



**THE DATASHEET OF
DG413DY+**





Improved, Quad, SPST Analog Switches

DG411/DG412/DG413

General Description

Maxim's redesigned DG411/DG412/DG413 analog switches now feature low on-resistance matching between switches (3Ω max) and guaranteed on-resistance flatness over the signal range ($\Delta 4\Omega$ max). These low on-resistance switches conduct equally well in either direction. They guarantee low charge injection, low power consumption, and an ESD tolerance of 2000V minimum per Method 3015.7. The new design offers lower off-leakage current over temperature (less than 5nA at +85°C).

The DG411/DG412/DG413 are quad, single-pole/single-throw (SPST) analog switches. The DG411 is normally closed (NC), and the DG412 is normally open (NO). The DG413 has two NC switches and two NO switches. Switching times are less than 150ns max for t_{ON} and less than 100ns max for t_{OFF} . These devices operate from a single +10V to +30V supply, or bipolar $\pm 4.5V$ to $\pm 20V$ supplies. Maxim's improved DG411/DG412/DG413 are fabricated with a 44V silicon-gate process.

Applications

- | | |
|----------------------------|--------------------------|
| Sample-and-Hold Circuits | Communication Systems |
| Test Equipment | Battery-Operated Systems |
| Heads-Up Displays | PBX, PABX |
| Guidance & Control Systems | Audio Signal Routing |
| Military Radios | |

New Features

- ◆ Plug-In Upgrade for Industry-Standard DG411/DG412/DG413
- ◆ Improved $R_{DS(ON)}$ Match Between Channels (3Ω max)
- ◆ Guaranteed $R_{FLAT(ON)}$ Over Signal Range ($\Delta 4\Omega$)
- ◆ Improved Charge Injection (10pC max)
- ◆ Improved Off-Leakage Current Over Temperature (< 5nA at +85°C)
- ◆ Withstand Electrostatic Discharge (2000V min) per Method 3015.7

Existing Features

- ◆ Low $R_{DS(ON)}$ (35Ω max)
- ◆ Single-Supply Operation +10V to +30V
- ◆ Bipolar-Supply Operation $\pm 4.5V$ to $\pm 20V$
- ◆ Low Power Consumption ($35\mu W$ max)
- ◆ Rail-to-Rail Signal Handling
- ◆ TTL/CMOS-Logic Compatible

Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|----------|----------------|----------------|
| DG411CJ | 0°C to +70°C | 16 Plastic DIP |
| DG411CUE | 0°C to +70°C | 16 TSSOP |
| DG411EUE | -40°C to +85°C | 16 TSSOP |
| DG411CY | 0°C to +70°C | 16 Narrow SO |
| DG411C/D | 0°C to +70°C | Dice† |

Ordering Information continued at end of data sheet.

†Contact factory for dice specifications.

Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW

DIP/SO/TSSOP
DG411

| LOGIC | SWITCH |
|-------|--------|
| 0 | ON |
| 1 | OFF |

DIP/SO/TSSOP
DG412

| LOGIC | SWITCH |
|-------|--------|
| 0 | OFF |
| 1 | ON |

DIP/SO/TSSOP
DG413

| LOGIC | SWITCHES 1, 4 | SWITCHES 2, 3 |
|-------|---------------|---------------|
| 0 | OFF | ON |
| 1 | ON | OFF |

SWITCHES SHOWN FOR LOGIC "0" INPUT

Pin Configurations and Functional Diagrams continued at end of data sheet.



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ABSOLUTE MAXIMUM RATINGS

(All Voltages Referenced to V-.)

| | |
|--|---|
| V+ |44V |
| GND |25V |
| V _L |(GND -0.3V) to (V+ +0.3V) |
| Digital Inputs, V _S , V _D (Note 1) |(V- -2V) to (V+ +2V) or 30mA (whichever occurs first) |
| Continuous Current (any terminal) |30mA |
| Peak Current (pulsed at 1ms, 10% duty cycle max) |100mA |

Continuous Power Dissipation (T_A = +70°C)

| | |
|--|-------------|
| 16-Pin Plastic DIP (derate 10.53mW/°C above +70°C) | .842mW |
| 16-Pin Narrow SO (derate 8.70mW/°C above +70°C) | ...696mW |
| 16-Pin CERDIP (derate 10.00mW/°C above +70°C) |800mW |
| 16-Pin TSSOP (derate 6.7mW/°C above +70°C) |457mW |
| 16-Pin QFN (derate 19.2mW/°C above +70°C) |1538mW |

Operating Temperature Ranges

| | |
|-----------------------------------|----------------------|
| DG41_C |0°C to +70°C |
| DG41_D |-40°C to +85°C |
| DG41_AK |-55°C to +125°C |
| Storage Temperature Range |-65°C to +150°C |
| Lead Temperature (soldering, 10s) |+300°C |

Note 1: Signals on S, D, or IN exceeding V+ or V- are clamped by internal diodes. Limit forward current to maximum current rating.

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, V_L = 5V, V_{GND} = 0V, V_{INH} = 2.4V, V_{INL} = 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)} | V+ = 13.5V, V- = -13.5V, V _D = ±8.5V, I _S = -10mA | T _A = +25°C | C, D | 17 | 45 | Ω | |
| | | | | A | 17 | 30 | | |
| | | | T _A = T _{MIN} to T _{MAX} | | | 45 | | |
| On-Resistance Match Between Channels (Note 4) | ΔR _{DS(ON)} | V+ = 15V, V- = -15V, V _D = ±10V, I _S = -10mA | T _A = +25°C | | | 3 | Ω | |
| | | | | T _A = T _{MIN} to T _{MAX} | | 5 | | |
| On-Resistance Flatness (Note 4) | R _{FLAT(ON)} | V+ = 15V, V- = -15V, V _D = ±5V, 0V, I _S = -10mA | T _A = +25°C | | | 4 | Ω | |
| | | | | T _A = T _{MIN} to T _{MAX} | | 6 | | |
| Source Off-Leakage Current (Note 7) | I _{S(OFF)} | V+ = 16.5V, V- = -16.5V, V _D = ±15.5V, V _S = ±15.5V | T _A = +25°C | C, D, A | -0.25 | -0.10 | 0.25 | nA |
| | | | | C, D | -5 | | 5 | |
| | | | | A | -10 | | 10 | |
| Drain Off-Leakage Current (Note 7) | I _{D(OFF)} | V+ = 16.5V, V- = -16.5V, V _D = ±15.5V, V _S = ±15.5V | T _A = +25°C | C, D, A | -0.25 | -0.10 | 0.25 | nA |
| | | | | C, D | -5 | | 5 | |
| | | | | A | -10 | | 10 | |
| Drain On-Leakage Current (Note 7) | I _{D(ON)} + I _{S(ON)} | V+ = 16.5V, V- = -16.5V, V _D = ±15.5V, V _S = ±15.5V | T _A = +25°C | C, D, A | -0.4 | -0.1 | 0.4 | nA |
| | | | | C, D | -20 | | 20 | |
| | | | | A | -40 | | 40 | |

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DG411/DG412/DG413

ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = 15V, V- = -15V, VL = 5V, VGND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP (Note 2) | MAX | UNITS | |
|---------------------------------------|--------------------|--|-------------------|-----------------|---------|-------|----|
| INPUT | | | | | | | |
| Input Current with Input Voltage High | I _{INH} | IN = 2.4V, all others = 0.8V | -0.500 | 0.005 | 0.500 | μA | |
| Input Current with Input Voltage Low | I _{INL} | IN = 0.8V, all others = 2.4V | -0.500 | 0.005 | 0.500 | μA | |
| SUPPLY | | | | | | | |
| Power-Supply Range | | | ±4.5 | | ±20.0 | V | |
| Positive Supply Current | I+ | All channels on or off, V+ = 16.5V, V- = -16.5V, VIN = 0V or 5V | TA = +25°C | -1 | 0.0001 | 1 | μA |
| | | | TA = TMIN to TMAX | -5 | | 5 | |
| Negative Supply Current | I- | All channels on or off, V+ = 16.5V, V- = -16.5V, VIN = 0V or 5V | TA = +25°C | -1 | -0.0001 | 1 | μA |
| | | | TA = TMIN to TMAX | -5 | | 5 | |
| Logic Supply Current | IL | All channels on or off, V+ = 16.5V, V- = -16.5V, VIN = 0V or 5V | TA = +25°C | -1 | 0.0001 | 1 | μA |
| | | | TA = TMIN to TMAX | -5 | | 5 | |
| Ground Current | IGND | All channels on or off, V+ = 16.5V, V- = -16.5V, VIN = 0V or 5V | TA = +25°C | -1 | -0.0001 | 1 | μA |
| | | | TA = TMIN to TMAX | -5 | | 5 | |
| DYNAMIC | | | | | | | |
| Turn-On Time | t _{ON} | VD = ±10V, Figure 2 | TA = +25°C | 110 | 175 | ns | |
| | | | TA = TMIN to TMAX | | 220 | | |
| Turn-Off Time | t _{OFF} | VD = ±10V, Figure 2 | TA = +25°C | 100 | 145 | ns | |
| | | | TA = TMIN to TMAX | | 160 | | |
| Break-Before-Make Time Delay | t _D | DG413 only, RL = 300Ω, CL = 35pF, Figure 3 | TA = +25°C | 25 | | ns | |
| Charge Injection (Note 3) | Q | CL = 1.0nF, VGEN = 0V, RGEN = 0Ω, Figure 4 | TA = +25°C | 5 | 10 | pC | |
| Off-Isolation (Note 5) | OIRR | RL = 50Ω, CL = 5pF, f = 1MHz, Figure 5 | TA = +25°C | 68 | | dB | |
| Crosstalk (Note 6) | | RL = 50Ω, CL = 5pF, f = 1MHz, Figure 6 | TA = +25°C | 85 | | dB | |
| Source Off-Capacitance | CS(OFF) | f = 1MHz, Figure 7 | TA = +25°C | 9 | | pF | |
| Drain Off-Capacitance | CD(OFF) | f = 1MHz, Figure 7 | TA = +25°C | 9 | | pF | |
| Drain On-Capacitance | CD(ON) + CS(ON) | f = 1MHz, Figure 8 | TA = +25°C | 35 | | pF | |

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ELECTRICAL CHARACTERISTICS—Single Supply

(V+ = 12V, V- = 0V, VL = 5V, VGND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP (Note 2) | MAX | UNITS |
|------------------------------|---------|--|-------------------|-----|-----------------|-----|-------|
| SWITCH | | | | | | | |
| Analog Signal Range | VANALOG | (Note 3) | | 0 | | 12 | V |
| Drain-Source On-Resistance | RDS(ON) | V+ = 10.8V, VD = 3.8V, IS = -10mA | TA = +25°C | | 40 | 80 | Ω |
| | | | TA = TMIN to TMAX | | | 100 | |
| SUPPLY | | | | | | | |
| Positive Supply Current | I+ | All channels on or off, V+ = 13.2V, VIN = 0V or 5V | TA = +25°C | -1 | 0.0001 | 1 | μA |
| | | | TA = TMAX | -5 | | 5 | |
| Negative Supply Current | I- | All channels on or off, V+ = 13.2V, VIN = 0V or 5V | TA = +25°C | -1 | 0.0001 | 1 | μA |
| | | | TA = TMAX | -5 | | 5 | |
| Logic Supply Current | IL | All channels on or off, VL = 5.25V, VIN = 0V or 5V | TA = +25°C | -1 | 0.0001 | 1 | μA |
| | | | TA = TMAX | -5 | | 5 | |
| Ground Current | IGND | All channels on or off, VL = 5.25V, VIN = 0V or 5V | TA = +25°C | -1 | -0.0001 | 1 | μA |
| | | | TA = TMAX | -5 | | 5 | |
| DYNAMIC | | | | | | | |
| Turn-On Time | tON | VS = 8V, Figure 2 | TA = +25°C | | 175 | 250 | ns |
| | | | TA = TMIN to TMAX | | | 315 | |
| Turn-Off Time | tOFF | VS = 8V, Figure 2 | TA = +25°C | | 95 | 125 | ns |
| | | | TA = TMIN to TMAX | | | 140 | |
| Break-Before-Make Time Delay | tD | DG413 only, RL = 300Ω, CL = 35pF, Figure 3 | TA = +25°C | | 25 | | ns |
| Charge Injection (Note 3) | Q | CL = 1.0nF, VGEN = 0V, RGEN = 0V, Figure 4 | TA = +25°C | | 5 | 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: $\Delta R_{ON} = \Delta R_{ON\ max} - \Delta R_{ON\ min}$. On-resistance match between channels and flatness are guaranteed only with bipolar-supply operation. 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: Off-Isolation = $20\log(V_D/V_S)$, VD = output, VS = input to off switch. See Figure 5.

Note 6: Between any two switches. See Figure 6.

Note 7: Leakage parameters IS(OFF), ID(OFF), and ID(ON) are 100% tested at the maximum-rated hot temperature and guaranteed by correlation at +25°C.

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Typical Operating Characteristics

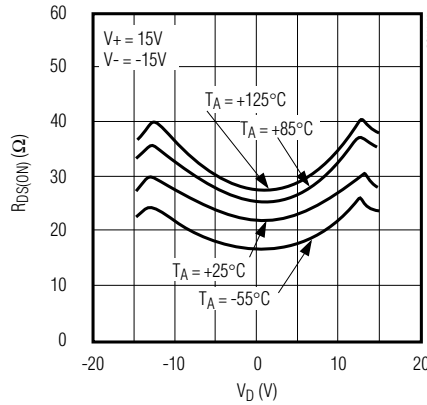
($T_A = +25^\circ\text{C}$, unless otherwise noted.)

DG411/DG412/DG413

ON-RESISTANCE vs. V_D AND POWER-SUPPLY VOLTAGE



ON-RESISTANCE vs. V_D AND TEMPERATURE



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



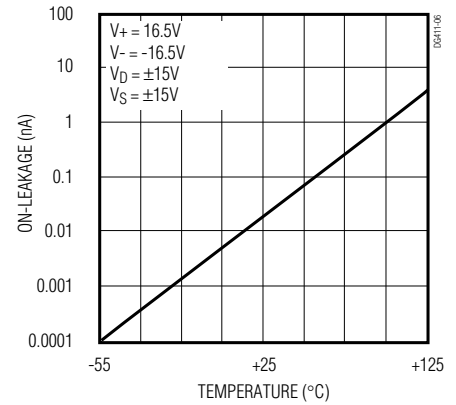
ON-RESISTANCE vs. V_D (SINGLE SUPPLY)



OFF-LEAKAGE CURRENTS vs. TEMPERATURE



ON-LEAKAGE CURRENTS vs. TEMPERATURE



CHARGE INJECTION vs. ANALOG VOLTAGE



SUPPLY CURRENT vs. TEMPERATURE



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Pin Description

| PIN | | NAME | FUNCTION |
|--------------|--------------|----------------|--|
| DIP/SO/TSSOP | QFN | | |
| 1, 16, 9, 8 | 15, 14, 7, 6 | IN1–IN4 | Input |
| 2, 15, 10, 7 | 16, 13, 8, 5 | D1–D4 | Analog Switch Drain Terminal |
| 3, 14, 11, 6 | 1, 12, 9, 4 | S1–S4 | Analog Switch Source Terminal |
| 4 | 2 | V- | Negative-Supply Voltage Input |
| 5 | 3 | GND | Ground |
| 12 | 10 | V _L | Logic Supply Voltage |
| 13 | 11 | V+ | Positive-Supply Voltage Input—Connected to Substrate |
| — | — | EP | Exposed Paddle (QFN Only). Connect EP to V+. |

Applications Information

Operation with Supply Voltages Other Than 15V

Using supply voltages other than 15V will reduce the analog signal range. The DG411/DG412/DG413 switches operate with $\pm 4.5\text{V}$ to $\pm 20\text{V}$ bipolar supplies or with a +10V to +30V single supply; connect V- to 0V when operating with a single supply. Also, all device types can operate with unbalanced supplies such as +24V and -5V. V_L must be connected to +5V to be TTL compatible, or to V+ for CMOS-logic level inputs. The *Typical Operating Characteristics* graphs show typical on-resistance with $\pm 15\text{V}$, $\pm 10\text{V}$, and $\pm 5\text{V}$ supplies. (Switching times increase by a factor of two or more for operation at $\pm 5\text{V}$.)

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, followed by V_L, V-, and logic inputs. If power-supply sequencing is not possible, add two small, external signal diodes in series with supply pins for overvoltage protection (Figure 1).

Adding diodes reduces the analog signal range to 1V below V+ and 1V below V-, without affecting low switch resistance and low leakage characteristics. Device operation is unchanged, and the difference between V+ and V- should not exceed +44V.



Figure 1. Overvoltage Protection Using External Blocking Diodes

Improved, Quad, SPST Analog Switches

Timing Diagrams/Test Circuits

DG411/DG412/DG413

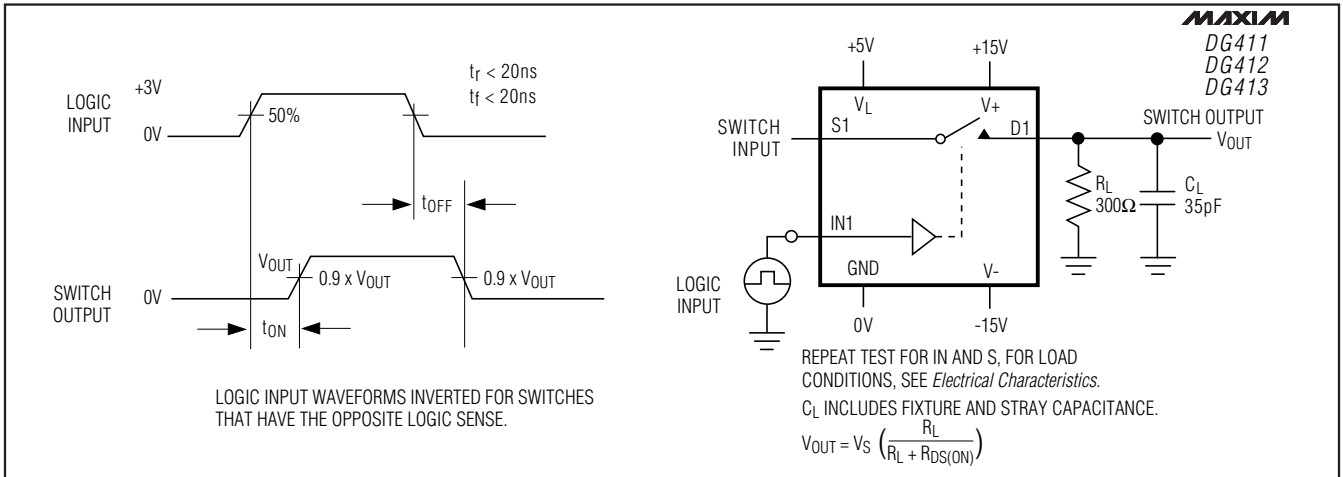


Figure 2. Switching-Time

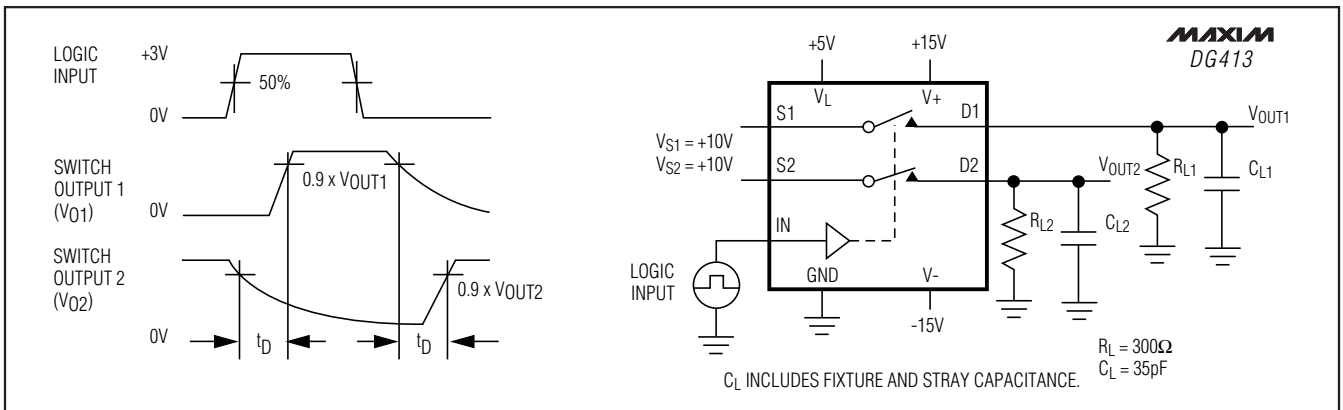


Figure 3. DG413 Break-Before-Make

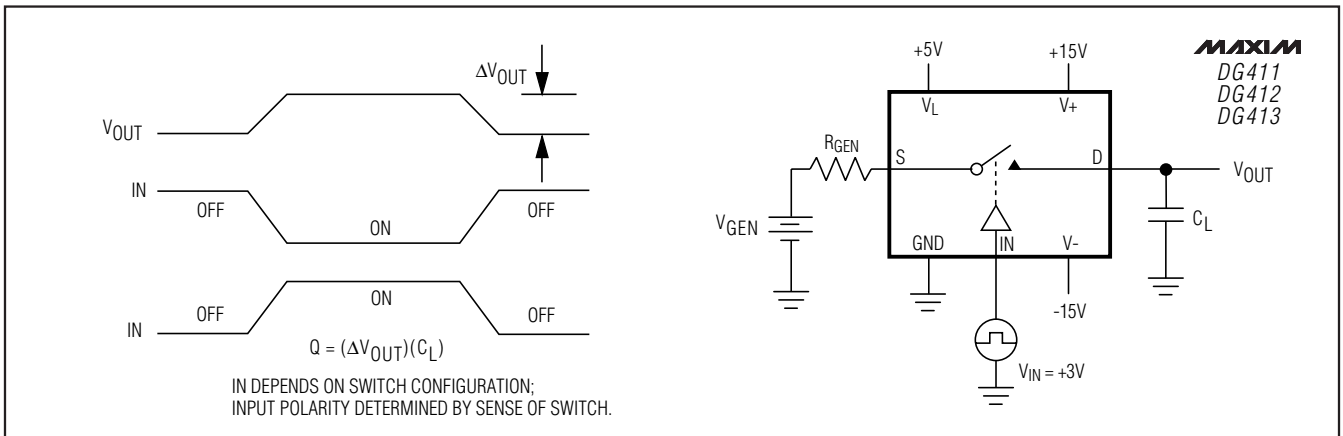


Figure 4. Charge-Injection

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Timing Diagrams/Test Circuits (continued)

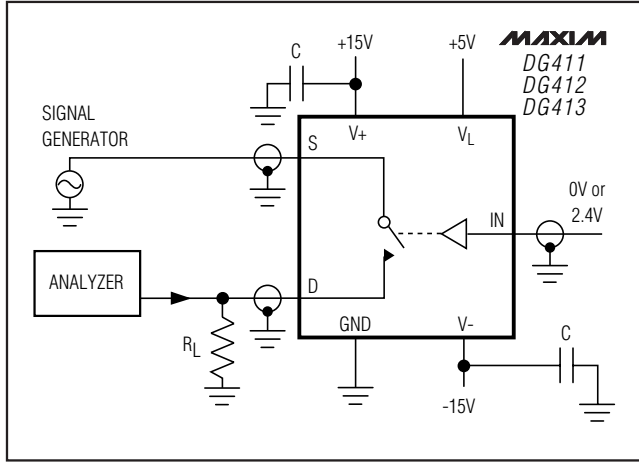


Figure 5. Off-Isolation

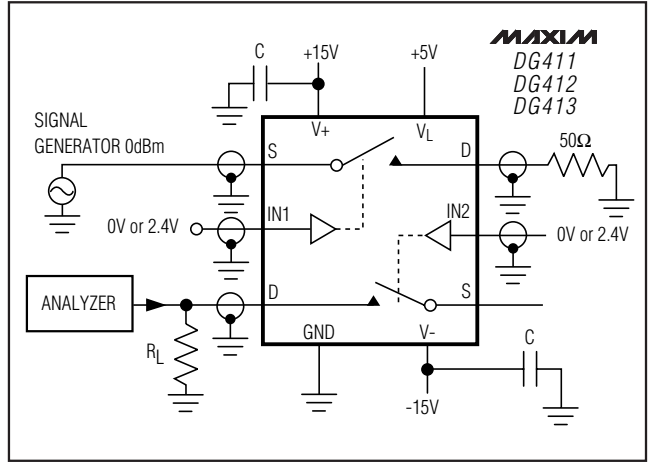


Figure 6. Crosstalk



Figure 7. Channel Off-Capacitance

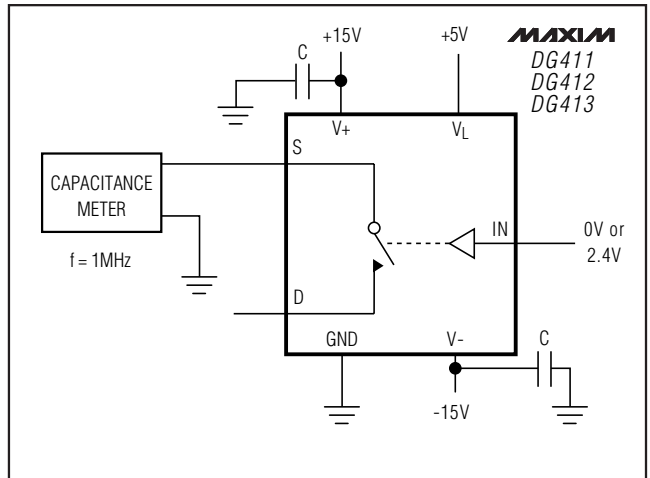


Figure 8. Channel On-Capacitance

Improved, Quad, SPST Analog Switches

DG411/DG412/DG413

Ordering Information (continued)

| PART | TEMP RANGE | PIN-PACKAGE |
|----------------|-----------------|----------------|
| DG411EGE | -40°C to +85°C | 16 QFN-EP* |
| DG411DJ | -40°C to +85°C | 16 Plastic DIP |
| DG411DY | -40°C to +85°C | 16 Narrow SO |
| DG411DK | -40°C to +85°C | 16 CERDIP |
| DG411AK | -55°C to +125°C | 16 CERDIP** |
| DG411MY/PR | -55°C to +125°C | 16 SO*** |
| DG411MY/PR-T | -55°C to +125°C | 16 SO*** |
| DG412CJ | 0°C to +70°C | 16 Plastic DIP |
| DG412CUE | 0°C to +70°C | 16 TSSOP |
| DG412EUE | -40°C to +85°C | 16 TSSOP |
| DG412CY | 0°C to +70°C | 16 Narrow SO |
| DG412C/D | 0°C to +70°C | Dice† |
| DG412DJ | -40°C to +85°C | 16 Plastic DIP |
| DG412EGE | -40°C to +85°C | 16 QFN-EP* |
| DG412DY | -40°C to +85°C | 16 Narrow SO |
| DG412DK | -40°C to +85°C | 16 CERDIP |
| DG412AK | -55°C to +125°C | 16 CERDIP** |
| DG412MY/PR | -55°C to +125°C | 16 SO*** |
| DG412MY/PR-T | -55°C to +125°C | 16 SO*** |
| DG413CJ | 0°C to +70°C | 16 Plastic DIP |
| DG413CUE | 0°C to +70°C | 16 TSSOP |
| DG413EUE | -40°C to +85°C | 16 TSSOP |
| DG413CY | 0°C to +70°C | 16 Narrow SO |
| DG413C/D | 0°C to +70°C | Dice† |
| DG413EGE | -40°C to +85°C | 16 QFN-EP* |
| DG413DJ | -40°C to +85°C | 16 Plastic DIP |
| DG413DY | -40°C to +85°C | 16 Narrow SO |
| DG413DK | -40°C to +85°C | 16 CERDIP |
| DG413AK | -55°C to +125°C | 16 CERDIP** |

†Contact factory for dice specifications.

*EP = Exposed pad.

**Contact factory for availability and processing to MIL-STD-883B.

***Contact factory for availability.

Chip Topography



Improved, Quad, SPST Analog Switches

Pin Configurations/Functional Diagrams (continued)



Improved, Quad, SPST Analog Switches

Package Information

For the latest package outline information and land patterns, go to www.maxim-ic.com/packages.

| PACKAGE TYPE | PACKAGE CODE | DOCUMENT NO. |
|----------------|--------------|-------------------------|
| 16 QFN-EP | G1655-3 | 21-0091 |
| 16 Plastic DIP | P16-1 | 21-0043 |
| 16 TSSOP | U16-2 | 21-0066 |
| 16 CERDIP | J16-3 | 21-0045 |
| 16 Narrow SO | S16-1 | 21-0041 |
| 16 SO | S16-1 | 21-0041 |

DG411/DG412/DG413

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Revision History



| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|------------------------|----------------------|--|----------------------|
| 6 | 9/07 | Addition of exposed pad information | 1, 6, 9, 14, 15 |
| 7 | 9/08 | Addition of rugged plastic information | 1, 9 |

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