

MAXIM

Improved, Quad, SPST Analog Switches

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

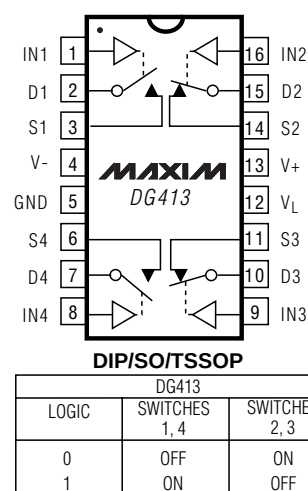
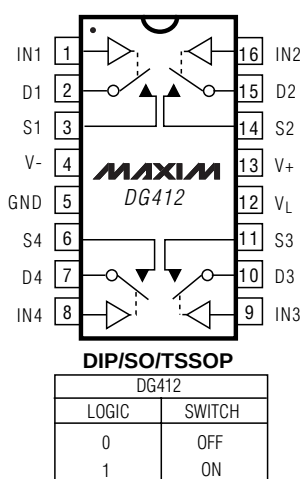
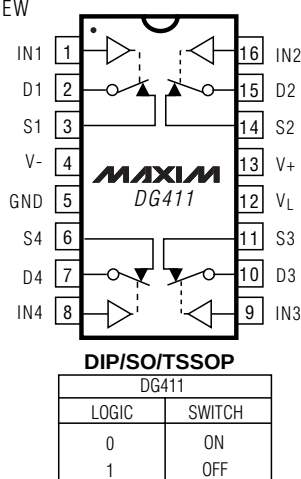
PART	TEMP RANGE	PIN-PACKAGE
DG411CJ	0°C to +70°C	16 Plastic DIP
DG411CUE	0°C to +70°C	16 TSSOP
DG411CY	0°C to +70°C	16 Narrow SO
DG411C/D	0°C to +70°C	Dice*

Ordering Information continued at end of data sheet.

*Contact factory for dice specifications.

Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW



Pin Configurations continued at end of data sheet.

SWITCHES SHOWN FOR LOGIC "0" INPUT



Maxim Integrated Products 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

DG411/DG412/DG413

Improved, Quad, SPST Analog Switches

ABSOLUTE MAXIMUM RATINGS

(Voltage 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, 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 MAX (Note 2)			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}					
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
			T _A = T _{MIN} to T _{MAX}	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
			T _A = T _{MIN} to T _{MAX}	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
			T _A = T _{MIN} to T _{MAX}	C, D	-20		20	
				A	-40		40	

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DG411/DG412/DG413

ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V₊ = 15V, V₋ = -15V, V_L = 5V, 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
INPUT							
Input Current with Input Voltage High	I _{INH}	I _N = 2.4V, all others = 0.8V		-0.500	0.005	0.500	μA
Input Current with Input Voltage Low	I _{INL}	I _N = 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, V _{IN} = 0V or 5V	T _A = +25°C	-1	0.0001	1	μA
			T _A = T _{MIN} to T _{MAX}	-5		5	
Negative Supply Current	I ₋	All channels on or off, V ₊ = 16.5V, V ₋ = -16.5V, V _{IN} = 0V or 5V	T _A = +25°C	-1	-0.0001	1	μA
			T _A = T _{MIN} to T _{MAX}	-5		5	
Logic Supply Current	I _L	All channels on or off, V ₊ = 16.5V, V ₋ = -16.5V, V _{IN} = 0V or 5V	T _A = +25°C	-1	0.0001	1	μA
			T _A = T _{MIN} to T _{MAX}	-5		5	
Ground Current	I _{GND}	All channels on or off, V ₊ = 16.5V, V ₋ = -16.5V, V _{IN} = 0V or 5V	T _A = +25°C	-1	-0.0001	1	μA
			T _A = T _{MIN} to T _{MAX}	-5		5	
DYNAMIC							
Turn-On Time	t _{ON}	V _D = ±10V, Figure 2	T _A = +25°C		110	175	ns
			T _A = T _{MIN} to T _{MAX}			220	
Turn-Off Time	t _{OFF}	V _D = ±10V, Figure 2	T _A = +25°C		100	145	ns
			T _A = T _{MIN} to T _{MAX}			160	
Break-Before-Make Time Delay	t _D	DG413 only, R _L = 300Ω, C _L = 35pF, Figure 3	T _A = +25°C		25		ns
Charge Injection (Note 3)	Q	C _L = 1.0nF, V _{GEN} = 0V, R _{GEN} = 0Ω, Figure 4	T _A = +25°C		5	10	pC
Off-Isolation (Note 5)	OIRR	R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 5	T _A = +25°C		68		dB
Crosstalk (Note 6)		R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 6	T _A = +25°C		85		dB
Source Off-Capacitance	C _{S(OFF)}	f = 1MHz, Figure 7	T _A = +25°C		9		pF
Drain Off-Capacitance	C _{D(OFF)}	f = 1MHz, Figure 7	T _A = +25°C		9		pF
Drain On-Capacitance	C _{D(ON)} + C _{S(ON)}	f = 1MHz, Figure 8	T _A = +25°C		35		pF

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ELECTRICAL CHARACTERISTICS—Single Supply

(V₊ = 12V, V₋ = 0V, V_L = 5V, 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)		0		12	V
Drain-Source On-Resistance	R _{D_S(ON)}	V ₊ = 10.8V, V _D = 3.8V, I _S = -10mA	T _A = +25°C	40		80	Ω
			T _A = T _{MIN} to T _{MAX}			100	
SUPPLY							
Positive Supply Current	I ₊	All channels on or off, V ₊ = 13.2V, V _{IN} = 0V or 5V	T _A = +25°C	-1	0.0001	1	μA
			T _A = T _{MAX}	-5		5	
Negative Supply Current	I ₋	All channels on or off, V ₊ = 13.2V, V _{IN} = 0V or 5V	T _A = +25°C	-1	0.0001	1	μA
			T _A = T _{MAX}	-5		5	
Logic Supply Current	I _L	All channels on or off, V _L = 5.25V, V _{IN} = 0V or 5V	T _A = +25°C	-1	0.0001	1	μA
			T _A = T _{MAX}	-5		5	
Ground Current	I _{GND}	All channels on or off, V _L = 5.25V, V _{IN} = 0V or 5V	T _A = +25°C	-1	-0.0001	1	μA
			T _A = T _{MAX}	-5		5	
DYNAMIC							
Turn-On Time	t _{ON}	V _S = 8V, Figure 2	T _A = +25°C	175		250	ns
			T _A = T _{MIN} to T _{MAX}			315	
Turn-Off Time	t _{OFF}	V _S = 8V, Figure 2	T _A = +25°C	95		125	ns
			T _A = T _{MIN} to T _{MAX}			140	
Break-Before-Make Time Delay	t _D	DG413 only, R _L = 300Ω, C _L = 35pF, Figure 3	T _A = +25°C	25			ns
Charge Injection (Note 3)	Q	C _L = 1.0nF, V _{GEN} = 0V, R _{GEN} = 0V, Figure 4	T _A = +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: ΔR_{ON} = ΔR_{ON} max - ΔR_{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), V_D = output, V_S = input to off switch. See Figure 5.

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

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

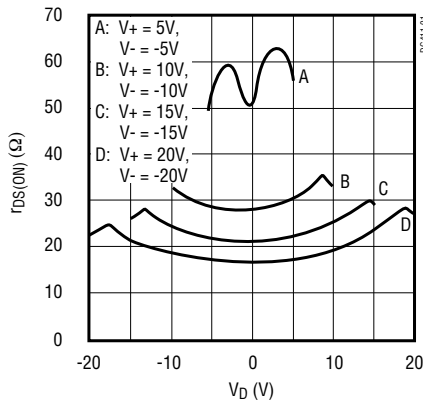
Improved, Quad, SPST Analog Switches

Typical Operating Characteristics

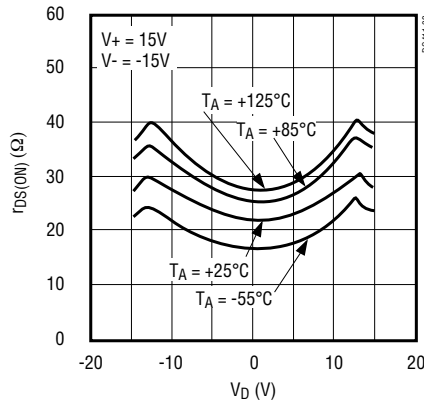
($T_A = +25^\circ\text{C}$, unless otherwise noted.)

DG411/DG412/DG413

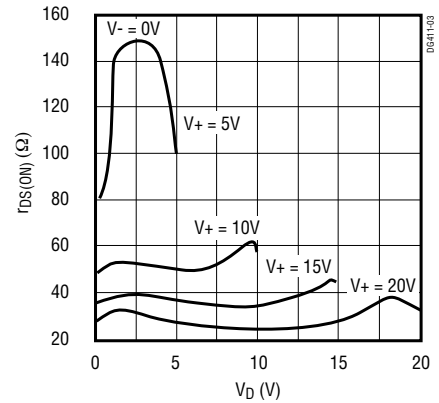
ON-RESISTANCE vs. V_D AND POWER-SUPPLY VOLTAGE



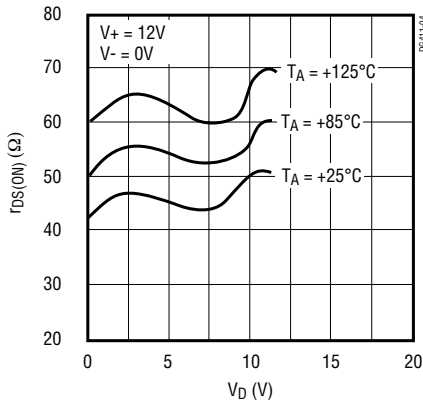
ON-RESISTANCE vs. V_D AND TEMPERATURE



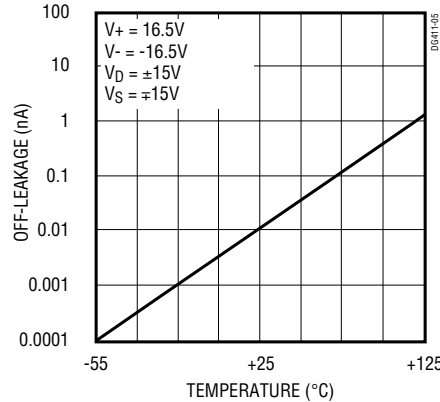
ON-RESISTANCE vs. V_D AND TEMPERATURE (SINGLE SUPPLY)



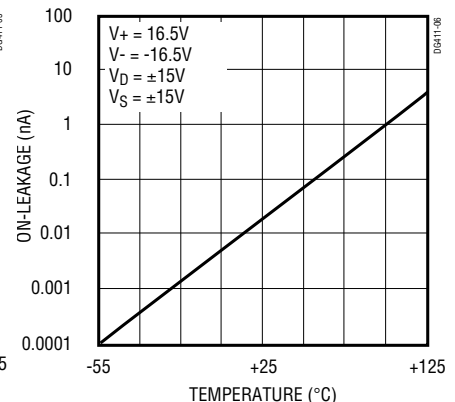
ON-RESISTANCE vs. V_D (SINGLE SUPPLY)



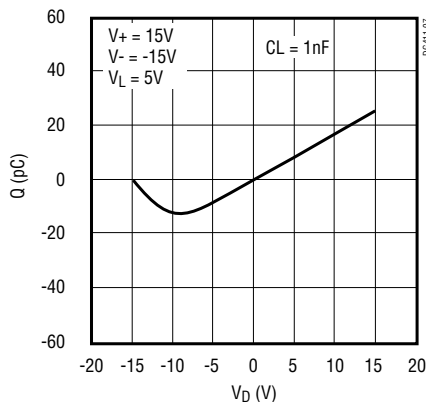
OFF-LEAKAGE CURRENTS vs. TEMPERATURE



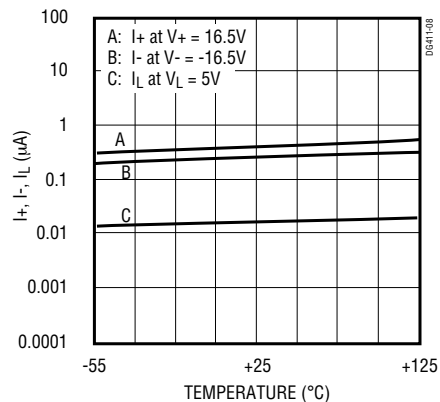
ON-LEAKAGE CURRENTS vs. TEMPERATURE



CHARGE INJECTION vs. ANALOG VOLTAGE



SUPPLY CURRENT vs. TEMPERATURE



Improved, Quad, SPST Analog Switches

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

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 $+10\text{V}$ to $+30\text{V}$ single supply; connect V- to 0V when operating with a single supply. Also, all device types can operate with unbalanced supplies such as $+24\text{V}$ and -5V . V_L must be connected to $+5\text{V}$ 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 $+44\text{V}$.

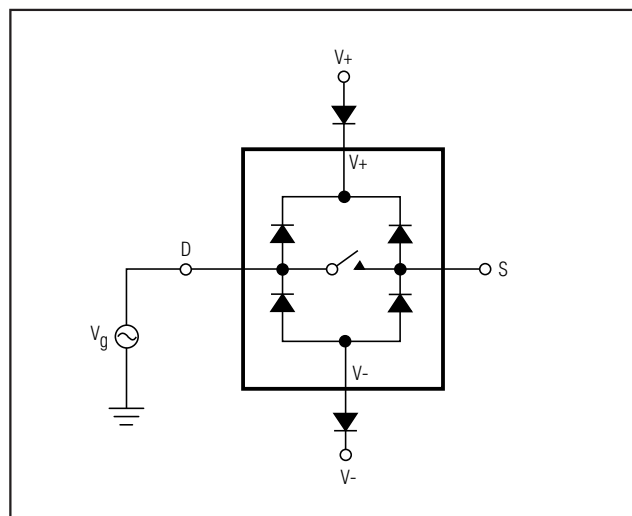


Figure 1. Overvoltage Protection Using External Blocking Diodes

DG411/DG412/DG413

Timing Diagrams/Test Circuits

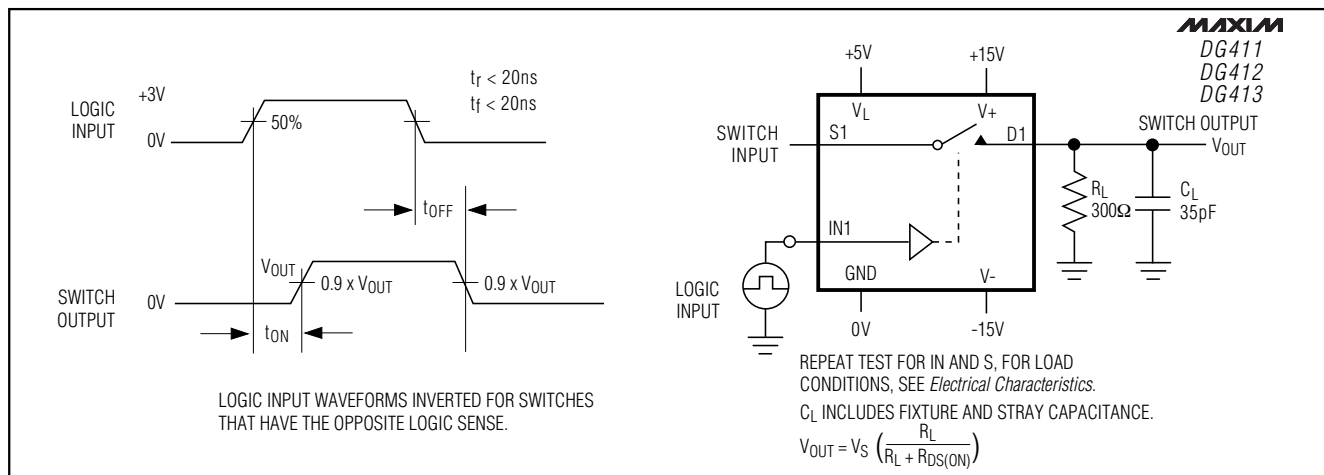


Figure 2. Switching-Time

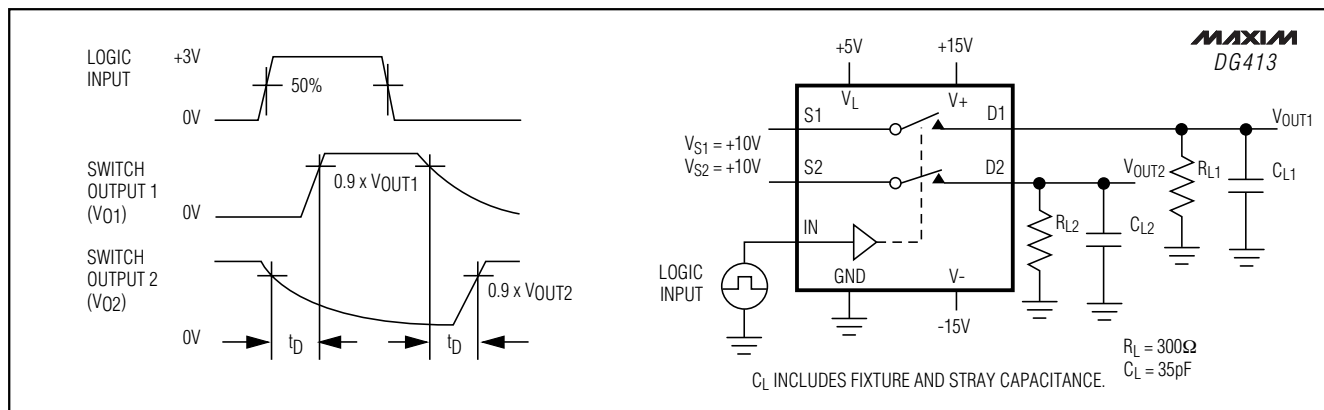


Figure 3. DG413 Break-Before-Make

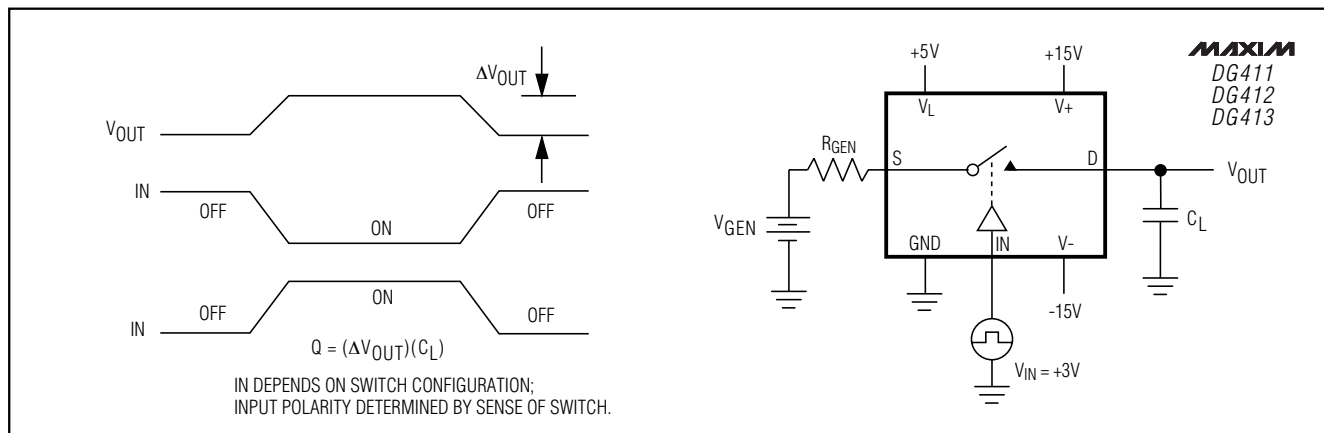


Figure 4. Charge-Injection

Improved, Quad, SPST Analog Switches

Timing Diagrams/Test Circuits (continued)

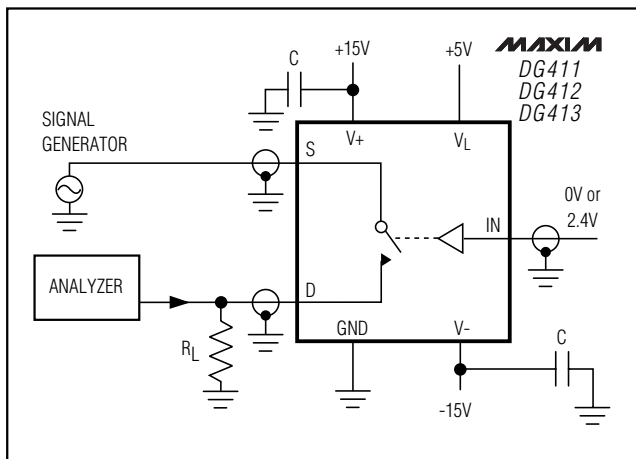


Figure 5. Off-Isolation

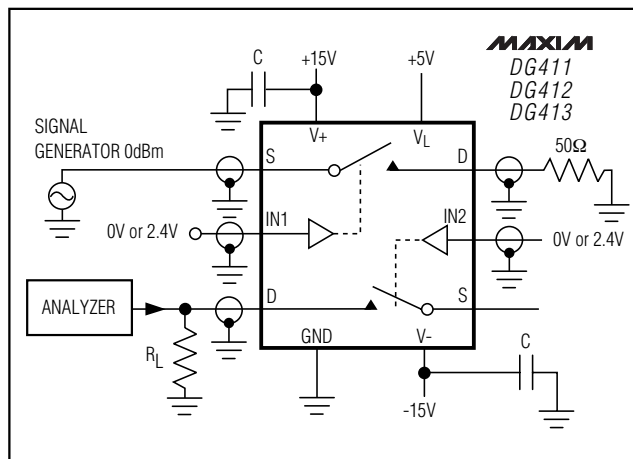


Figure 6. Crosstalk

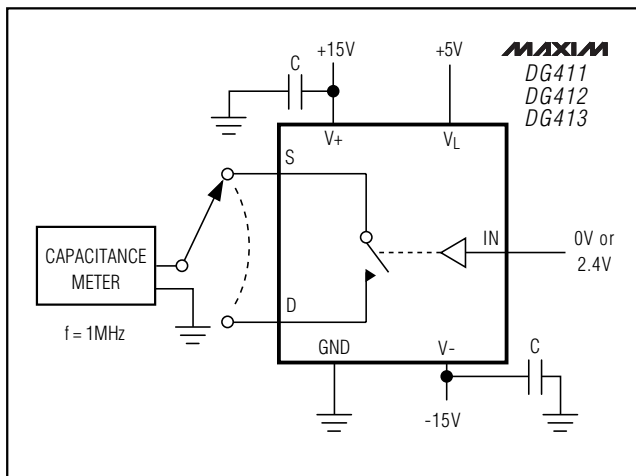


Figure 7. Channel Off-Capacitance

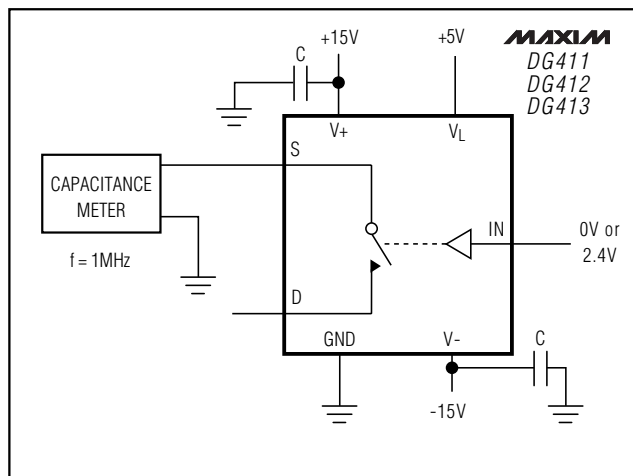


Figure 8. Channel On-Capacitance

Improved, Quad, SPST Analog Switches

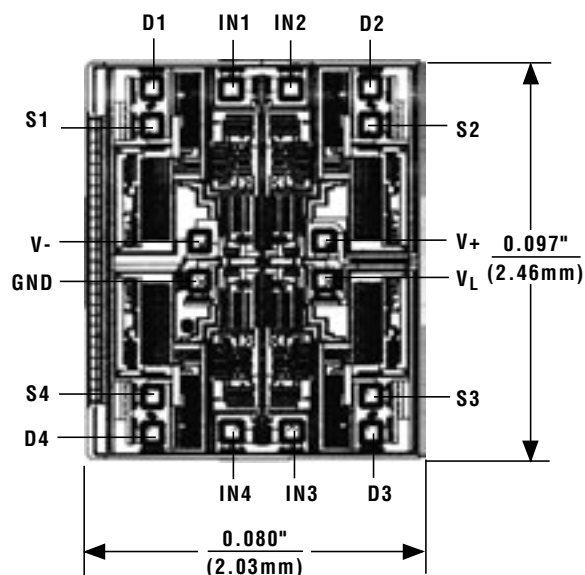
Ordering Information (continued)

PART	TEMP RANGE	PIN-PACKAGE
DG411EGE	-40°C to +85°C	16 QFN
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**
DG412CJ	0°C to +70°C	16 Plastic DIP
DG412CUE	0°C to +70°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
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**
DG413CJ	0°C to +70°C	16 Plastic DIP
DG413CUE	0°C to +70°C	16 TSSOP
DG413CY	0°C to +70°C	16 Narrow SO
DG413C/D	0°C to +70°C	Dice*
DE413EGE	-40°C to +85°C	16 QFN
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.

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

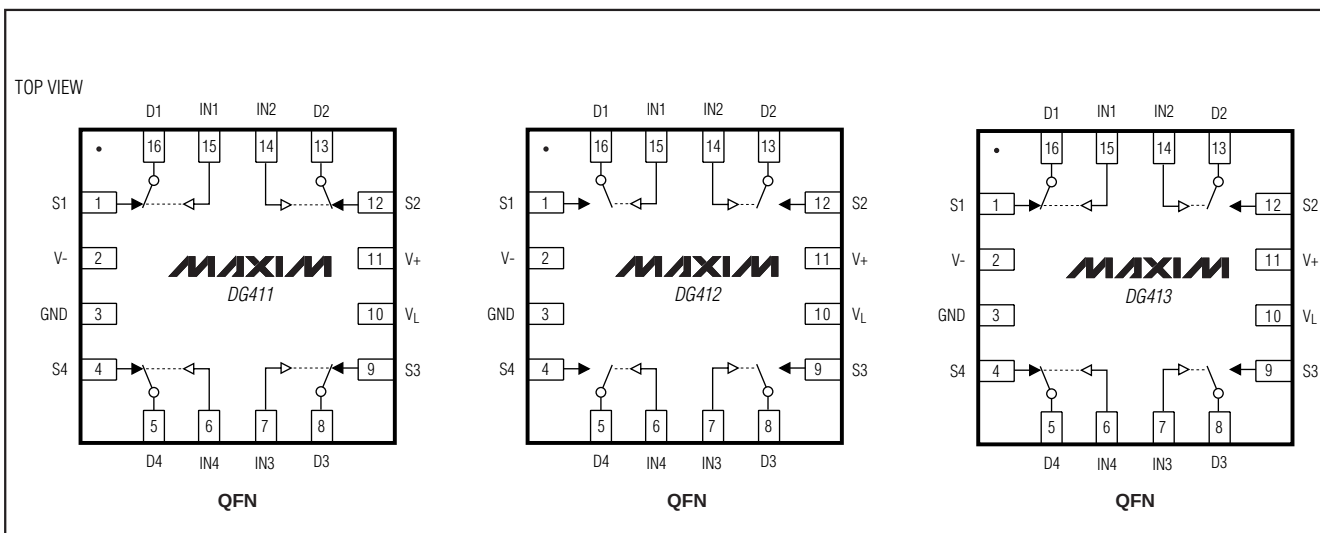
Chip Topography



TRANSISTOR COUNT: 136
SUBSTRATE CONNECTED TO V+

DG411/DG412/DG413

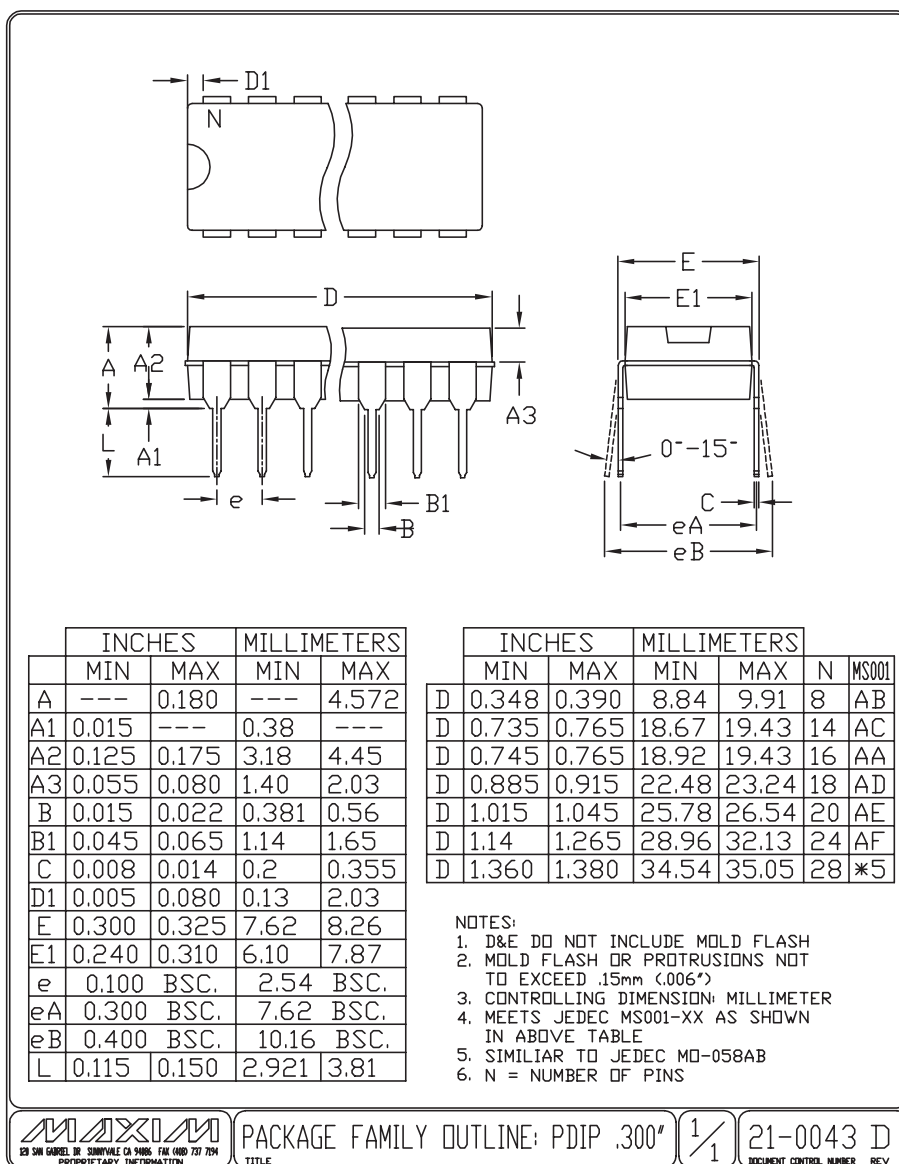
Pin Configurations/Functional Diagrams (continued)



Improved, Quad, SPST Analog Switches

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)



PDFN.EPS



PACKAGE FAMILY OUTLINE: PDIP .300"

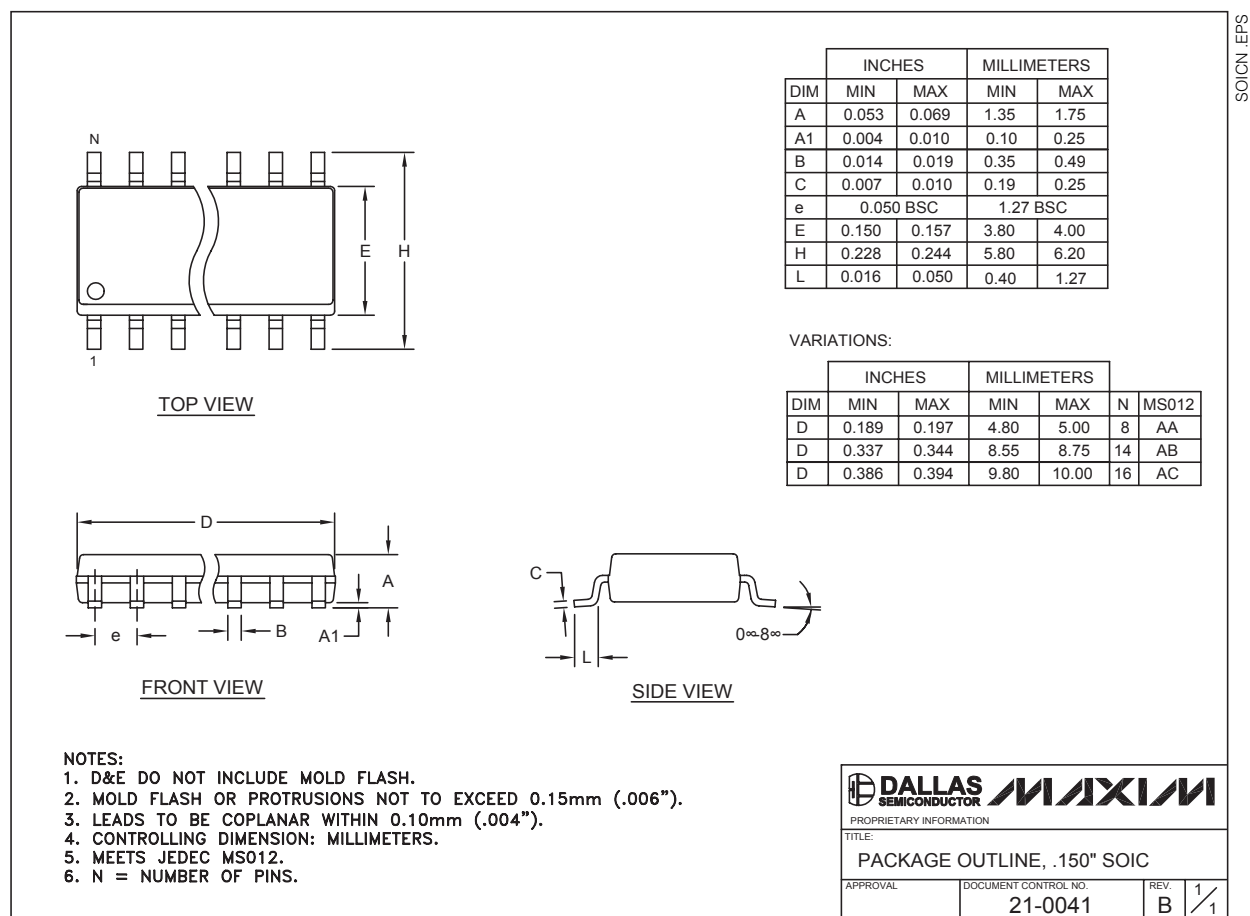
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Improved, Quad, SPST Analog Switches

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)

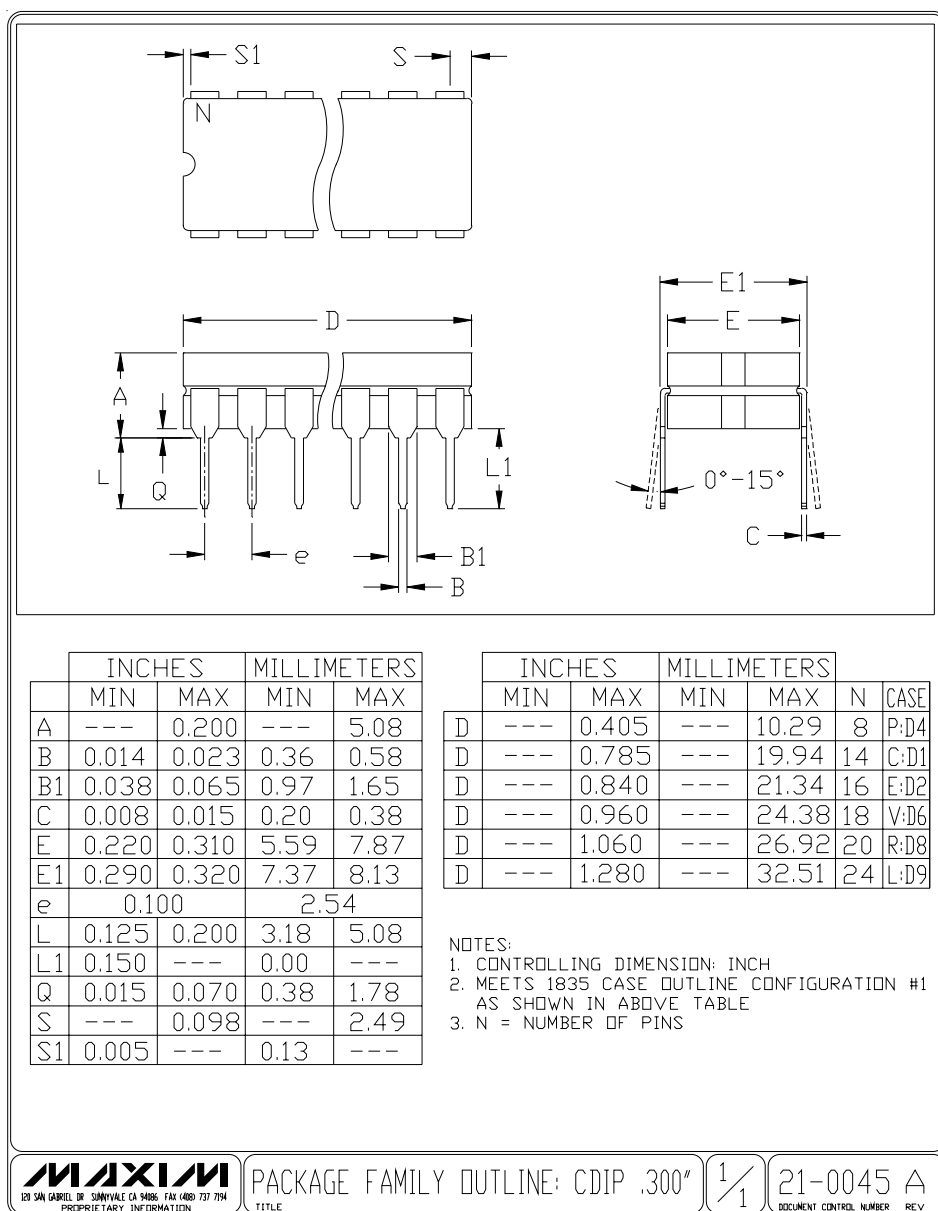


DG411/DG412/DG413

Improved, Quad, SPST Analog Switches

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)



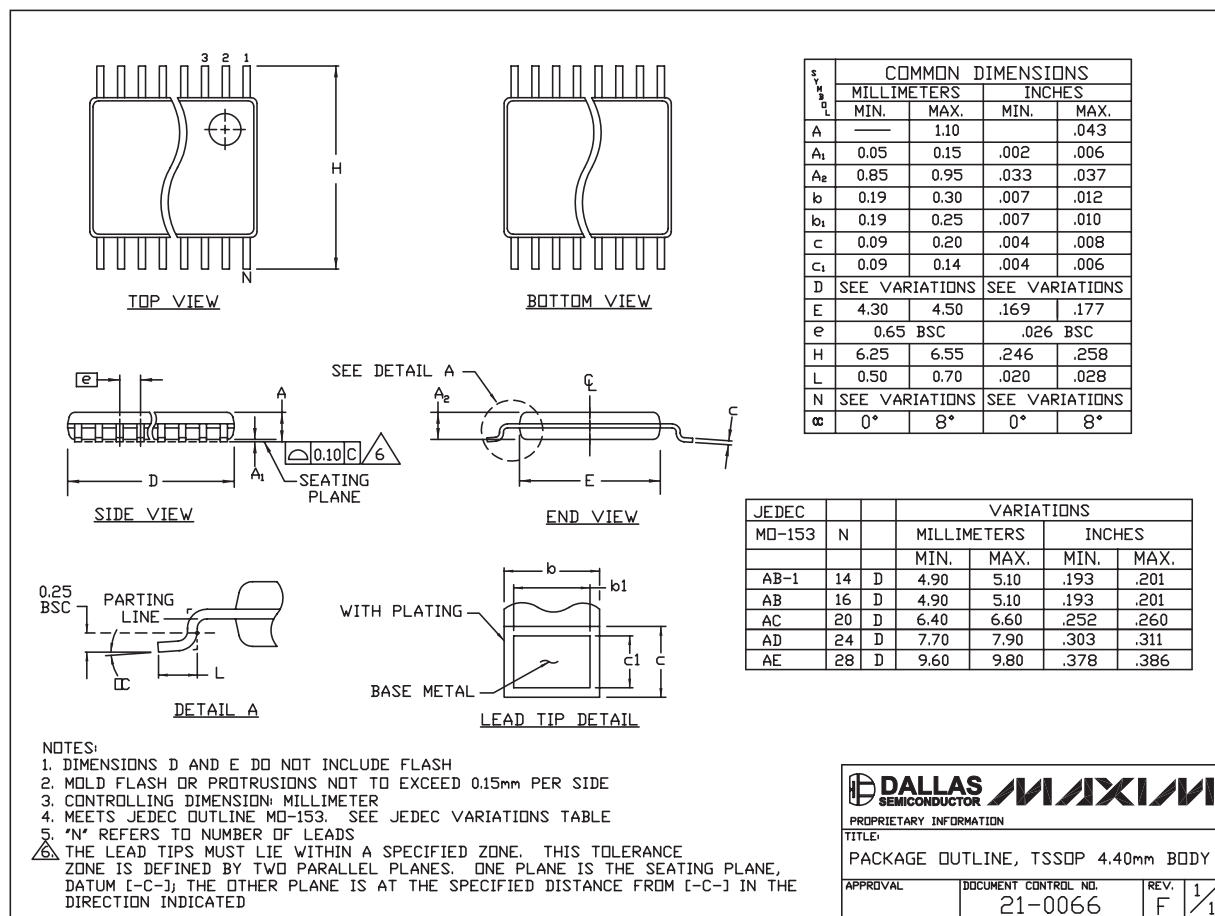
Improved, Quad, SPST Analog Switches

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)

DG411/DG412/DG413

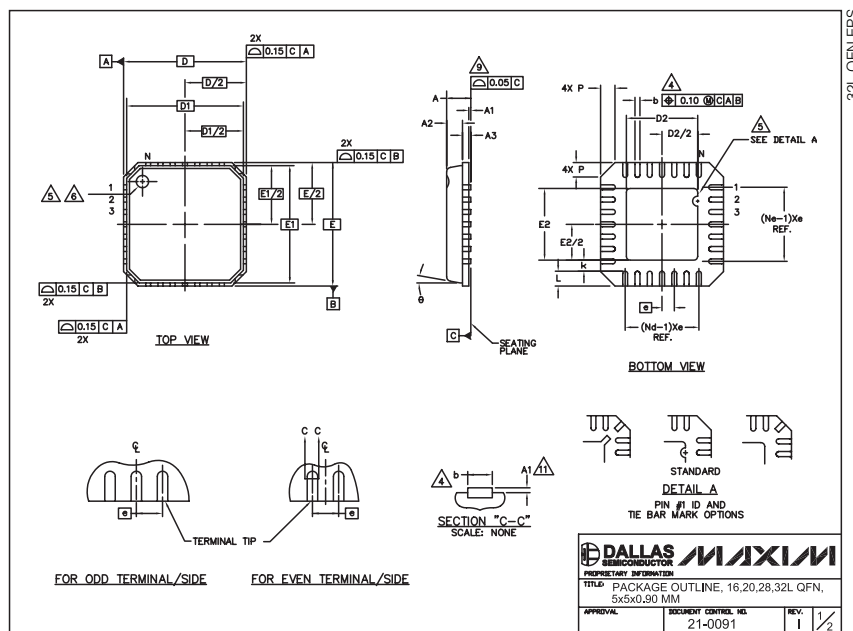
TSSOP4.40mm.EPS



Improved, Quad, SPST Analog Switches

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to www.maxim-ic.com/packages.)



32L QFN EPS

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