19-2038; Rev 0; 5/01

EVALUATION KIT AVAILABLE

MAXIM

Miniature Chip-Scale GSM900/DCS1800/PCS1900 Power Amplifier

MAX2216

General Description

The MAX2216 is a miniature chip-scale, low-voltage power amplifier for GSM/DCS/PCS. This dual power amplifier is packaged in a tiny UCSP™ to minimize implementation size and solution cost.

Output power is +34.5dBm (V_{CC} ≥ +3.2V) in the GSM band and +32dBm in the DCS or PCS band. The power amplifier is functional at supply voltages as low as 2.5V, at a reduced output power level. Frequency of operation is from 880MHz to 915MHz for the low band, 1710MHz to 1785MHz for the high band tuned for DCS applications, and 1850MHz to 1910MHz for the high band tuned for PCS applications. Peak efficiency is 50% in the GSM band. An analog power-control input permits more than 40dB power-control range for each band.

The device operates from three NiCd/NiMH cells or a single Li+ cell, allowing single-supply operation from +2.5V to +5.5V.

Applications

Dual-Mode GSM/DCS Handsets

Dual-Mode GSM/PCS Handsets

PCS Handsets

Dual-Mode AMPS/PCS Handsets

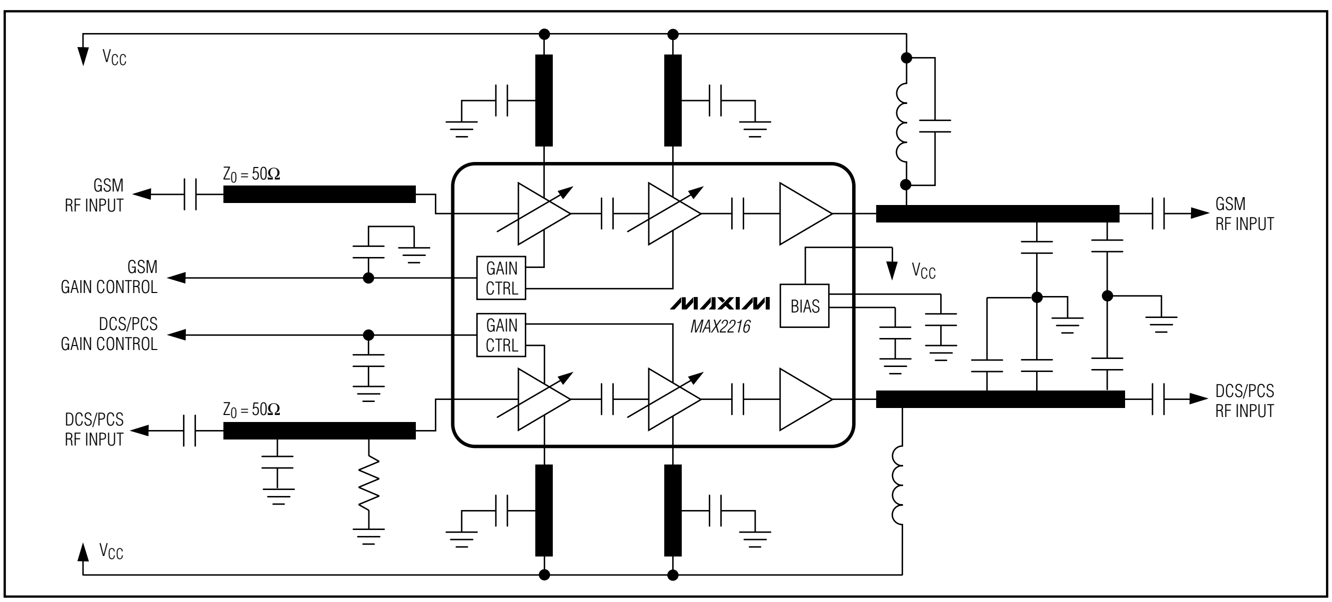
Features

- ♦ **Miniature Chip-Scale Package (UCSP): 2.5mm × 3.0mm**
- ♦ **+34.5dBm Output Power (V_{CC} ≥ +3.2V)**
- ♦ **Low Voltage Operation—Down to 2.5V**
- ♦ **Low-Cost Solution**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX2216EBV	-40°C to +85°C	30 5 x 6 UCSP

Typical Operating Circuit



Miniature Chip-Scale GSM900/DCS1800/PCS1900 Power Amplifier

ABSOLUTE MAXIMUM RATINGS

V_{CC}, GSMOUT, DCSOUT to GND.........................-0.3V to +6.0V
GC to GND ....-0.3V to (V_{CC} + 0.3V)
GSMIN, DCSIN Input Power 14dBm
GSMOUT, DCSOUT Maximum VSWR Tolerance.................10:1
Continuous Power Dissipation
30-bump 5 x 6 UCSP (derate 45mW/°C above +70°C)...3.6W
θ_{JA}...22°C/W

Operating Temperature Range ....-40°C to +85°C
Junction Temperature...+150°C
Storage Temperature Range ....-65°C to +150°C
Bump Temperature (soldering)
Infrared (15s) ....+220°C
Vapor Phase (60s) ....+215°C

This device is constructed using a unique set of packaging techniques that impose a limit on the thermal profile it can be exposed to during board level solder attach and rework. This limit permits only the use of solder profiles recommended in the industry standard specification, JEDEC 020A, paragraph 7.6, Table 3 for IT/VPR and convection reflow. Preheating is required. Hand or wave soldering is not allowed. See application note "Wafer-Level Chip-Scale Package" on Maxim's website for more information.

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.

DC ELECTRICAL CHARACTERISTICS

(V_{CC} = +2.5V to +5.5V, RF inputs and outputs terminated in 50Ω, no RF signal applied. Typical values are at V_{CC} = +3.2V, T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{CC}			2.5		5.5	V
Shutdown Supply Current	I_{CC}	Full shutdown mode, V_{GSMGC} < 0.4V, V_{DCSGC} < 0.4V	T_A = +25°C			5	µA
			T_A = -40°C to +85°C			50	
GC Input Current	I_{GC}	V_{GSMGC} = +2.4V, V_{DCSGC} = +2.4V				5	mA
		V_{GSMGC} < 0.4V, V_{DCSGC} < 0.4V				10	µA

AC ELECTRICAL CHARACTERISTICS (GSM900 Operation)

(MAX2216 EV Kit, V_{CC} = +3.2V, +4dBm < P_{IN} < +12dBm, f_{IN} = 900MHz, 1:8 duty cycle (T_{ON} = 577µs), 50Ω system. Typical values are at P_{IN} = +8dBm, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Frequency Range	f_{IN}	(Note 3)		880		915	MHz
Output Power	P_{OUT}	V_{GSMGC} = 2.4V	V_{CC} = +3.2V	34.5	35.2		dBm
			V_{CC} = +2.7V, T_A = -40°C to +85°C	31.8	33.7		
			V_{CC} = +2.5V	31.9	32.6		
		V_{GSMGC} = 0.4V	+2.5V < V_{CC} < +5.5V, T_A = -40°C to +85°C			-23	
Efficiency		Maximum P_{OUT}			50		%
		P_{OUT} = 34.5dBm			48		
		P_{OUT} = 20dBm			9		
Maximum Gain Control Slope		P_{OUT} > -10dBm				325	dB/V
Maximum Operating Duty Cycle		(Note 4)		25	50		%
Maximum Operating V_{CC} Under Load Mismatch		T_A = +85°C (Note 4)	Duty cycle = 12.5%	5.5			V
			Duty cycle = 25%	3.2			
		T_A = +65°C (Note 4)	Duty cycle = 12.5%	5.5			
			Duty cycle = 25%	4.2			
Noise Power		Noise in 100kHz BW, +2.5V < V_{CC} < +5.5V, 0V < V_{GSMGC} < 2.4V	925MHz to 935MHz band			-78	dBm
			935MHz to 960MHz band		-84.5		
Harmonic Levels		-10dBm < P_{OUT} < +35dBm	2nd harmonic; some harmonic attenuation achieved from EV kit matching circuit; this is included in this specification.			-6.6	dBm
			2nd harmonic falling in DCS output			-10	
			3rd harmonic			-18	
Input VSWR	VSWR	P_{OUT} > +20dBm			3.2:1		
		-10dBm < P_{OUT} < +20dBm			5.1:1		
Maximum Nonharmonic Spurious Output Due to Load Mismatch		+2.5V < V_{CC} < 5.5V, +0.4V < V_{GSMGC} < +2.4V (Note 5)				-36	dBm
Power Rise/Fall-Time		V_{GSMGC} stepped from 0 to +2.4V (Note 6)				1	µs

Miniature Chip-Scale GSM900/DCS1800/PCS1900 Power Amplifier

AC ELECTRICAL CHARACTERISTICS (DCS1800 Operation)

(MAX2216 EV Kit, V_{CC} = +3.2V, +6dBm < P_{IN} < +12dBm, f_{IN} = 1750MHz, 1:8 duty cycle (T_{ON} = 577µs), 50Ω system. Typical values are at P_{IN} = +8dBm, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Frequency Range	f_{IN}	(Note 3)		1710		1785	MHz
Output Power	P_{OUT}	V_{DCSGC} = 2.4V	V_{CC} = +3.2V	32	33.2		dBm
			V_{CC} = +2.7V, T_A = -40°C to +85°C	29.5	31.6		
			V_{CC} = +2.5V	29.5	30.8		
		V_{DCSGC} = 0.4V	+2.5V < V_{CC} < +5.5V, T_A = -40°C to +85°C			-30	
Efficiency		Maximum P_{OUT}, V_{GCDCS} = 2.1V			41		%
		P_{OUT} = 32dBm			38		
		P_{OUT} = 22dBm			12		
Maximum Gain Control Slope		P_{OUT} > -10dBm				315	dB/V
Maximum Operating Duty Cycle		(Note 4)		25	50		%
Maximum Operating V_{CC} Under Load Mismatch		T_A = +85°C (Note 4)	Duty cycle = 12.5%	5.5			V
			Duty cycle = 25%	4.8			
Noise Power		Noise in 100kHz BW, +2.5V < V_{CC} < +5.5V, 0 < V_{DCSGC} < 2.4V, noise in 1805MHz to 1880MHz band			-74		dBm
Harmonic Levels		-10dBm < P_{OUT} < +32.5dBm	2nd harmonic			-8	dBm
			3rd harmonic			-15	
Input VSWR	VSWR	P_{OUT} > +20dBm			3.1:1		
		-10dBm < P_{OUT} < +20dBm			10.8:1		
Maximum Nonharmonic Spurious Output Due to Load Mismatch		+2.5V < V_{CC} < 5.5V, +0.4V < V_{DCSGC} < +2.4V (Note 5)				-36	dBm
Power Rise/Fall-Time		V_{DCSGC} stepped from 0 to +2.4V (Note 6)				1	µs

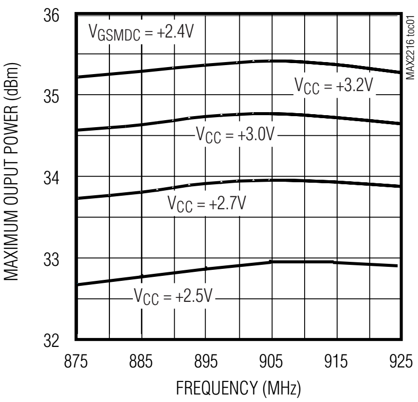
Contact Factory for PCS1900 AC Electrical Characteristics.

Note 1: Parameters are 100% production tested at T_A = +25°C and guaranteed over temperature by design and characterization.
Note 2: Parameters guaranteed by design and characterization.
Note 3: Output power, harmonic levels, and maximum nonharmonic spurious outputs due to load mismatch specifications are met over this frequency range.
Note 4: Maximum duty cycle is determined by maximum die temperature (150°C) with θ_{JA} = 22°C/W, load VSWR = 8:1, GSMGC adjusted for P_{OUT} = 34.5dBm; DCSGC adjusted for P_{OUT} = 32dBm; P_{OUT} measured using directional coupler.
Note 5: GSMGC adjusted for P_{OUT} = 34.5dBm; DCSGC adjusted for P_{OUT} = 32dBm; POUT measured using directional coupler.
Note 6: For shutdown, time is for P_{OUT} to fall below -20dBm.

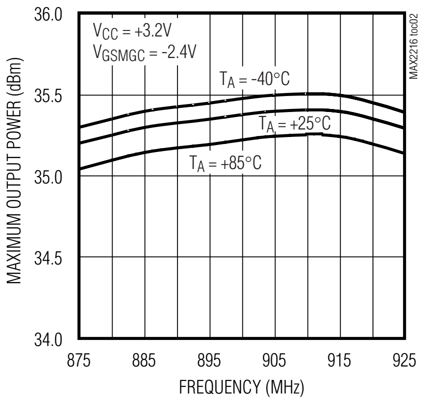
Typical Operating Characteristics

(MAX2216 EV Kit, 50Ω system, V_{CC} = +3.2V; GSM measurements: f_{GSMIN} = 900MHz, V_{GSMGC} = 2.4V, V_{DCSGC} = 0; DCS measurements: f_{DCSIN} = 1750MHz, V_{GSMGC} = 0, V_{DCSGC} = 2.4V; CW input of +8dBm, 1:8 duty cycle (T_{ON} = 577µs) T_A = +25°C,unless otherwise noted.)

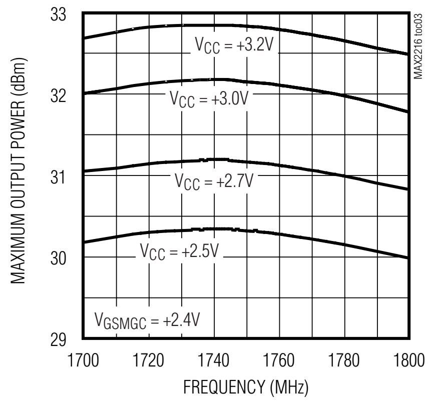
MAXIMUM OUTPUT POWER vs. FREQUENCY GSM BAND



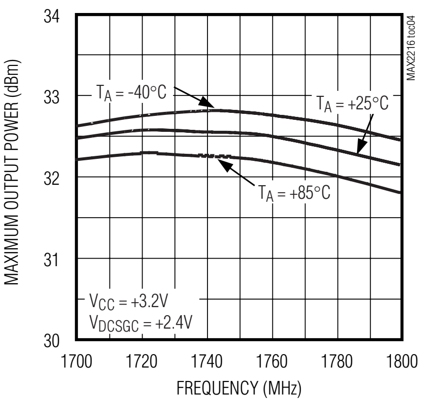
MAXIMUM OUTPUT POWER vs. FREQUENCY GSM BAND



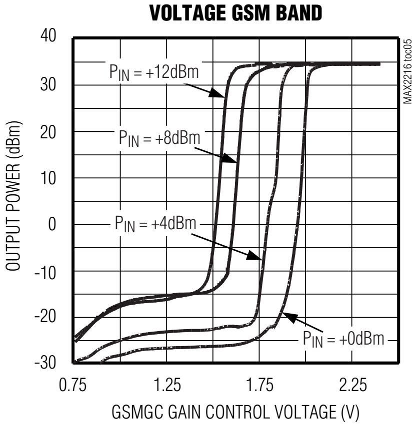
MAXIMUM OUTPUT POWER vs. FREQUENCY DCS BAND



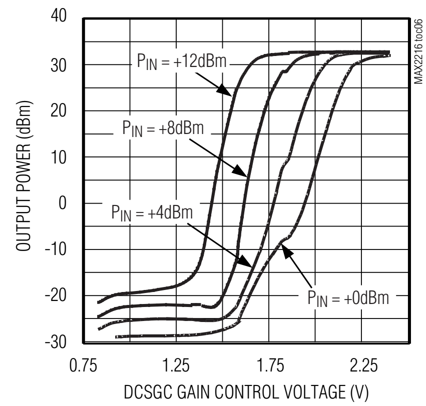
MAXIMUM OUTPUT POWER vs. FREQUENCY DCS BAND



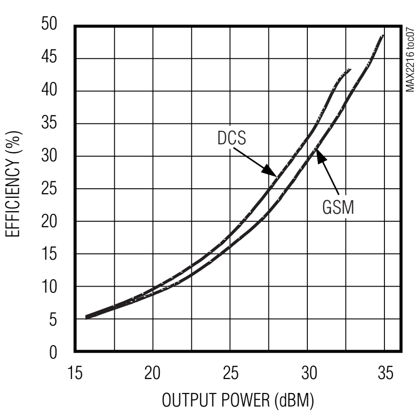
OUTPUT POWER vs. GSMGC CONTROL VOLTAGE GSM BAND



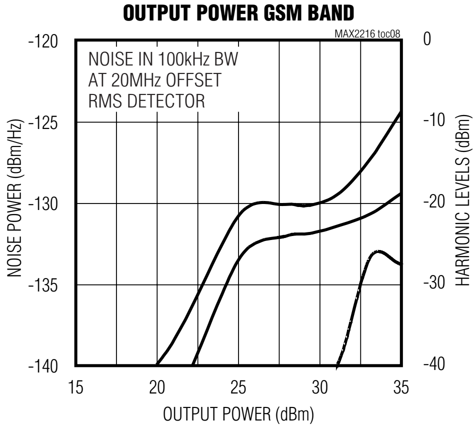
OUTPUT POWER vs. DCSGC CONTROL VOLTAGE DCS BAND



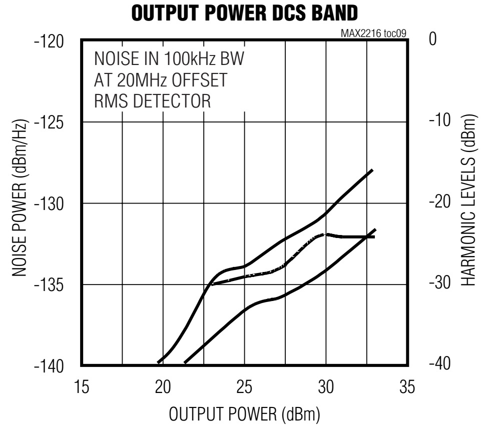
EFFICIENCY vs. OUTPUT POWER



NOISE AND HARMONIC LEVELS vs. OUTPUT POWER GSM BAND



NOISE AND HARMONIC LEVELS vs. OUTPUT POWER DCS BAND



Miniature Chip-Scale GSM900/DCS1800/PCS1900 Power Amplifier

Pin Description

PIN	NAME	FUNCTION
A1, A3, A5, B5, C3, C5, D5, E1, E3, E5	GND	Ground Connection. Provide a low-inductance path to ground plane.
A2, A4, E2, E4	V_{CC}	Interstage Power-Supply Connections. Bypass capacitor values and placement are critical for proper operation. See MAX2216 Evaluation Kit data sheet for component placement guide.
A6, B6, C6	GSMOUT	GSM PA Output. Open-collector output of GSM power amplifier. Connect together, DC-bias with an RF choke, and reactively tune to 50Ω.
B1	GSMIN	GSM PA Input. AC-couple to this bump.
B2	GSMGC	GSM Gain Control Input. Connect GSM gain control to this bump.
B3	GSMCAP	Bias Filter Capacitor
C2	V_{CC}	Power-Supply Connection. Decouple with 100pF capacitor to GND.
D1	DCSIN	DCS PA Input. AC-couple to this bump. Shunt capacitor is required for best match.
D2	DCSGC	DCS Gain Control Input. Connect DCS DC gain control to this bump. Decouple this signal with 100pF to GND near the IC for noise filtering.
D3	DCSCAP	Bias Filter Capacitor
D6, E6	DCSOUT	DCS PA Output. Open-Collector output of DCS power amplifier. Connect together, and DC-bias with an RF choke, and reactively tune to 50Ω.

There are no solder bumps located at the following positions: B4, C1, C4, D4.

Detailed Description

The MAX2216 offers two fully independent three-stage power amplifiers (PAs), one for the GSM band and one for the DCS/PCS band, integrated into a tiny 5 × 6 chip-scale package. This dual PA is perfect for tri-band GSM/DCS/PCS, dual-band GSM/DCS, single-band PCS handsets, and US GSM/PCS handsets. The PAs are fully characterized over the 880MHz to 915MHz European GSM band, the 1710MHz to 1785MHz European DCS band, and the 1850MHz to 1910MHz US PCS band (contact Factory for PCS characterization data). The MAX2216 operates from a single +2.5V to +5.5V supply, allowing for single-cell Li+ or three-cell NiCd/NiMH battery operation.

GSM Power Amplifier

The GSM band PA is optimized for operation in the 880MHz to 915MHz European GSM band. The amplifier requires an output-matching circuit (see *Applications Information* section). A gain-control input (GSMGC) offers analog control of output power, providing more than 40dB dynamic range. The PA enters a low-power shutdown when V_{GSMGC} < 0.4V. Guaranteed output power is +34.5dBm from a +3.2V supply.

DCS/PCS Power Amplifier

The DCS/PCS band PA is optimized for operation in the 1710MHz to 1785MHz European DCS band and the 1850MHz to 1910MHz US PCS band. The amplifier requires input and output matching circuits (see *Applications Information* section). A gain-control input (DCSGC) offers analog control of output power, providing more than 40dB dynamic range. The PA enters a low-power shutdown when V_{GC} < 0.4V. Maximum output power is +32dBm from a +3.2V supply.

Applications Information

Optimizing the Output Match

For best results, base the new design on the MAX2216 EV kit layout and component values. Use Table 1 for modeling output-match design. Further adjustment will be necessary to optimize output power and efficiency.

Optimizing the Input Match

The GSM input is adequately matched to 50Ω, and requires no matching. A good match for the DCS input is achieved with a single shunt capacitor placed on a 50Ω line (see MAX2216 EV kit). An external shunt resistor to ground at GSMIN is intended to help flatten the gain-control slope. It affects the input match minimally, so its position is at the circuit designer's discretion.

Table 1. Required Load Impedance as Seen From Output

GSM	1.8 + j 0.3
DCS	2.7 - j 1.0
PCS	2.7 - j 1.2

Tuning the First- and Second-Stage Amplifiers

Supply bumps A2 and A4 feed the collectors of the first- and second-stage amplifiers, respectively, for the GSM PA. Likewise, supply bumps E2 and E4 feed the first- and second-stage amplifiers for the DCS/PCS PA. The PC board trace together with a properly placed decoupling capacitor creates the proper matching impedance required at these pins. Additional decoupling capacitors may be required for long supply lines.

Multislot Operation

Thermal dissipation is the limiting factor when considering the maximum duty-cycle of the PA. Although the UCSP is very small, the fact that there are 26 solder connections to the PC board allows excellent thermal performance.

As measured on the MAX2216 EV kit, the thermal resistance of the IC (θ_{JC}) is 16°C/W, and the total thermal resistance from the IC to ambient (θ_{JA}) is 22°C/W. Therefore at +70°C, the IC can dissipate 3.6W with the IC's junction temperature below 150°C. These results will vary dependent upon PC board construction and ground plane layout.

Maximum PA power dissipation occurs under worst-case load mismatch conditions and maximum supply voltage. See "Maximum Operating V_{CC} Under Load Mismatch" in the *Electrical Characteristics* table.

Grounding

Proper grounding of the GND bumps is fundamental. For best results, ground bumps should use vias in pads. A separate via should be used for each ground bump, connecting to a shallow ground plane.

Pad Layout

The UCSP has a bump pitch of 0.5mm (19.7mil) and a bump diameter of 0.3mm (12mil). Therefore, lay out the solder pad spacing on 0.5mm (19.7mil) centers; use a pad size of 0.25mm (10mil); and a solder mask opening of 0.33mm (13mil). Round or square pads are permissible. Refer to the Maxim application note, "*Wafer Level Ultra-Chipscale Packaging*" for additional detailed information on UCSP layout and handling.

Prototype Chip Installation

Alignment keys on the PC board around the area where the chip is located will be helpful in the prototype assembly process. It is best to align the chip on the board before any other components are placed, and then place the board on a hotplate until the solder begins to flow. After about 20 seconds, carefully remove the board from the hotplate without disturbing the position of the IC, and let it cool down to room temperature before stuffing any more components.

To remove an IC, place the PC board on a hotplate preheated to about 300°C until the IC begins to reflow. Remove the IC so as not to disturb other components. Remove the PC board from the hotplate—do not attempt to solder a new IC yet. Allow the PC board to cool and, under a microscope, carefully clean the residual solder and flux away from the mounting pads. The MAX2216 EV kit has a few particularly narrow traces. When cleaning the mounting area, do not use excessive heat; in particular, the gain control traces can easily lift and be destroyed. Once the area is clean, repeat the steps above to reinstall the IC.

UCSP Reliability

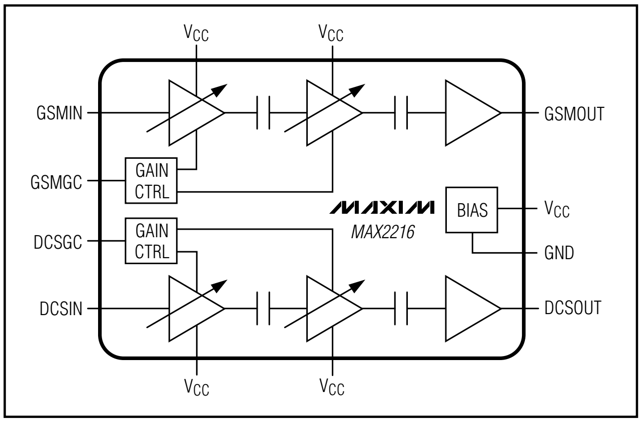
The UCSP represents a unique package that greatly reduces board space compared to other packages. UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and usage environment. The user should closely review these areas when considering use of a UCSP. This form factor may not perform equally to a packaged product through traditional mechanical reliability tests. Performance through operating life test and moisture resistance remains uncompromised as it is primarily determined by the wafer-fabrication process.

Mechanical stress performance is a greater consideration for a UCSP. UCSP solder-joint contact integrity must be considered since the package is attached through direct solder contact to the user's PC board. Testing done to characterize the UCSP reliability performance shows that it is capable of performing reliably through environmental stresses. Results of environmental stress tests and additional usage data and recommendations are detailed in the UCSP application note, "*Wafer-Level Chip-Scale Package*" on Maxim's website, *www.maxim-ic.com*.

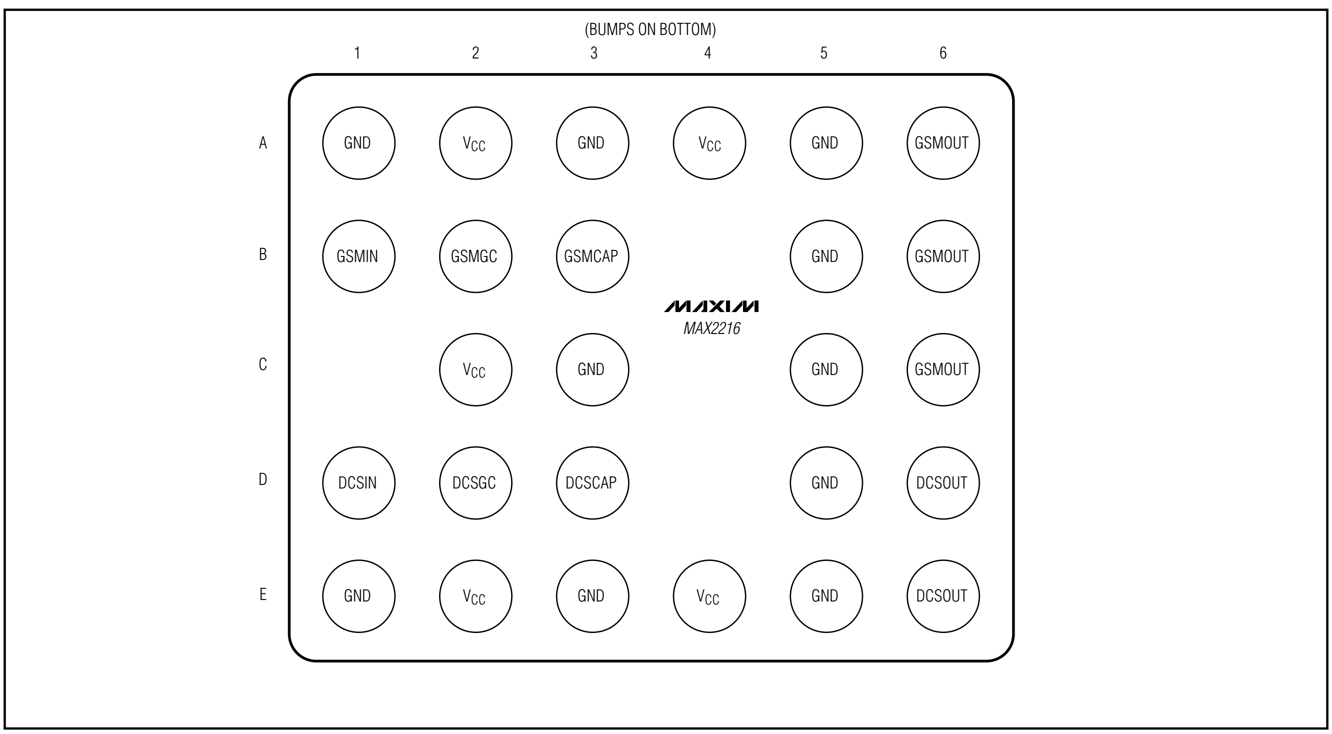
Chip Information

TRANSISTOR COUNT: 2302

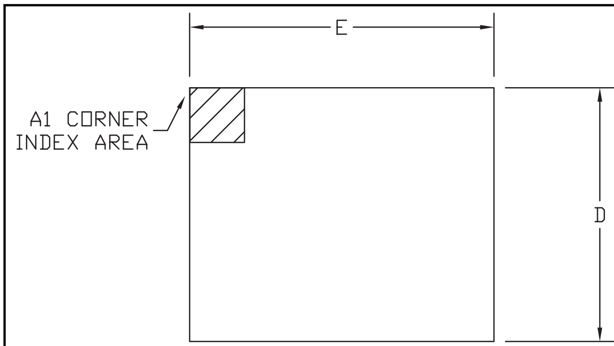
Functional Diagram



Pin Configuration

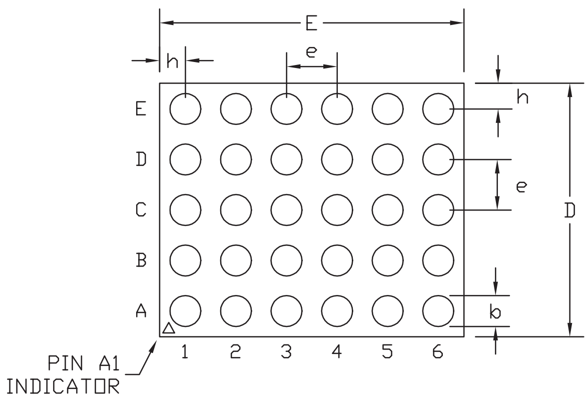


Package Information

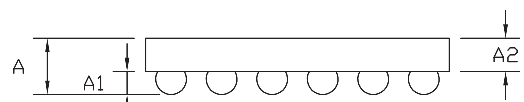


TOP VIEW

SYMBOL	DIMENSIONS
A	0.022 ±.002
D	0.0988 ±.002
E	0.1185 ±.002
e	0.0197 BASIC
b	ø 0.0120 BASIC
A1	0.009±.0015
A2	0.013 Ref.
h	0.010 Ref.



BOTTOM VIEW



SIDE VIEW

NOTES:
1. ALL DIMENSIONS ARE IN INCHES.
2. MEETS JEDEC M0195.

MAXIM
PROPRIETARY INFORMATION
TITLE:
PACKAGE OUTLINE, 30L UCSP, 6x5

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0123	A	1/1