19-4729; Rev 3; 6/99

MAXIM

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

DG406/DG407

_____General Description
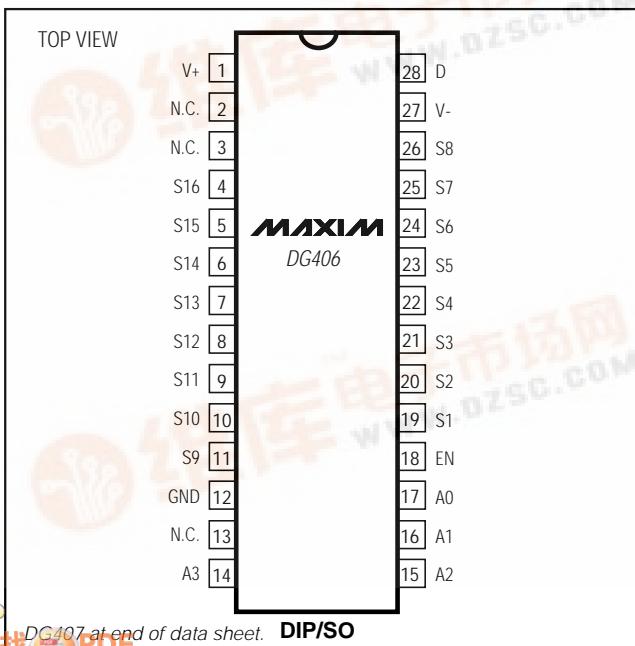
Maxim's redesigned DG406 and DG407 CMOS analog multiplexers now feature guaranteed matching between channels (8Ω max) and flatness over the specified signal range (9Ω max). These low on-resistance muxes (100Ω max) conduct equally well in either direction and feature guaranteed low charge injection (15pC 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**
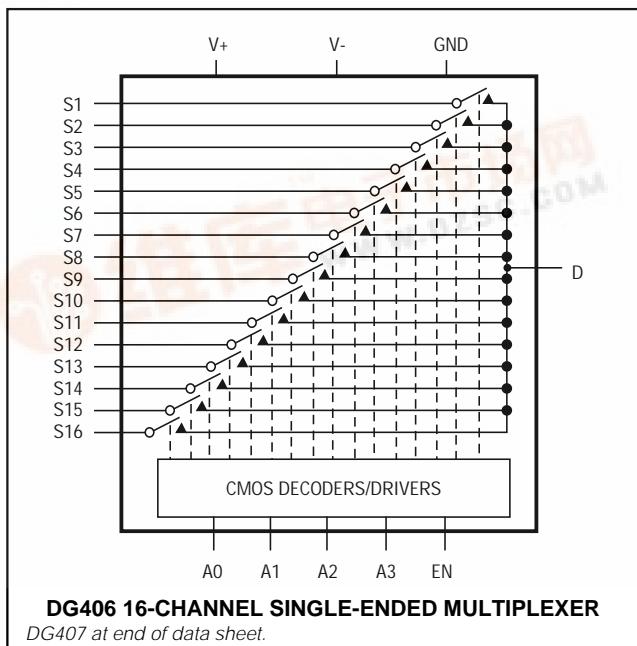
_____Ordering Information

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

TOP VIEW

DG406

V+ 1	28 D
N.C. 2	27 V-
N.C. 3	26 S8
S16 4	25 S7
S15 5	24 S6
S14 6	23 S5
S13 7	22 S4
S12 8	21 S3
S11 9	20 S2
S10 10	19 S1
S9 11	18 EN
GND 12	17 A0
N.C. 13	16 A1
A3 14	15 A2

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

_____Functional Diagrams

DG406 16-CHANNEL SINGLE-ENDED MULTIPLEXER
DG407 at end of data sheet.

_____ **Maxim Integrated Products   1**

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	Δr$_{DS(ON)}$	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	

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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.)

DG406/DG407

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		

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

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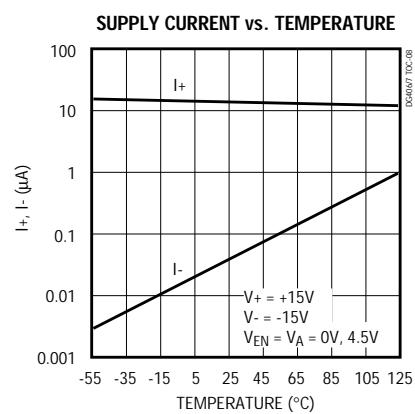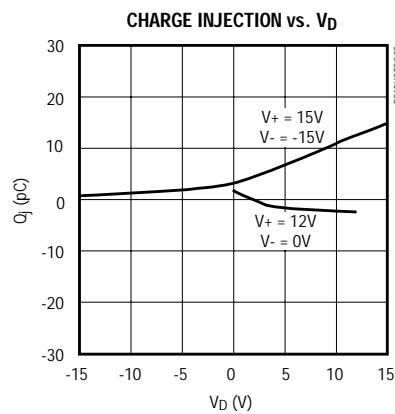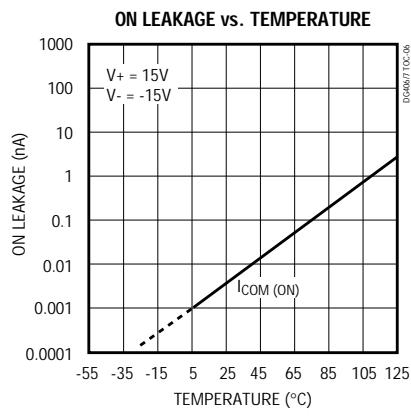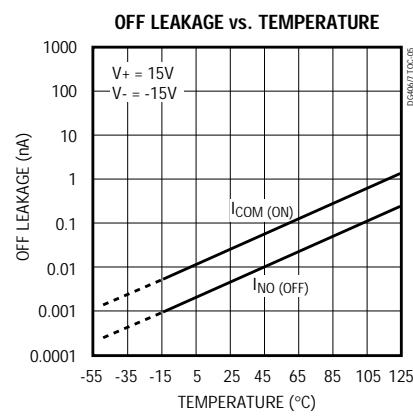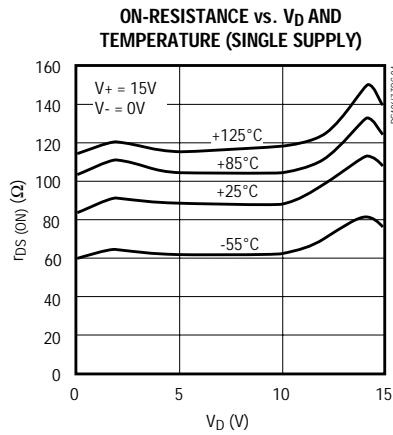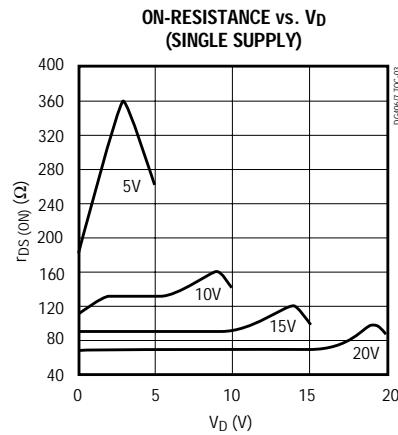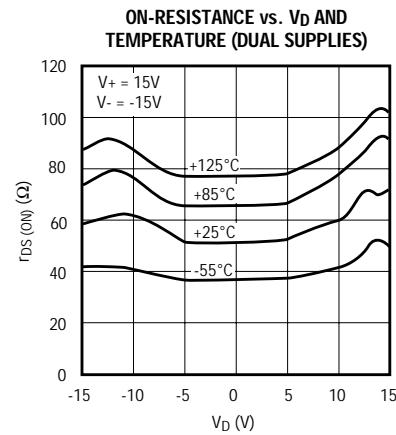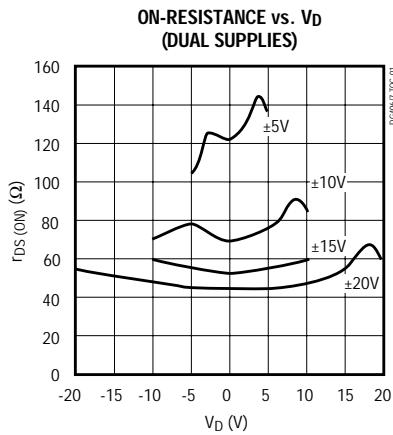
Note 5: Leakage parameters are 100% tested at the maximum rated hot temperature and guaranteed by correlation at +25°C.

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

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(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

DG406/DG407

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

_____**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.
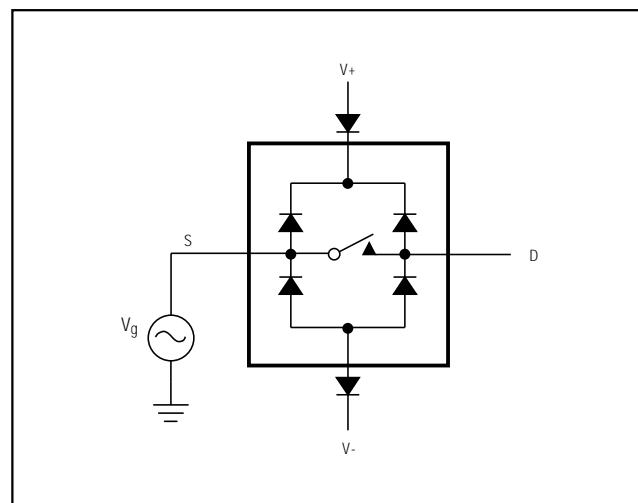

Figure 1. Overvoltage Protection Using External Blocking Diodes

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

_____Test Circuits/Timing Diagrams
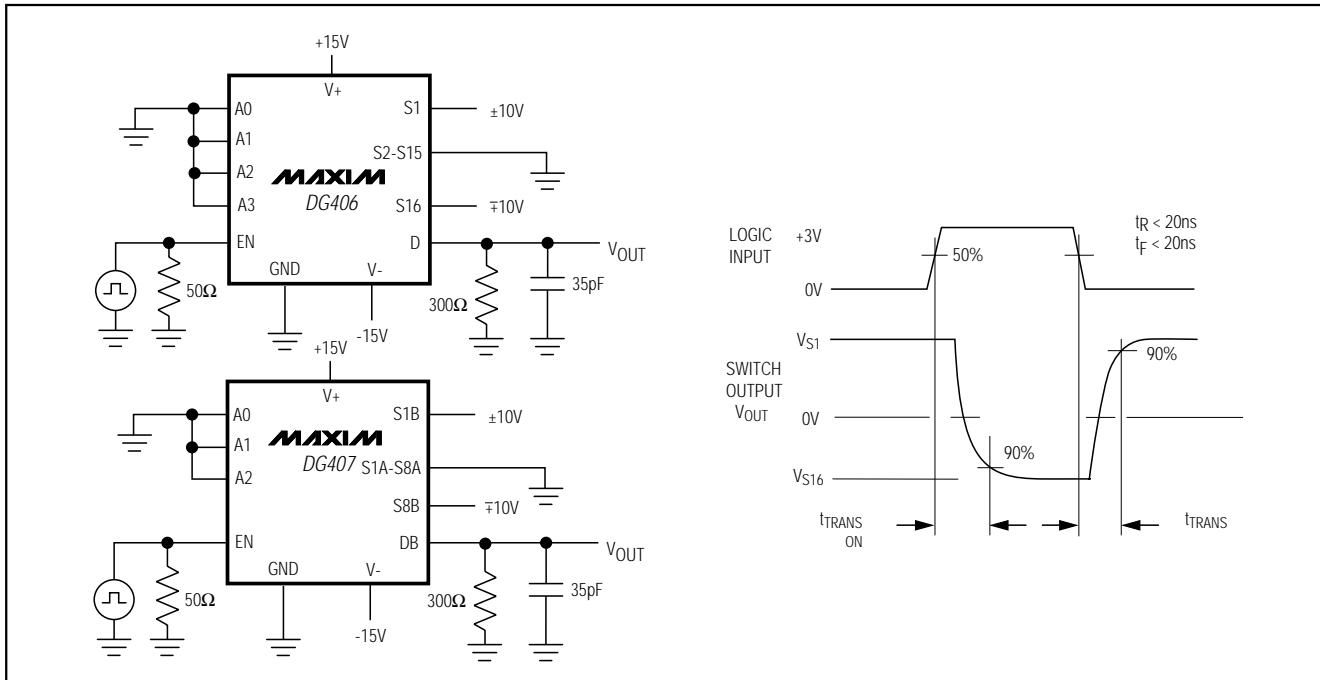

Figure 2. Transition Time
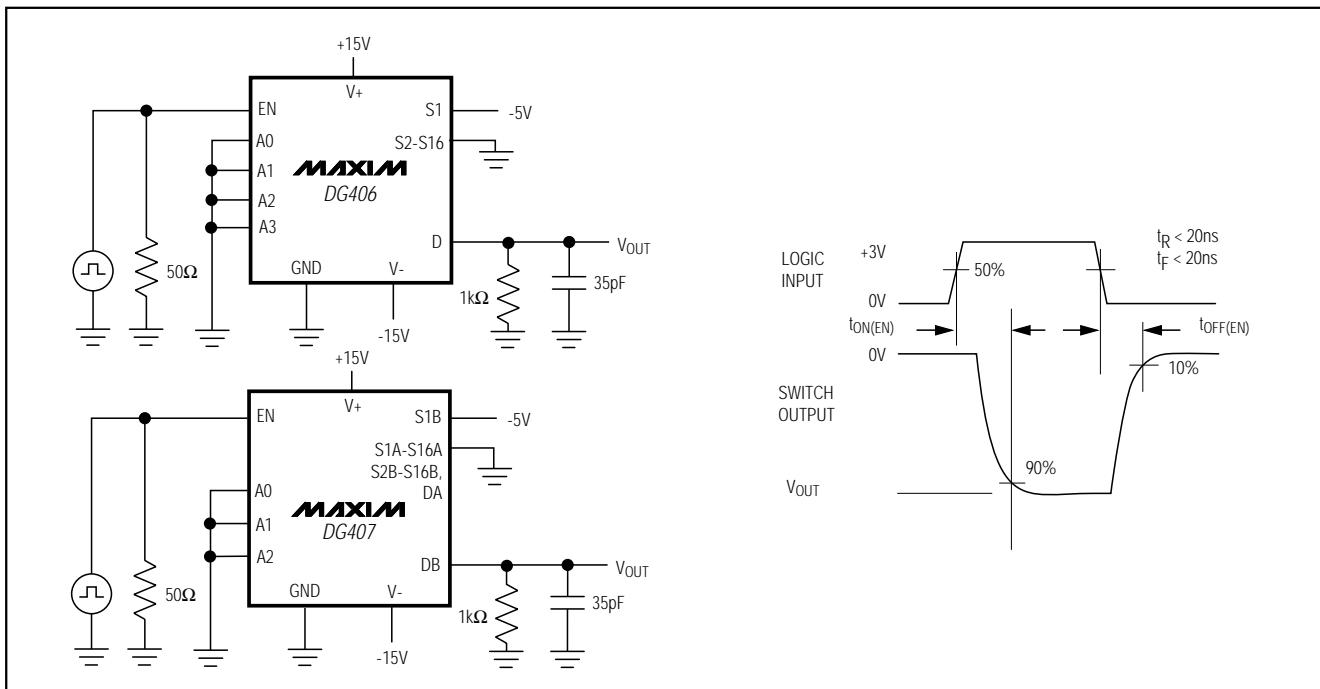
Figure 3. Enable Switching Time

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

Figure 4. Break-Before-Make Interval
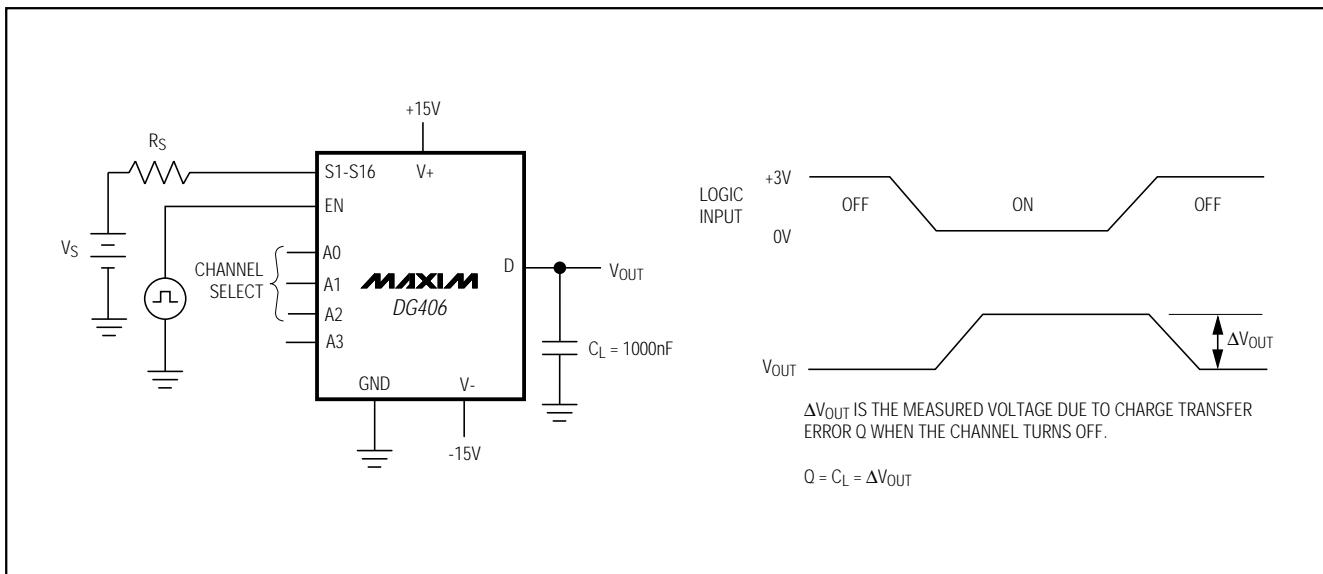
Figure 5. Charge Injection

_____Test Circuits/Timing Diagrams (continued)

Figure 6. Off Isolation
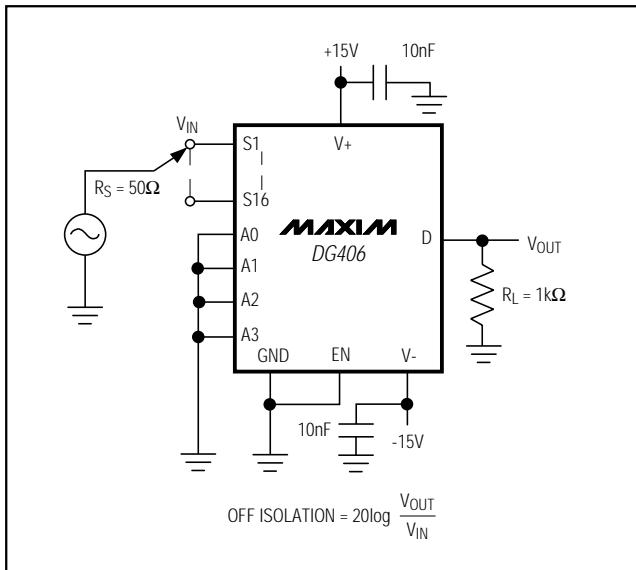
$$\text{OFF ISOLATION} = 20\log \frac{V_{OUT}}{V_{IN}}$$
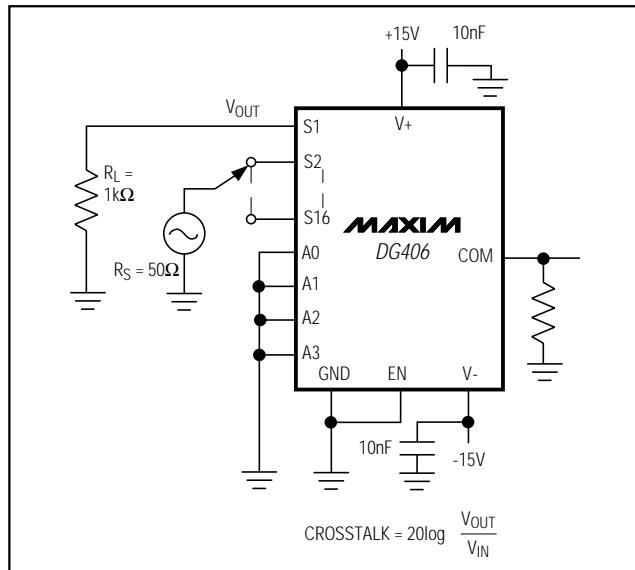
Figure 7. Crosstalk

$$\text{CROSSTALK} = 20\log \frac{V_{OUT}}{V_{IN}}$$
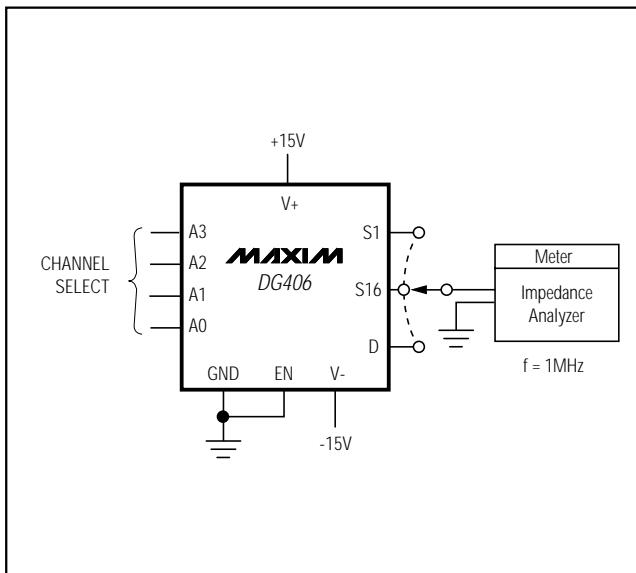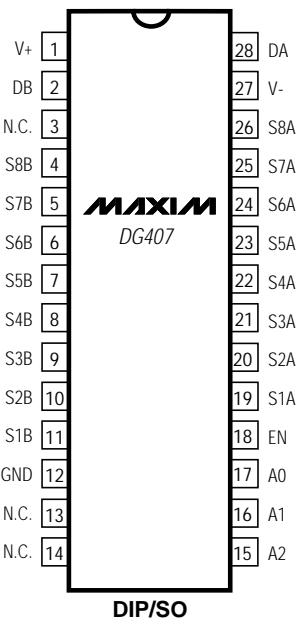
Figure 8. Source/Drain Capacitance

Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers
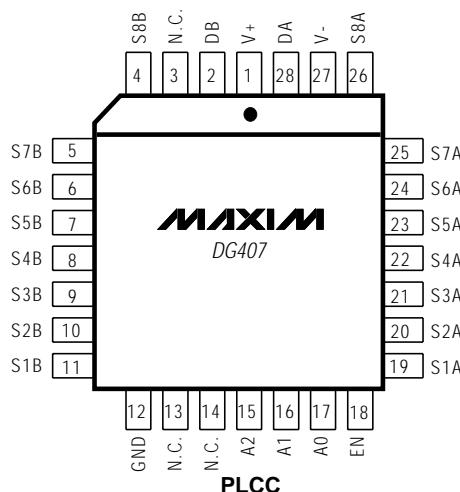
_____Pin Configurations/Functional Diagrams/Truth Tables (continued)

DG406/DG407

TOP VIEW

```
        ┌────────────┐
   V+  1│            │28  DA
   DB  2│            │27  V-
  N.C. 3│            │26  S8A
  S8B  4│   MAXIM    │25  S7A
  S7B  5│   DG407    │24  S6A
  S6B  6│            │23  S5A
  S5B  7│            │22  S4A
  S4B  8│            │21  S3A
  S3B  9│            │20  S2A
  S2B 10│            │19  S1A
  S1B 11│            │18  EN
  GND 12│            │17  A0
  N.C. 13│           │16  A1
  N.C. 14│           │15  A2
        └────────────┘
```

DIP/SO

```
      S8B  N.C.  DB  V+  DA  V-  S8A
       4    3    2   1   28  27  26
      ┌──────────────────────────┐
  S7B 5│                          │25  S7A
  S6B 6│                          │24  S6A
  S5B 7│        MAXIM             │23  S5A
  S4B 8│        DG407             │22  S4A
  S3B 9│                          │21  S3A
  S2B 10│                         │20  S2A
  S1B 11│                         │19  S1A
      └──────────────────────────┘
       12   13   14  15  16  17  18
      GND  N.C. N.C. A2  A1  A0  EN
```

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" = $V_{AH} \geq 2.4V$
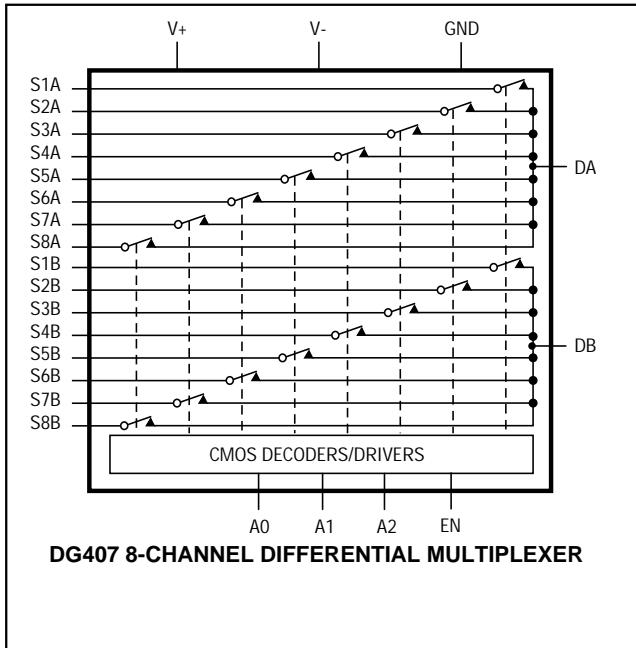
A2	A1	A0	EN	ON Switch
X	X	X	0	None
0	0	0	1	1
0	0	1	1	2
0	1	0	1	3
0	1	1	1	4
1	0	0	1	5
1	0	1	1	6
1	1	0	1	7
1	1	1	1	8

DG407

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

MAXIM

DG406/DG407

__Functional Diagrams (continued)

DG407 8-CHANNEL DIFFERENTIAL MULTIPLEXER
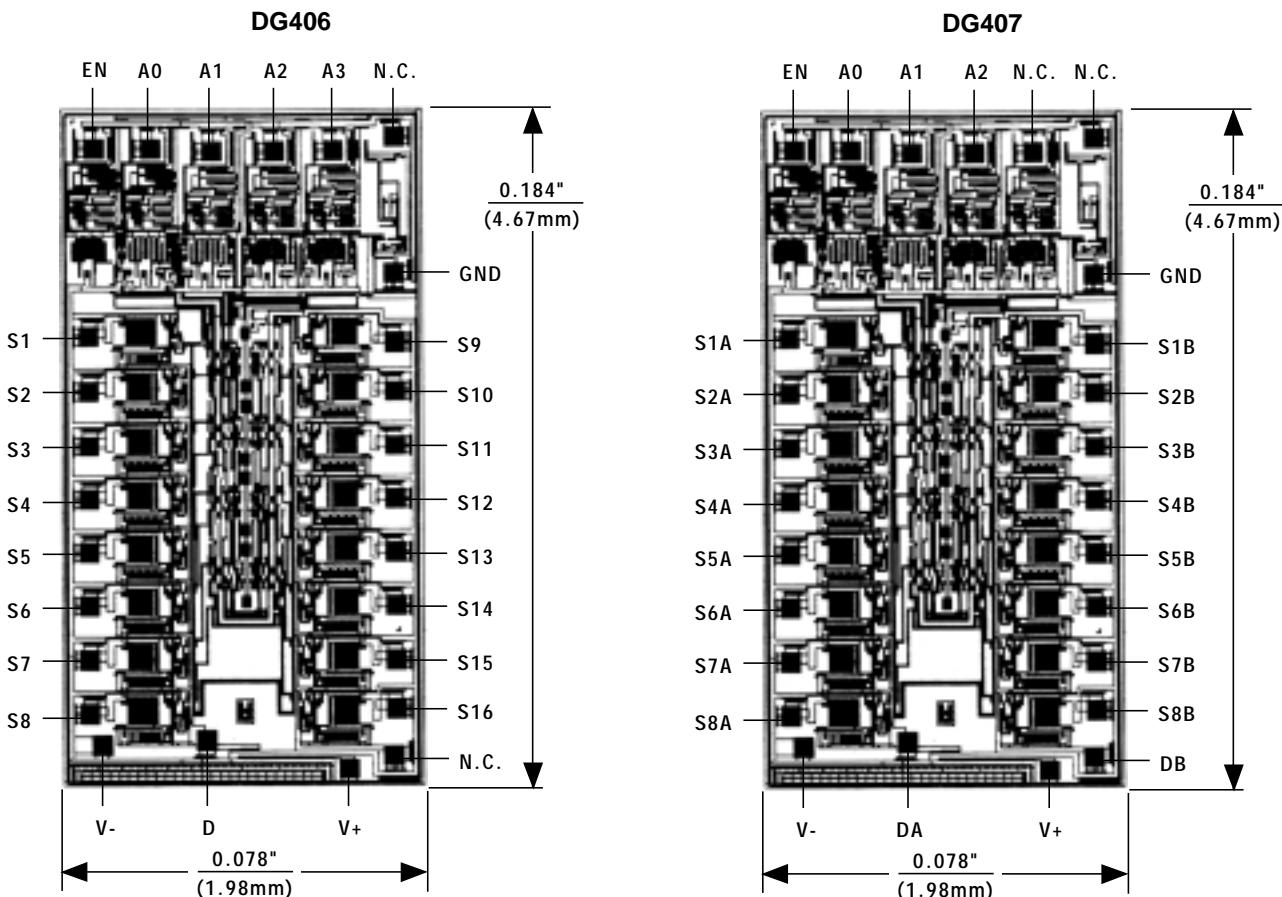
_Ordering Information (continued)

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

| EN | A0 | A1 | A2 | A3 | N.C. |

0.184"
(4.67mm)

GND

S1 — — S9
S2 — — S10
S3 — — S11
S4 — — S12
S5 — — S13
S6 — — S14
S7 — — S15
S8 — — S16
— N.C.

V-   D   V+

0.078"
(1.98mm)

DG407

| EN | A0 | A1 | A2 | N.C. | N.C. |

0.184"
(4.67mm)

GND

S1A — — S1B
S2A — — S2B
S3A — — S3B
S4A — — S4B
S5A — — S5B
S6A — — S6B
S7A — — S7B
S8A — — S8B
— DB

V-   DA   V+

0.078"
(1.98mm)

N.C. = NO INTERNAL CONNECTION

TRANSISTOR COUNT: 269
SUBSTRATE IS INTERNALLY CONNECTED TO V+

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