#### **General Description**

Maxim's redesigned DG444/DG445 analog switches now feature on-resistance matching (4 $\Omega$  max) between switches and guaranteed on-resistance flatness over the signal range (9 $\Omega$  max). These low on-resistance switches conduct equally well in either direction. They guarantee low charge injection (10pC max), low power consumption (35µW max), and an electrostatic discharge (ESD) tolerance of 2000V (min) per Method 3015.7. The new design offers lower off-leakage current over temperature (less than 5nA at +85°C).

The DG444/DG445 are quad, single-pole/single-throw (SPST) analog switches. The DG444 has four normally closed switches and the DG445 has four normally open switches. Switching times are less than 250ns for ton and less than 70ns for toFF. Operation is from a single +10V to +30V supply, or bipolar  $\pm$ 4.5V to  $\pm$ 20V supplies. Maxim's improved DG444/DG445 continue to be 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 and Control	Audio Signal Routing
Systems	Modems/Faxes
Military Radios	

#### \_New Features

- Plug-In Upgrades for Industry-Standard DG444/DG445
- Improved Ron Match Between Channels (4Ω max)
- Guaranteed RFLAT(ON) Over Signal Range (9Ω max)
- Improved Charge Injection (10pC max)
- Improved Off-Leakage Current Over Temperature (< 5nA at +85°C)</li>
- Withstand ESD (2000V min) per Method 3015.7

#### **Existing Features**

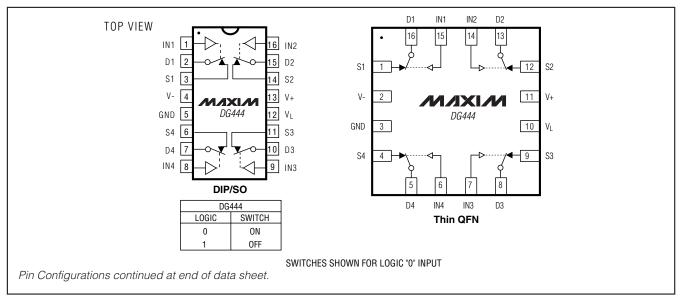
- Low RDS(ON) (85Ω max)
- Single-Supply Operation +10V to +30V Bipolar-Supply Operation ±4.5V to ±20V
- Low Power Consumption (35µW max)
- Rail-to-Rail Signal Handling
- TTL/CMOS-Logic Compatible

#### **Ordering Information**

PART	TEMP RANGE	PIN-PACKAGE
DG444CJ	0°C to +70°C	16 Plastic DIP
DG444CY	0°C to +70°C	16 Narrow SO
DG444C/D	0°C to +70°C	Dice*
DG444DJ	-40°C to +85°C	16 Plastic DIP
DG444DY	-40°C to +85°C	16 Narrow SO

Ordering Information continued at end of data sheet. \*Contact factory for dice specifications.

#### Pin Configurations/Functional Diagrams/Truth Tables



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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.

# DG444/DG445

#### ABSOLUTE MAXIMUM RATINGS

(Voltage Referenced to V-)

V+
GND
V <sub>L</sub> (GND - 0.3V) to (V+ + 0.3V)
Digital Inputs V <sub>S</sub> , V <sub>D</sub> (Note 1)(V 2V) to (V+ + 2V) or 30mA
(whichever occurs first)
Continuous Current (any terminal)
Peak Current, S or D (pulsed at 1ms, 10% duty cycle max) .100mA

Continuous Power Dissipation ( $T_A = +70^{\circ}C$ )
6-Pin Narrow SO (derate 8.70mW/°C above +70°C)696mW
16-Pin PDIP (derate 10.53mW/°C above +70°C)842mW
16-Pin Thin QFN (derate 33.3mW/°C above +70°C)2667mW
Operating Temperature Ranges
DG444C/DG445C0°C to +70°C
DG444D, E/DG445D, E40°C to +85°C
Storage Temperature Range65°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**

 $(V + = 15V, V - = -15V, V_L = 5V, GND = 0, V_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN}$  to T<sub>MAX</sub>, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
SWITCH							
Analog Signal Range	VANALOG	(Note 3)		-15		+15	V
Drain-Source	Rds(on)	V+ = 13.5V, V- = -13.5V,	$T_A = +25^{\circ}C$		50	85	Ω
On-Resistance	103(011)	$V_D = \pm 8.5 V$ , $I_S = -10 mA$	$T_{\text{A}} = T_{\text{MIN}}$ to $T_{\text{MAX}}$			100	52
On-Resistance Match	$\Delta R_{DS(ON)}$	$V_D = \pm 10V$ ,	$T_A = +25^{\circ}C$			4	Ω
Between Channels (Note 4)	ANDS(ON)	I <sub>S</sub> = -10mA	$T_A = T_{MIN}$ to $T_{MAX}$			5	52
On-Resistance Flatness (Note 4)	Deuteron	$V_D = \pm 5V$ ,	$T_A = +25^{\circ}C$			9	Ω
On-nesistance Flatness (Note 4)	nflat(ON)	IS = -10mA	$T_A = T_{MIN}$ to $T_{MAX}$			15	52
Source Leakage Current		$V_{+} = 16.5V, V_{-} = -16.5V, V_{D} = \pm 15.5V,$	$T_A = +25^{\circ}C$	-0.50	+0.01	+0.50	nA
(Note 5)	IS(OFF)	$V_{\rm S} = \pm 15.5 V$ , $V_{\rm S} = \pm 15.5 V$	$T_A = T_{MIN}$ to $T_{MAX}$	-5		+5	ПА
Drain Off-Leakage Current		V+ = 16.5V, V- = -16.5V,	$T_A = +25^{\circ}C$	-0.50	+0.01	+0.50	nA
(Note 5)	ID(OFF)	$V_{D} = \pm 15.5V,$ $V_{S} = \mp 15.5V$	$T_A = T_{MIN}$ to $T_{MAX}$	-5		+5	ПА
Drain On-Leakage Current	ID(ON)	$V_{+} = 16.5V, V_{-} = -16.5V, V_{D} = \pm 15.5V.$	$T_A = +25^{\circ}C$	-0.50	+0.08	+0.50	
(Note 5)	or I <sub>S(ON)</sub>	$V_{\rm S} = \pm 15.5 V$ , $V_{\rm S} = \pm 15.5 V$	$T_A = T_{MIN}$ to $T_{MAX}$	-10		+10	nA
INPUT							
Input Current with Input Voltage High	I <sub>INH</sub>	$V_{IN} = 2.4V$ , all others = 0.8V		-0.5	-0.00001	+0.5	μA
Input Current with Input Voltage Low	I <sub>INL</sub>	$V_{IN} = 0.8V$ , all others = 2.4V		-0.5	-0.00001	+0.5	μA

#### **ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)**

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

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	МАХ	UNITS
SWITCH							
Power-Supply Range	V+, V-			±4.5		±20.0	V
Positive Supply Current	+	All channels on or off, V+ = 16.5V, V- = -16.5V, VJN = 0V	$T_A = +25^{\circ}C$	-1	-0.001	+1	μA
r ositive Supply Current		or 5V	$T_A = T_{MIN}$ to $T_{MAX}$	-5		+5	μΛ
Negative Supply Current	-	All channels on or off, V+ = 16.5V, V- = -16.5V, VI = -16.5V, V- = -16.5V, VIN = 0V	$T_A = +25^{\circ}C$	-1	-0.0001	+1	μA
Negative Supply Current	1-	or 5V	$T_A = T_{MIN}$ to $T_{MAX}$	-5		+5	μΑ
Logic Supply Current	IL	All channels on or off, $V$ + = 16.5V, V- = -16.5V, V <sub>IN</sub> = 0V	$T_A = +25^{\circ}C$	-1	-0.001	+1	
Logic Supply Current		or 5V	$T_A = T_{MIN}$ to $T_{MAX}$	-5		+5	μA
Ground Current		All channels on or off, $V_{+} =$	$T_A = +25^{\circ}C$	-1	-0.0001	+1	
Ground Current	IGND	16.5V, V- = -16.5V, V <sub>IN</sub> = 0V or 5V	$T_A = T_{MIN}$ to $T_{MAX}$	-5		μA +5	
INPUT				•			
Turn-On Time	ton	$V_S = \pm 10V$ , Figure 2	$T_A = +25^{\circ}C$		150	250	ns
Turn-Off Time	torr	DG444, $V_S = \pm 10V$ , Figure 2	$T_A = +25^{\circ}C$		90	120	ns
	tOFF	DG445, $V_S = \pm 10V$ , Figure 2	$T_A = +25^{\circ}C$		110	170	ns
Charge Injection (Note 3)	Q	$C_L = 1nF$ , $V_{GEN} = 0$ , $R_{GEN} = 0\Omega$ , Figure 3	$T_A = +25^{\circ}C$		5	10	рС
Off-Isolation Rejection Ratio (Note 6)	OIRR	$R_L = 50\Omega$ , $C_L = 5pF$ , f = 1MHz, Figure 4	$T_A = +25^{\circ}C$		60		dB
Crosstalk (Note 7)		$R_L -50\Omega$ , $C_L = 5pF$ , f = 1MHz, Figure 5	$T_A = +25^{\circ}C$		100		dB
Source Off-Capacitance	C <sub>S(OFF)</sub>	f = 1MHz, Figure 6	$T_A = +25^{\circ}C$		4		рF
Drain Off-Capacitance	CD(OFF)	f = 1MHz, Figure 6	$T_A = +25^{\circ}C$		4		рF
Source On-Capacitance	C <sub>S(ON)</sub>	f = 1MHz, Figure 7	$T_A = +25^{\circ}C$		16		рF
Drain On-Capacitance	C <sub>D(ON)</sub>	f = 1MHz, Figure 7	$T_A = +25^{\circ}C$		16		рF

#### ELECTRICAL CHARACTERISTICS—Single Supply

 $(V + = 12V, V - = 0, V_L = 5V, GND = 0, V_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
SWITCH							1
Analog Signal Range	VANALOG	(Note 3)		0		12	V
Drain-Source	Descent	$V_{+} = 10.8V; V_{L} = 5.25V;$ $V_{D} = 3V, 8V; I_{S} = -10mA$	$T_A = +25^{\circ}C$		100	160	- Ω
On-Resistance	R <sub>DS</sub> (ON)		$T_A = T_{MIN}$ to $T_{MAX}$			200	
SUPPLY							
Power-Supply Range	V+, V-			10.8		24.0	V
Power-Supply Current	+	All channels on or off, $V_{IN} = 0V \text{ or } 5V$	$T_A = +25^{\circ}C$	-1	+0.001	+1	
Fower-Supply Current	1+		$T_A = T_{MIN}$ to $T_{MAX}$	-5		+5	- μΑ
Negative Supply Current	-	All channels on or off, $V_{IN} = 0V$ or 5V	$T_A = +25^{\circ}C$	-1	-0.0001	+1	μA
Negative Supply Culterit	1-		$T_A = T_{MIN}$ to $T_{MAX}$	-5		+5	μΑ
Logic Supply Current	IL	All channels on or off,	T <sub>A</sub> = +25°C	-1	+0.001	+1	
Logic Supply Current	I IL	$V_{IN} = 0V \text{ or } 5V$	$T_A = T_{MIN}$ to $T_{MAX}$	-5		+5	μΑ
Ground Current	loup	All channels on or off,	TA = +25°C	-1	-0.0001	+1	
Giouria Current	IGND	$V_{IN} = 0V \text{ or } 5V$	$T_A = T_{MIN}$ to $T_{MAX}$	-5		+5	μA
DYNAMIC							
Turn-On Time	ton	V <sub>S</sub> = 8V, Figure 2	$T_A = +25^{\circ}C$		300	400	ns
Turn-Off Time	toff	$V_{\rm S}$ = 8V, Figure 2	$T_A = +25^{\circ}C$		60	200	ns
Charge Injection (Note 3)	Q	$C_L = 1nF$ , $V_{GEN} = 0$ , $R_{GEN} = 0\Omega$ , Figure 3	TA = +25°C		5	10	рС

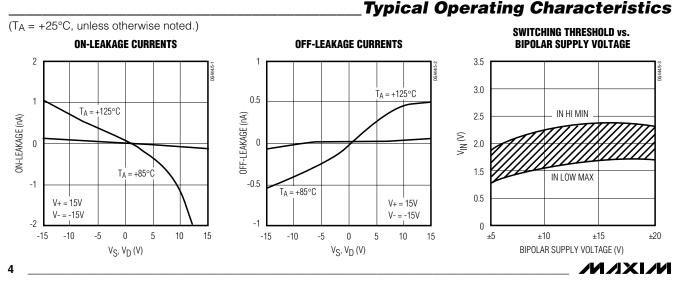
Note 2: Typical values are for **design aid only**, are not guaranteed, and are not subject to production testing. The algebraic convention, where the most negative value is a minimum and the most positive value a maximum, is used in this data sheet.

Note 3: Guaranteed by design.

**Note 4:** On-resistance match between channels and flatness are guaranteed only with bipolar-supply operation. Flatness is defined as the difference between the maximum and the minimum value of on-resistance as measured at the extremes of the specified analog signal range.

**Note 5:** Leakage parameters  $I_{S(OFF)}$ ,  $I_{D(OFF)}$ ,  $I_{D(OFF)}$ ,  $I_{D(ON)}$ , and  $I_{S(ON)}$  are 100% tested at the maximum rated hot temperature and guaranteed at +25°C. **Note 6:** Off-Isolation Rejection Ratio = 20log (V<sub>D</sub>/V<sub>S</sub>), V<sub>D</sub> = output, V<sub>S</sub> = input to off switch.

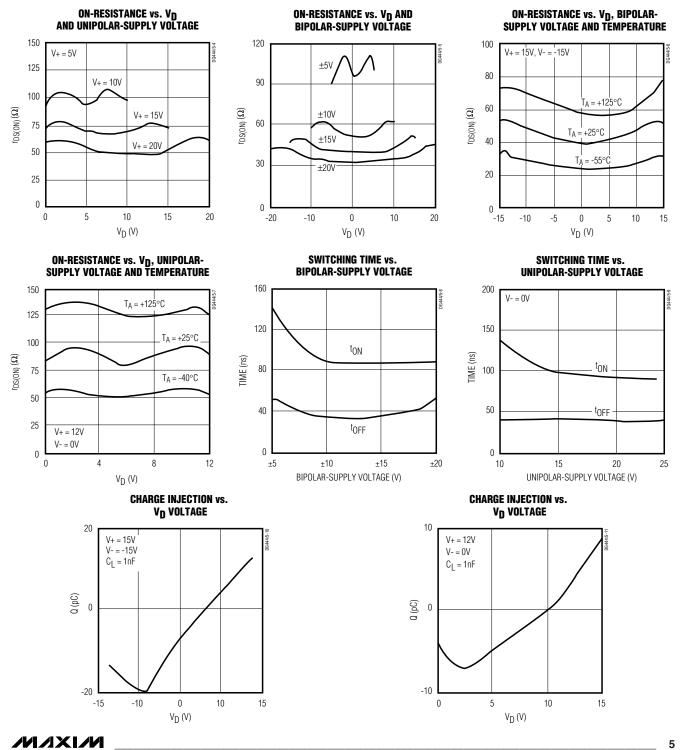
**Note 7:** Between any two switches.



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#### **Typical Operating Characteristics**

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



DG444/DG445

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45	
64	DIP/SO
ğ	1, 16, 9,
4	2, 15, 10,
4	3, 14, 11,
64	4
	5
-	12

DIN

#### \_Pin Description

PI	N	NAME	FUNCTION
DIP/SO	THIN QFN	NAME	FUNCTION
1, 16, 9, 8	15, 14, 7, 6	IN1–IN4	Logic Control Inputs
2, 15, 10, 7	16, 13, 8, 5	D1–D4	Drain Outputs
3, 14, 11, 6	1, 12, 9 4	S1–S4	Source Outputs
4	2	V-	Negative-Supply Voltage Input
5	3	GND	Ground
12	10	VL	Logic-Supply Voltage Input
13	11	V+	Positive-Supply- Voltage Input—Connected to Substrate
_	EP	PAD	Exposed Pad Connect Pad to V+

#### **Applications Information**

#### **General Operation**

- Switches are open when power is off.
- IN, D, and S should not exceed V+ or V-, even with the power off.
- Switch leakage is from each analog switch terminal to V+ or V-, not to other switch terminals.

#### Operation with Supply Voltages Other than ±15V

Using supply voltages other than ±15V will reduce the analog signal range. The DG444/DG445 switches oper-

ate with  $\pm 4.5V$  to  $\pm 20V$  bipolar supplies or with a  $\pm 10V$  to  $\pm 30V$  single supply; connect V- to 0V when operating with a single supply. Also, all device types can operate with unbalanced supplies such as  $\pm 24V$  and  $\pm 5V$ . V<sub>L</sub> must be connected to  $\pm 5V$  to be TTL compatible, or to V+ for CMOS-logic level inputs. The *Typical Operating Characteristics* graphs show typical on-resistance with  $\pm 20V$ ,  $\pm 15V$ ,  $\pm 10V$ , and  $\pm 5V$  supplies. (Switching times increase by a factor of two or more for operation at  $\pm 5V$ .)

#### **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, followed by V<sub>L</sub>, 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 above V-, but low switch resistance and low leakage characteristics are unaffected. Device operation is unchanged, and the difference between V+ and Vshould not exceed +44V.

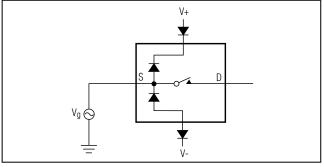


Figure 1. Overvoltage Protection Using External Blocking Diodes

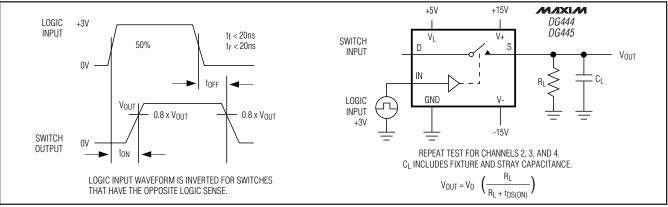


Figure 2. Switching Time

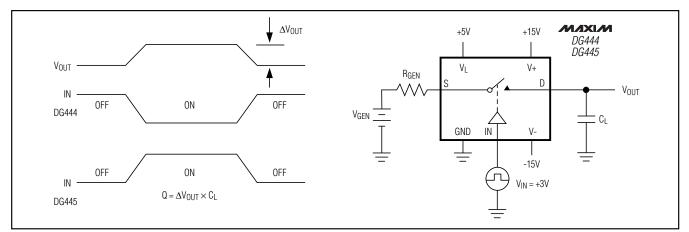


Figure 3. Charge Injection

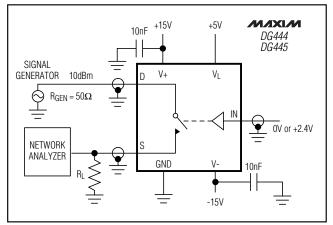


Figure 4. Off-Isolation Rejection Ratio

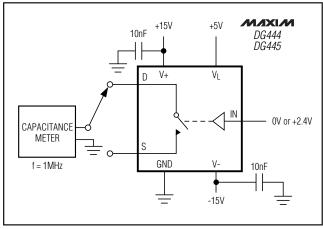


Figure 6. Source/Drain Off-Capacitance



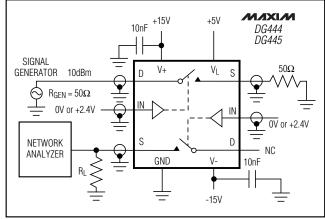


Figure 5. Crosstalk

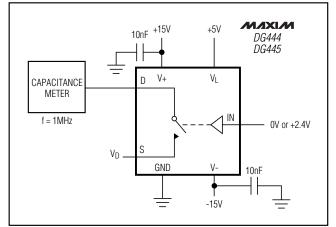
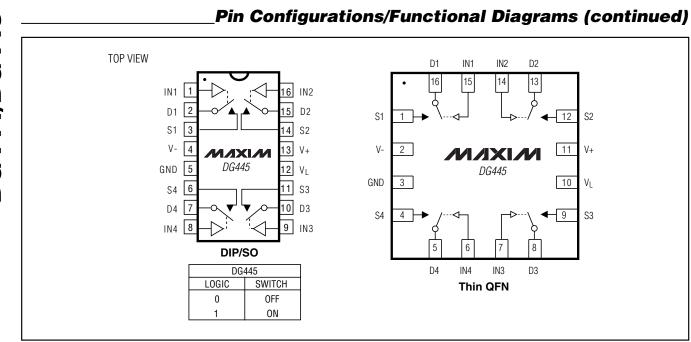


Figure 7. Source/Drain On-Capacitance

DG444/DG445



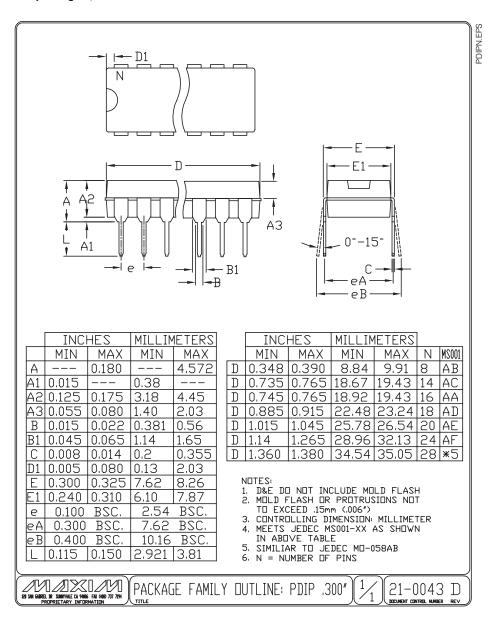
#### **Ordering Information (continued)**

PART	TEMP RANGE	PIN-PACKAGE
DG444ETE	-40°C to +85°C	16 Thin QFN (5mm x 5mm)
<b>DG445</b> CJ	0°C to +70°C	16 Plastic DIP
DG445CY	0°C to +70°C	16 Narrow SO
DG445C/D	0°C to +70°C	Dice*
DG445DJ	-40°C to +85°C	16 Plastic DIP
DG445DY	-40°C to +85°C	16 Narrow SO
DG445ETE	-40°C to +85°C	16 Thin QFN (5mm x 5mm)

\*Contact factory for dice specifications.

#### Package Information

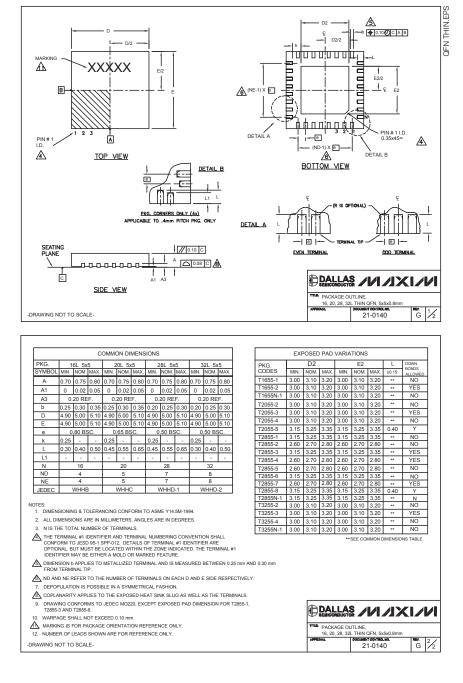
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



DG444/DG445

#### \_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**.)



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