ω max). These low on-resistance muxes (100Ω max) conduct equally well in either direction and feature guaranteed low charge injection (15pC max). In addition, these new muxes offer low input off-leakage current over temperature—less than 5nA at +85°C.

The DG406 is a 1 of 16 multiplexer/demultiplexer and the DG407 is a dual 8-channel multiplexer/demultiplexer. Both muxes operate with a +4.5V to +30V single supply and with ±4.5V to ±20V dual supplies. ESD protection is guaranteed to be greater than 2000V per Method 3015.7 of MIL-STD 883. These improved muxes are pin-compatible plug-in upgrades for the industry standard DG406 and DG407.

Applications

Sample-and-Hold Circuits

Test Equipment

Guidance and Control Systems

Communications Systems

Data-Acquisition Systems

Audio Signal Routing

Features

- **Pin-Compatible Plug-In Upgrade for Industry Standard DG406/DG407**
- **Guaranteed Matching Between Channels, 8Ω Max**
- **Guaranteed On-Resistance Flatness, 9Ω Max**
- **Guaranteed Low Charge Injection, 15pC Max**
- **Low On-Resistance 100Ω Max**
- **Input Leakage, 5nA Max at +85°C**
- **Low Power Consumption, 1.25mW Max**
- **Rail-to-Rail Signal Handling**
- **Digital Input Controls TTL/CMOS Compatible**
- **ESD Protection >2000V per Method 3015.7**

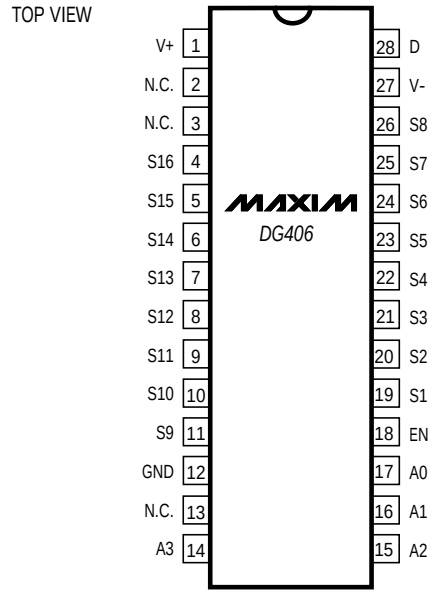
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
DG406CJ	0°C to +70°C	28 Plastic DIP
DG406CWI	0°C to +70°C	28 Wide SO
DG406C/D	0°C to +70°C	Dice*
DG406DJ	-40°C to +85°C	28 Plastic DIP
DG406DWI	-40°C to +85°C	28 Wide SO
DG406DN	-40°C to +85°C	28 PLCC
DG406AK	-55°C to +125°C	28 CERDIP

Ordering Information continued at end of data sheet.

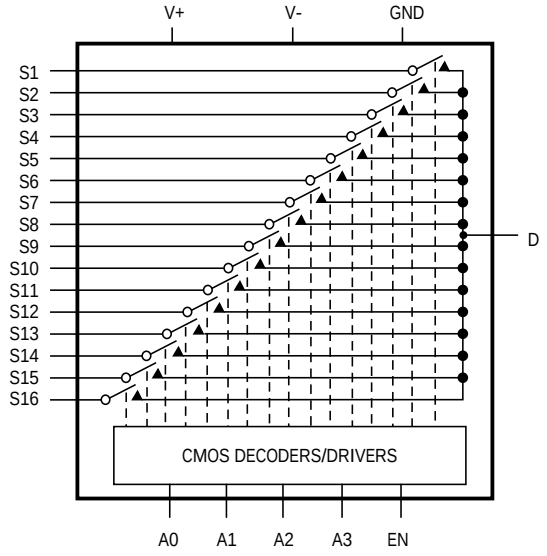
** Contact factory for dice specifications.*

Pin Configurations



DG407 at end of data sheet. **DIP/SO**

Functional Diagrams



DG406 16-CHANNEL SINGLE-ENDED MULTIPLEXER

DG407 at end of data sheet.

Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-
V+ .....-0.3V, 44V
GND .....-0.3V, 25V
Digital Inputs, S, D (Note 1).....(V- - 2V) to (V+ + 2V) or 30mA (whichever occurs first)
Continuous Current (any terminal).....30mA
Peak Current, S or D
(pulsed at 1ms, 10% duty cycle max) 100mA
Continuous Power Dissipation (T_A = +70°C)
Plastic DIP (derate 9.09mW/°C above +70°C) 727mW
Wide SO (derate 12.50mW/°C above +70°C).....1000mW
PLCC (derate 10.53mW/°C above +70°C) 842mW
CERDIP (derate 16.67mW/°C above +70°C).....1333mW
Operating Temperature Ranges
DG406/DG407C_ .....0°C to +70°C
DG406/DG407D_ .....-40°C to +85°C
DG406/DG407AK .....-55°C to +125°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10sec) .....+300°C

Note 1: Signals on S_, D_, A0, A1, A2, A3, or EN exceeding V+ or V- are clamped by internal diodes. Limit forward current to maximum current ratings.

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.

ELECTRICAL CHARACTERISTICS—Dual Supplies

(V+ = 15V, V- = -15V, GND = 0V, V_{AH} = +2.4V, V_{AL} = +0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS				MIN	TYP (Note 2)	MAX	UNITS
SWITCH									
Analog Signal Range	V_{ANALOG}	(Note 3)				-15		15	V
Drain-Source On-Resistance	$r_{DS(ON)}$	I_S = -1.0mA, V_D = ±10V		T_A = +25°C			60	100	Ω
				T_A = T_{MIN} to T_{MAX}				125	
On-Resistance Matching Between Channels	$\Delta r_{DS(ON)}$	I_S = -1.0mA, V_D = ±10V (Note 4)		T_A = +25°C			1.5	8	Ω
				T_A = T_{MIN} to T_{MAX}				10	
On-Resistance Flatness	r_{FLAT}	I_S = -1.0mA, V_D = ±5V or 0V		T_A = +25°C			1.8	9	Ω
				T_A = T_{MIN} to T_{MAX}				12	
Source-Off Leakage Current (Note 5)	$I_{S(OFF)}$	V_D = ∓10V, V_S = ±10V, V_{EN} = 0V		T_A = +25°C		-0.5	0.01	0.5	nA
				T_A = T_{MIN} to T_{MAX}	C, D	-5		5	
					A	-50		50	
Drain-Off Leakage Current (Note 5)	$I_{D(OFF)}$	V_D = ±10V, V_S = ∓10V, V_{EN} = 0V	DG406	T_A = +25°C		-1	0.02	1	nA
				T_A = T_{MIN} to T_{MAX}	C, D	-40		40	
					A	-200		200	
		V_D = ∓10V, V_S = ±10V, V_{EN} = 0V	DG407	T_A = +25°C		-1	0.02	1	
				T_A = T_{MIN} to T_{MAX}	C, D	-20		20	
					A	-100		100	
Drain-On Leakage Current (Note 5)	$I_{D(ON)}$ + $I_{S(ON)}$	V_D = ±10V, V_S = ±10V, sequence each switch on	DG406	T_A = +25°C		-1	0.02	1	nA
				T_A = T_{MIN} to T_{MAX}	C, D	-40		40	
					A	-200		200	
			DG407	T_A = +25°C		-1	0.02	1	
				T_A = T_{MIN} to T_{MAX}	C, D	-20		20	
					A	-100		100	

ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = 15V, V- = -15V, GND = 0V, V_{AH} = +2.4V, V_{AL} = +0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS			MIN	TYP (Note 2)	MAX	UNITS
INPUT								
Input Current with Input Voltage High	I_{AH}	V_A = 2.4V or 15V			-1.0		1.0	µA
Input Current with Input Voltage Low	I_{AL}	V_{EN} = 0V or 2.4V, V_A = 0V			-1.0		1.0	µA
SUPPLY								
Power-Supply Range					±4.5		±20	V
Positive Supply Current	I+	V_{EN} = V_A = 0V or 4.5V		T_A = +25°C		16	30	µA
				T_A = T_{MIN} to T_{MAX}			75	
		V_{EN} = 2.4V, $V_{A(ALL)}$ = 0V or 2.4V		T_A = +25°C		0.075	0.5	mA
				T_A = T_{MIN} to T_{MAX}			1	
Negative Supply Current	I-	V_{EN} = 2.4V, $V_{A(ALL)}$ = 0V or 2.4V		T_A = +25°C	-1		1	µA
				T_A = T_{MIN} to T_{MAX}	-10		10	
DYNAMIC								
Transition Time	t_{TRANS}	Figure 2		T_A = +25°C		110	300	ns
				T_A = T_{MIN} to T_{MAX}			400	
Break-Before-Make Interval	t_{OPEN}	Figure 4		T_A = +25°C	10	40		ns
Enable Turn-On Time	$t_{ON(EN)}$	Figure 3		T_A = +25°C		130	200	ns
				T_A = T_{MIN} to T_{MAX}			400	
Enable Turn-Off Time	$t_{OFF(EN)}$	Figure 3		T_A = +25°C		55	150	ns
				T_A = T_{MIN} to T_{MAX}			300	
Charge Injection (Note 3)	Q	C_L = 1.0nF, V_S = 0V, R_S = 0Ω, Figure 5		T_A = +25°C		2	15	pC
Off Isolation (Note 6)	V_{ISO}	V_{EN} = 0V, R_L = 1kΩ, f = 100kHz, Figure 6		T_A = +25°C		-69		dB
Crosstalk Between Channels	V_{CT}	V_{EN} = 2.4V, f = 100kHz, V_{GEN} = $1V_{P-P}$, R_L = 1kΩ, Figure 7		T_A = +25°C		-92		dB
Logic Input Capacitance	C_{IN}	f = 1MHz		T_A = +25°C		8		pF
Source-Off Capacitance	$C_{S(OFF)}$	f = 1MHz, V_{EN} = V_S = 0V, Figure 8		T_A = +25°C		8		pF
Drain-Off Capacitance	$C_{D(OFF)}$	f = 1MHz, V_{EN} = 0.8V, V_D = 0V, Figure 8	DG406	T_A = +25°C		130		pF
			DG407			65		
Drain-Source On Capacitance	$C_{D(ON)}$ + $C_{S(ON)}$	f = 1MHz, V_{EN} = 2.4V, V_D = 0V, Figure 8	DG406	T_A = +25°C		140		pF
			DG407			70		

ELECTRICAL CHARACTERISTICS—Single Supply

(V+ = 12V, V- = 0V, GND = 0V, V_{AH} = +2.4V, V_{AL} = +0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
SWITCH							
Analog Signal Range	V_{ANALOG}	(Note 3)		0		12	V
Drain-Source On-Resistance	$r_{DS(ON)}$	I_S = -1.0mA V_D = 3V or 10V	T_A = +25°C		120	175	Ω
DYNAMIC							
Transition Time (Note 3)	t_{TRANS}	V_{S1} = 8V, V_{S16} = 0V, V_A = 0V, Figure 2	T_A = +25°C		130	450	ns
Enable Turn-On Time (Note 3)	$t_{ON(EN)}$	V_{AL} = 0V, V_{S1} = 5V, Figure 3	T_A = +25°C		105	600	ns
Enable Turn-Off Time (Note 3)	$t_{OFF(EN)}$	V_{AL} = 0V, V_{S1} = 5V, Figure 3	T_A = +25°C		80	300	ns
Charge Injection (Note 3)	Q	C_L = 1.0nF, V_{S1} = 0V, R_S = 0Ω	T_A = +25°C		2	10	pC

Note 2: The algebraic convention where the most negative value is a minimum and the most positive value a maximum is used in this data sheet.

Note 3: Guaranteed by design.

Note 4: $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$. On-resistance match between channels and flatness are guaranteed only with specified voltages. Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured at the extremes of the specified analog signal range.

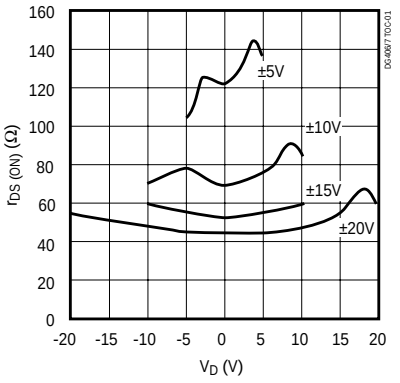
Note 5: Leakage parameters are 100% tested at the maximum rated hot temperature and guaranteed by correlation at +25°C.

Note 6: Off isolation = 20log V_D/V_S, where V_D = output and V_S = input to off switch.

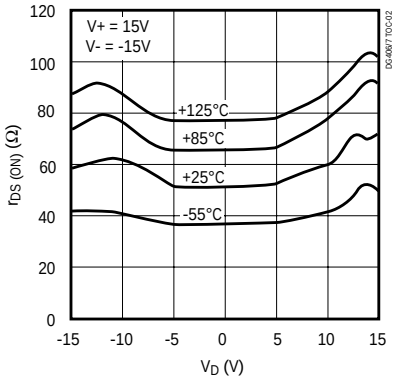
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

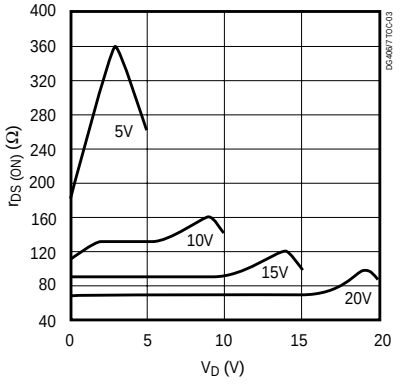
ON-RESISTANCE vs. V_D (DUAL SUPPLIES)



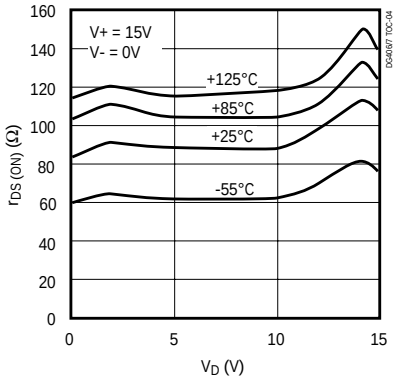
ON-RESISTANCE vs. V_D AND TEMPERATURE (DUAL SUPPLIES)



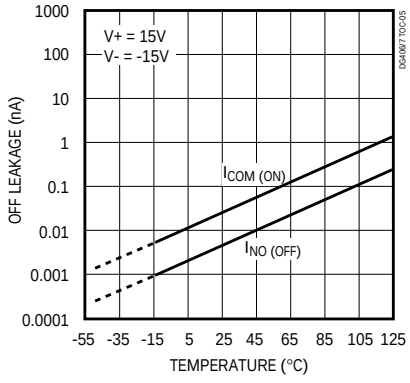
ON-RESISTANCE vs. V_D (SINGLE SUPPLY)



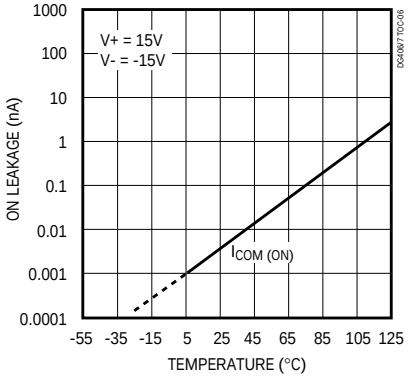
ON-RESISTANCE vs. V_D AND TEMPERATURE (SINGLE SUPPLY)



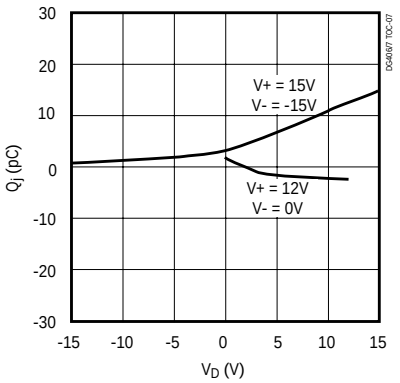
OFF LEAKAGE vs. TEMPERATURE



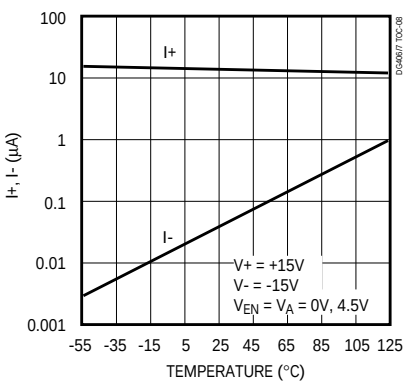
ON LEAKAGE vs. TEMPERATURE



CHARGE INJECTION vs. V_D



SUPPLY CURRENT vs. TEMPERATURE



Pin Descriptions

DG406 PIN	NAME	FUNCTION
1	V+	Positive Supply Voltage Input
2, 3, 13	N.C.	No Internal Connections
4–11	S16–S9	Bidirectional Analog Inputs
12	GND	Ground
14–17	A3–A0	Address Inputs
18	EN	Enable Inputs
19–26	S1–S8	Bidirectional Analog Inputs
27	V-	Negative Supply Voltage Input
28	D	Bidirectional Output

DG407 PIN	NAME	FUNCTION
1	V+	Positive Supply Voltage Input
2	DB	Bidirectional Output B
3, 13, 14	N.C.	No Internal Connection
4–11	S8B–S1B	Bidirectional Analog Inputs
12	GND	Ground
15, 16, 17	A2, A1, A0	Address Inputs
18	EN	Enable Input
19–26	S1A–S8A	Bidirectional Analog Inputs
27	V-	Negative Supply Voltage Input
28	DA	Bidirectional Output A

Applications Information

Operation with Supply Voltages Other than ±15V

Using supply voltages other than ±15V reduces the analog signal range. The DG406/DG407 switches operate with ±4.5V to ±20V bipolar supplies or with a +4.5V to +30V single supply; connect V- to GND when operating with a single supply. Also, both device types can operate with unbalanced supplies such as +24V and -5V. The *Typical Operating Characteristics* graphs show typical on-resistance with 20V, 15V, 10V, and 5V supplies. (Switching times increase by a factor of two or more for operation at 5V.)

Overvoltage Protection

Proper power-supply sequencing is recommended for all CMOS devices. Do not exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the devices. Always sequence V+ on first, then V-, followed by the logic inputs and analog signals. If power-supply sequencing is not possible, add two small signal diodes in series with supply pins for overvoltage protection (Figure 1). Adding diodes reduces the analog signal range to 1V above V+ and 1V below V-, but low switch resistance and low leakage characteristics are unaffected. Device operation is unchanged, and the difference between V+ and V- should not exceed +44V.

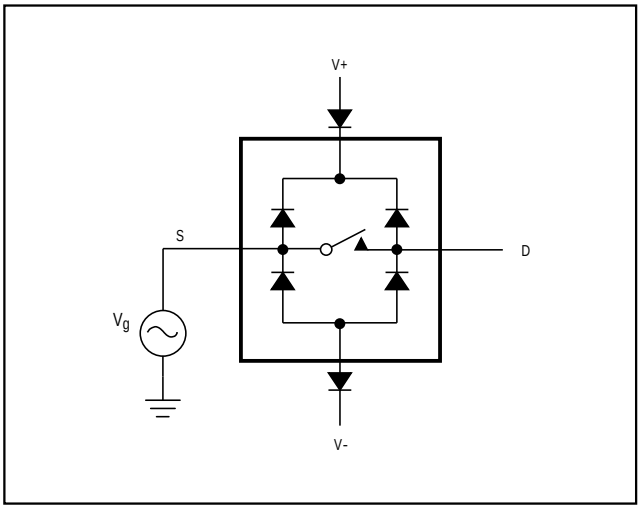


Figure 1. Overvoltage Protection Using External Blocking Diodes

Test Circuits/Timing Diagrams

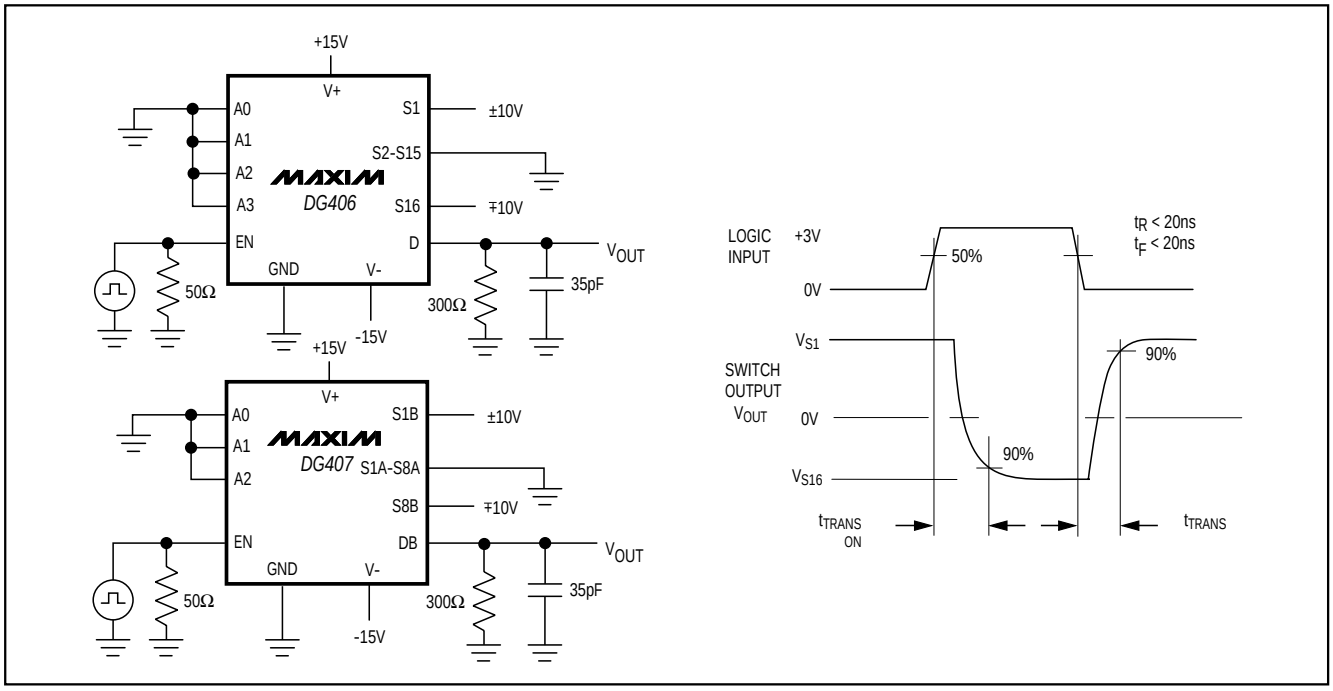


Figure 2. Transition Time

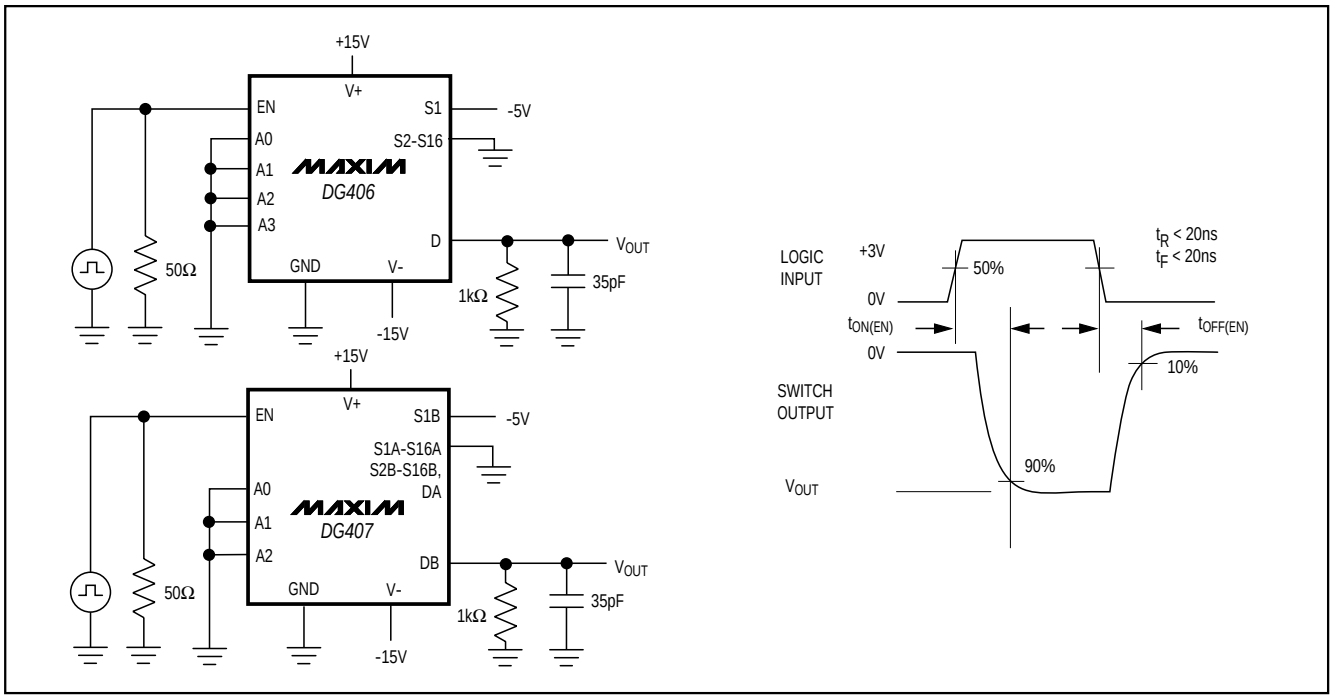


Figure 3. Enable Switching Time

Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

Test Circuits/Timing Diagrams (continued)

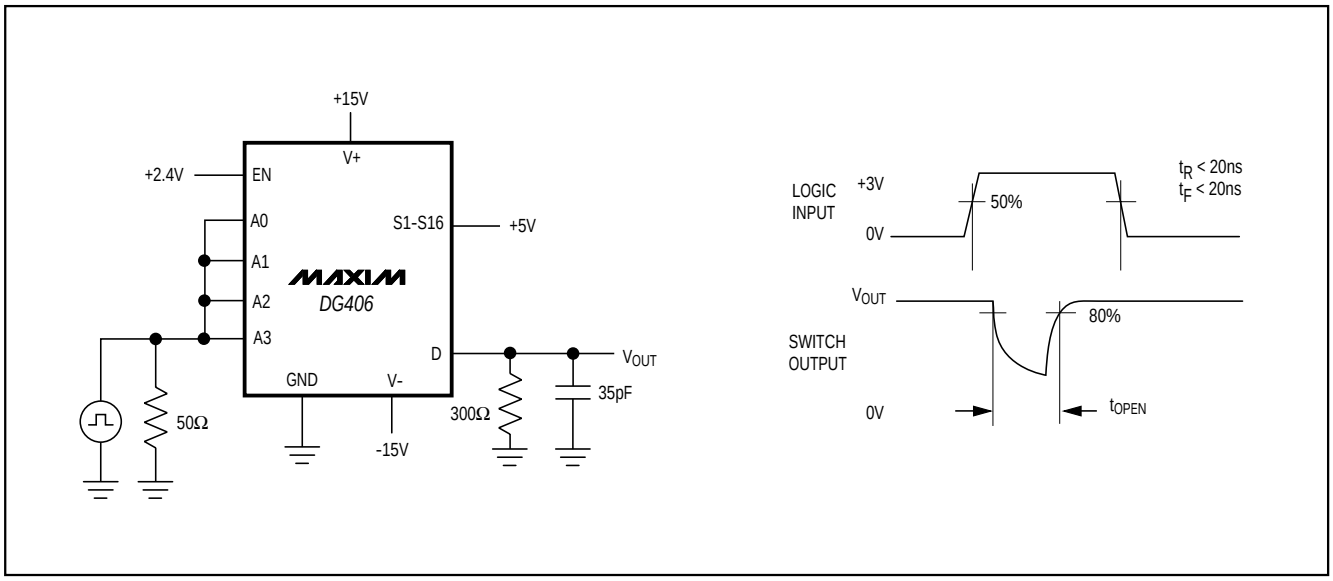


Figure 4. Break-Before-Make Interval

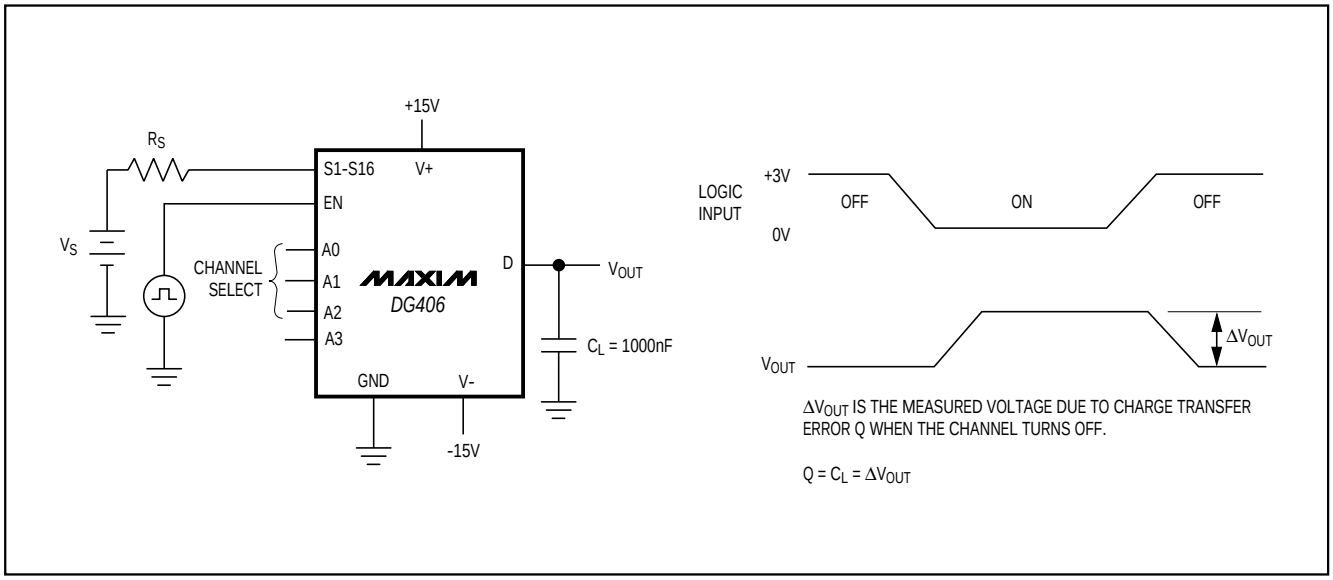


Figure 5. Charge Injection

Test Circuits/Timing Diagrams (continued)

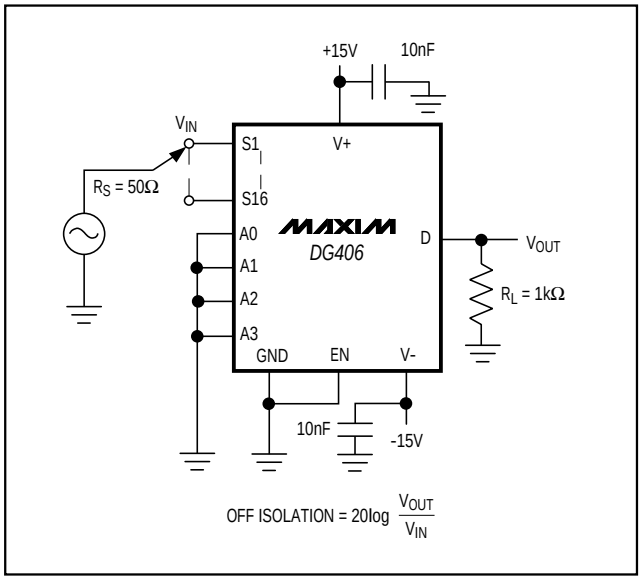


Figure 6. Off Isolation

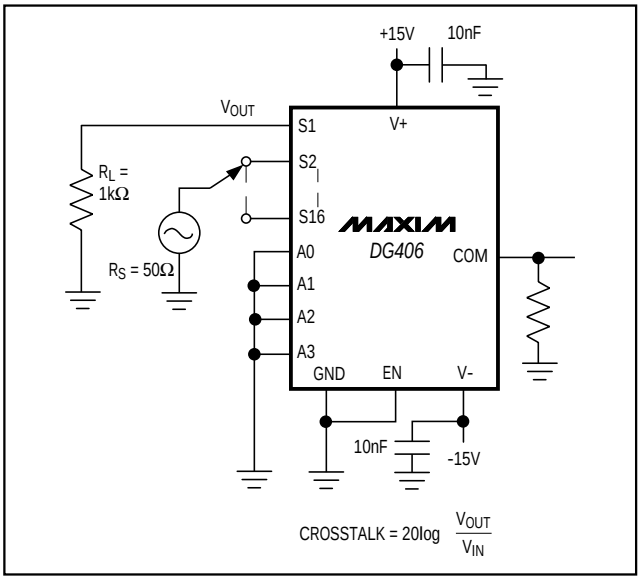


Figure 7. Crosstalk

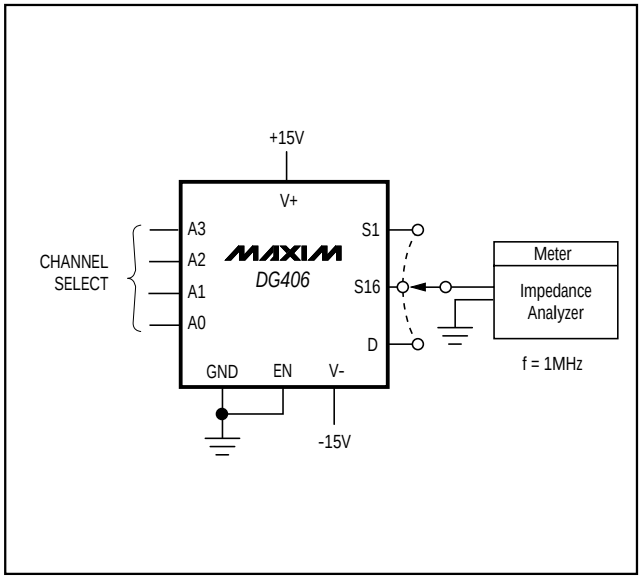
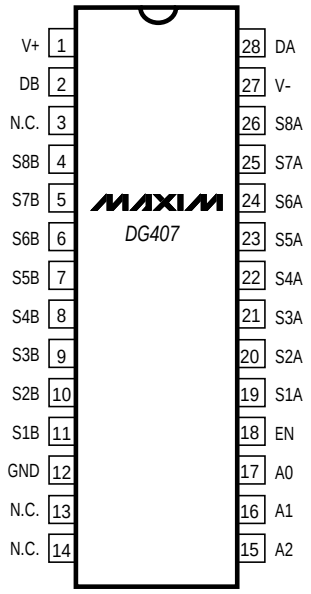


Figure 8. Source/Drain Capacitance

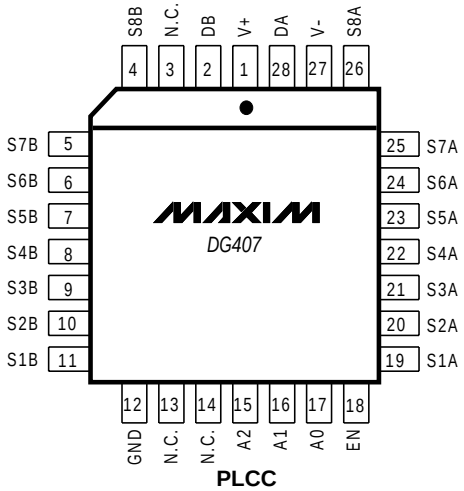
Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

Pin Configurations/Functional Diagrams/Truth Tables (continued)

TOP VIEW



DIP/SO



PLCC

N.C. = NO INTERNAL CONNECTION

A3	A2	A1	A0	EN	ON Switch
X	X	X	X	0	None
0	0	0	0	1	1
0	0	0	1	1	2
0	0	1	0	1	3
0	0	1	1	1	4
0	1	0	0	1	5
0	1	0	1	1	6
0	1	1	0	1	7
0	1	1	1	1	8
1	0	0	0	1	9
1	0	0	1	1	10
1	0	1	0	1	11
1	0	1	1	1	12
1	1	0	0	1	13
1	1	0	1	1	14
1	1	1	0	1	15
1	1	1	1	1	16

DG406

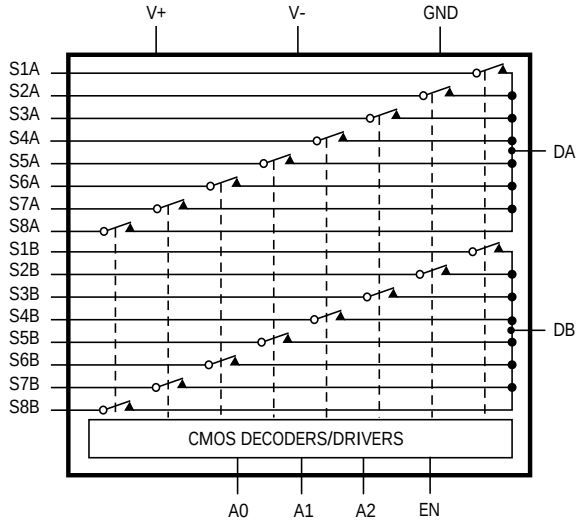
LOGIC "0" $V_{AL} \leq 0.8V$, LOGIC "1" = $V_{AH} \geq 2.4V$

A2	A1	A0	EN	ON Switch
X	X	X	0	None
0	0	0	1	1
0	0	1	1	2
0	1	0	1	3
0	1	1	1	4
1	0	0	1	5
1	0	1	1	6
1	1	0	1	7
1	1	1	1	8

DG407

LOGIC "0" $V_{AL} \leq 0.8V$, LOGIC "1" = $V_{AH} \geq 2.4V$

__Functional Diagrams (continued)



DG407 8-CHANNEL DIFFERENTIAL MULTIPLEXER

_Ordering Information (continued)

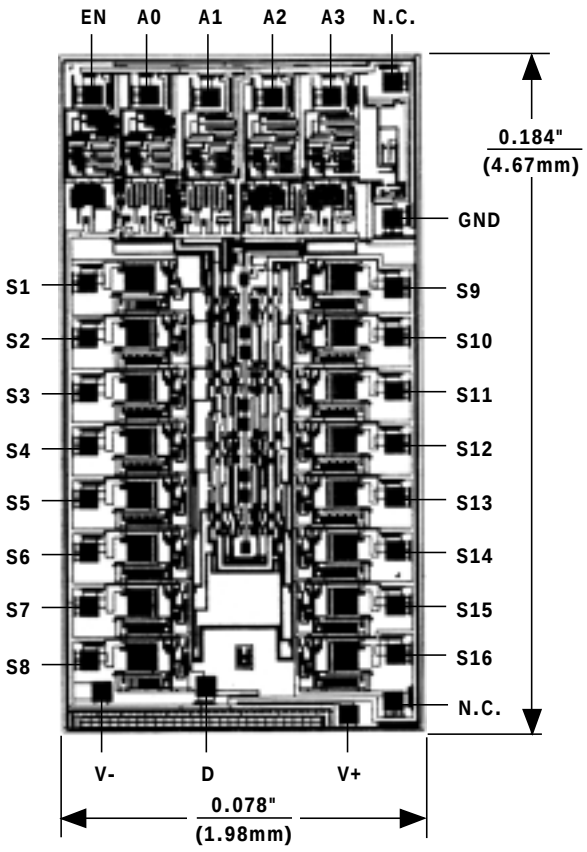
PART	TEMP. RANGE	PIN-PACKAGE
DG407CJ	0°C to +70°C	28 Plastic DIP
DG407CWI	0°C to +70°C	28 Wide SO
DG407C/D	0°C to +70°C	Dice*
DG407DJ	-40°C to +85°C	28 Plastic DIP
DG407DWI	-40°C to +85°C	28 Wide SO
DG407DN	-40°C to +85°C	28 PLCC
DG407AK	-55°C to +125°C	28 CERDIP

** Contact factory for dice specifications.*

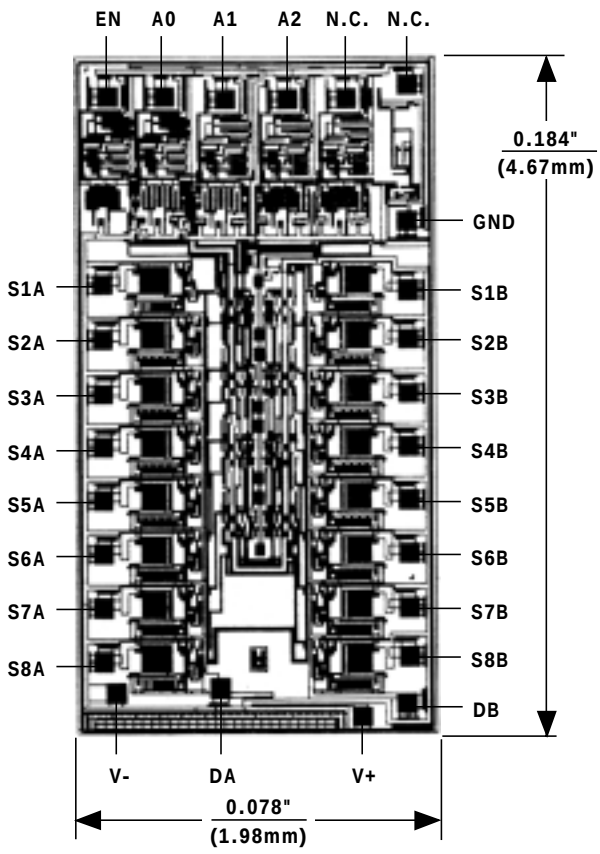
Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

Chip Topographies

DG406



DG407



N.C. = NO INTERNAL CONNECTION

TRANSISTOR COUNT: 269
SUBSTRATE IS INTERNALLY CONNECTED TO V+

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