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MAX1615EUK-T

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19-1225; Rev 3; 9/04

MAXIM

High-Voltage, Low-Power Linear Regulators for Notebook Computers
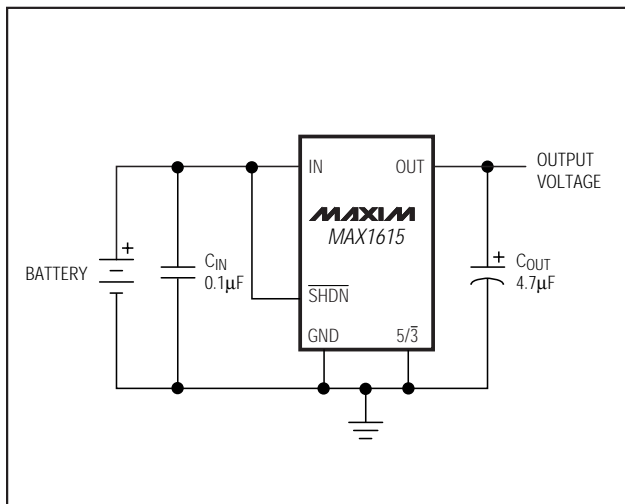
MAX1615/MAX1616

General Description

The MAX1615/MAX1616 are micropower, SOT23-5 linear regulators that supply always-on, keep-alive power to CMOS RAM and microcontrollers (μCs) in systems with high-voltage batteries. Key features include wide input voltage range, low dropout voltage, and low quiescent supply current.

Despite a miserly 8μA (max) no-load supply current, the MAX1615/MAX1616 have excellent line-transient response and AC power-supply rejection ratio. They provide a clean, fixed 5V or 3.3V output (MAX1615) or an adjustable 1.24V to 28V output (MAX1616), even when subjected to fast supply-voltage changes that occur during the switchover from battery to AC adapter input power. The space-saving SOT23-5 package has excellent thermal characteristics and tolerates up to 571mW of power dissipation. Fault protection is provided by internal foldback current limiting and thermal-shutdown circuitry. The MAX1615/MAX1616 are now available in lead-free packages.

Applications

CMOS/RTC Backup Power

Microcontroller Power

Notebook Computers

Smart-Battery Packs

PDAs and Handy-Terminals

Battery-Powered Systems

Features

♦ **4V to 28V Input Range**

♦ **8μA (max) Quiescent Supply Current**

♦ **<1μA Shutdown Supply Current**

♦ **3.3V or 5V, Pin-Selectable Output (MAX1615) Adjustable 1.24V to 28V Output (MAX1616)**

♦ **30mA Output Current**

♦ **±2% Initial Output Accuracy**

♦ **Thermal-Overload Protection**

♦ **5-Pin SOT23 Package**

♦ **Low Cost**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	SOT TOP MARK
MAX1615EUK-T	-40°C to +85°C	5 SOT23-5	ABZD
MAX1615EUK+T	-40°C to +85°C	5 SOT23-5	ABZD
MAX1616EUK-T	-40°C to +85°C	5 SOT23-5	ABZE
MAX1616EUK+T	-40°C to +85°C	5 SOT23-5	ABZE

+*Denotes lead-free package.*

Typical Operating Circuit

Pin Configuration
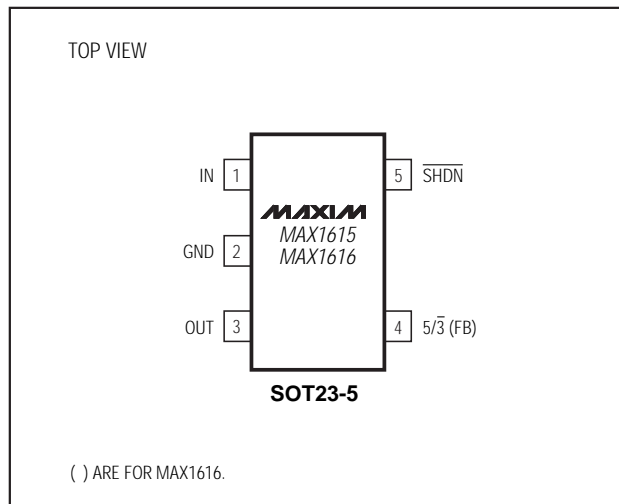
MAXIM _____ *Maxim Integrated Products* **1**

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.

High-Voltage, Low-Power Linear Regulators for Notebook Computers

MAX1615/MAX1616

ABSOLUTE MAXIMUM RATINGS

IN to GND ....-0.3V to 30V
Terminal Voltages to GND
 $\overline{\text{SHDN}}$ to GND...-0.3V to (V_{IN} + 0.3V)
 5/$\overline{3}$ to GND ....-0.3V to (V_{OUT} + 0.3V)
 FB (MAX1616) to GND ....-0.3V to (V_{OUT} + 0.3V)
 OUT to GND..-0.3V to 30V
 OUT Short-Circuit to GND 30sec

Continuous OUT Current...40mA
Continuous Power Dissipation (T_A = +70°C) (Note 1)
 SOT23-5 (derate 7.1mW/°C above +70°C)...................571mW
Operating Temperature Range
 MAX161_EUK-T ....-40°C to +85°C
Storage Temperature Range ....-65°C to +160°C
Lead Temperature (soldering, 10s) ....+300°C

Note 1: See *Operating Region and Power Dissipation* section.

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

(V_{IN} = 15V, $\overline{\text{SHDN}}$ = V_{IN}, I_{LOAD} = 5µA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}			4		28	V
Supply Current	I_{IN}	$\overline{\text{SHDN}}$ = IN, T_A = +25°C			6.2	8	µA
		$\overline{\text{SHDN}}$ = IN, V_{IN} = 6V to 28V, T_A = T_{MIN} to T_{MAX}				15	
Minimum Load Current						5	µA
Shutdown Supply Current	I_{IN}	$\overline{\text{SHDN}}$ = GND (shutdown mode)	T_A = +25°C			1.5	µA
			T_{MIN} = T_{MIN} to T_{MAX}			3	
Dropout Supply Current		Output set to 5V, V_{IN} = 4V	T_A = +25°C		70		µA
Output Voltage (MAX1615) (Note 3)		I_{LOAD} = 1mA, T_A = +25°C, V_{IN} = 6V to 28V	5/$\overline{3}$ = GND	3.26	3.33	3.40	V
			5/$\overline{3}$ = OUT	4.95	5.05	5.15	
		I_{LOAD} = 5µA to 30mA, T_A = T_{MIN} to T_{MAX}, V_{IN} = 6V to 28V	5/$\overline{3}$ = GND	3.15		3.48	
			5/$\overline{3}$ = OUT	4.75		5.25	
FB Threshold (MAX1616) (Note 3)	V_{FBT}	FB = OUT, V_{IN} = 6V to 28V	T_A = +25°C, I_{LOAD} = 1mA	1.215	1.240	1.265	V
			T_A = T_{MIN} to T_{MAX}, I_{LOAD} = 5µA to 30mA	1.18		1.28	
FB Input Current (MAX1616)	I_{FB}	V_{FB} = 1.3V		-10	12	30	nA
Dropout Voltage	ΔV_{DO}	I_{LOAD} = 30mA (Note 4)				350	mV
Output Current Limit		V_{IN} = 6V			100		mA
OUT Reverse Leakage Current		IN = unconnected, V_{OUT} forced to 5V			70		µA
Capacitive Load Requirements (Note 5)		MAX1615		0.16			µF/mA
		MAX1616		0.23			
Start-Up Time Response		Rising edge of IN or $\overline{\text{SHDN}}$ to OUT within specification limits, R_L = 500Ω, C_{OUT} = 6.8µF, V_{OUT} set to 5V				1	ms
Start-Up Overshoot	V_{OSH}	R_L = 500Ω, C_{OUT} = 10µF within 90% of nominal output voltage			0.5		%V_{OUT}

MAXIM

High-Voltage, Low-Power Linear Regulators
for Notebook Computers

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = 15V, $\overline{SHDN}$ = V_{IN}, I_{LOAD} = 5µA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
$\overline{SHDN}$ Input Threshold Voltage	V_{IL}				0.25	V
	V_{IH}		1.4			
$\overline{SHDN}$ Input Current		V $\overline{SHDN}$ = 0V or 15V	-1		1	µA
Thermal-Shutdown Temperature	T_{SHDN}	V $\overline{SHDN}$ = 0V or 15V, hysteresis = +20°C		150		°C

Note 2: Limits are 100% production tested at T_A = +25°C. Limits over the operating temperature range are guaranteed through correlation using standard quality-control (SQC) methods.
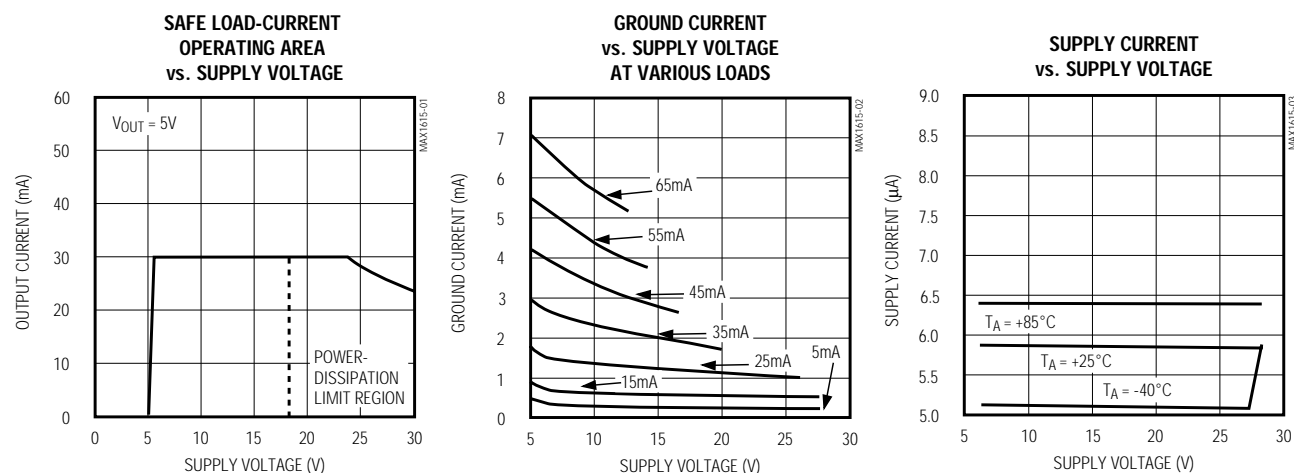
Note 3: Pulse tested at V_{IN} = 28V, I_{LOAD} = 30mA to avoid exceeding package power-dissipation limits.

Note 4: Guaranteed by design. Tested with V_{OUT} set to 5V. Dropout voltage is tested by reducing the input voltage until V_{OUT} drops to 100mV below its nominal value, measured with V_{IN} starting 2V above V_{OUT}.

Note 5: Use at least 1µF minimum for light loads. Add 0.125µF/mA (0.2µF/mA for the MAX1616) for loads greater than 100µA, not production tested. See *Capacitor Selection* in the *Applications Information* section.
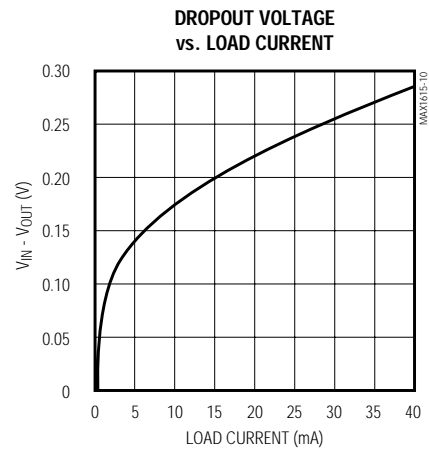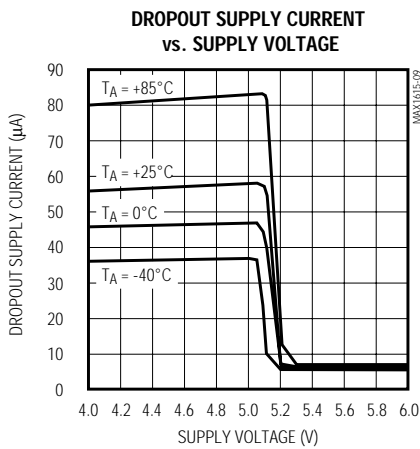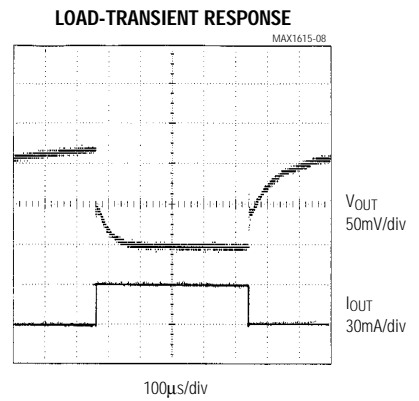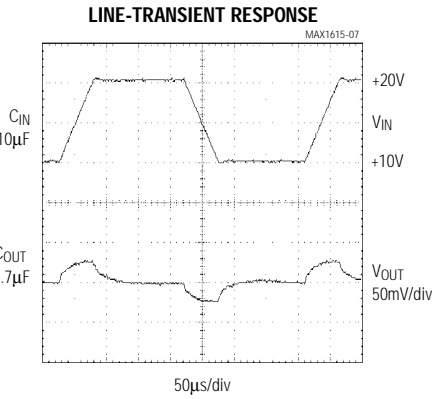
_____*Typical Operating Characteristics*

(V_{OUT} set to 5V, T_A = +25°C, unless otherwise noted.)

SAFE LOAD-CURRENT OPERATING AREA vs. SUPPLY VOLTAGE

GROUND CURRENT vs. SUPPLY VOLTAGE AT VARIOUS LOADS

SUPPLY CURRENT vs. SUPPLY VOLTAGE

High-Voltage, Low-Power Linear Regulators for Notebook Computers

MAX1615/MAX1616

_____Typical Operating Characteristics (continued)

(V_{OUT} set to 5V, T_A = +25°C, unless otherwise noted.)

SHUTDOWN SUPPLY CURRENT vs. SUPPLY VOLTAGE

RIPPLE REJECTION vs. FREQUENCY

TIME TO EXIT SHUTDOWN

LINE-TRANSIENT RESPONSE

LOAD-TRANSIENT RESPONSE

DROPOUT SUPPLY CURRENT vs. SUPPLY VOLTAGE

DROPOUT VOLTAGE vs. LOAD CURRENT

MAXIM
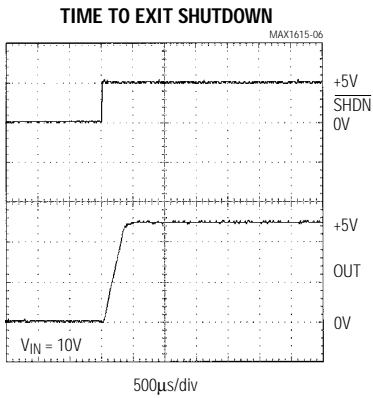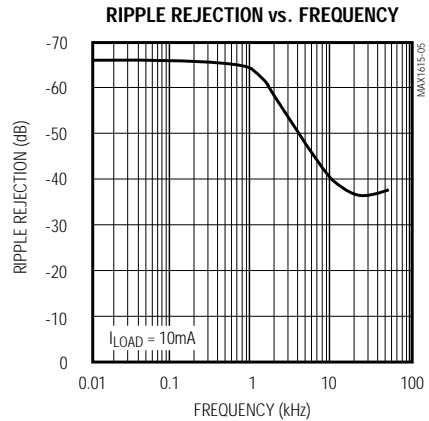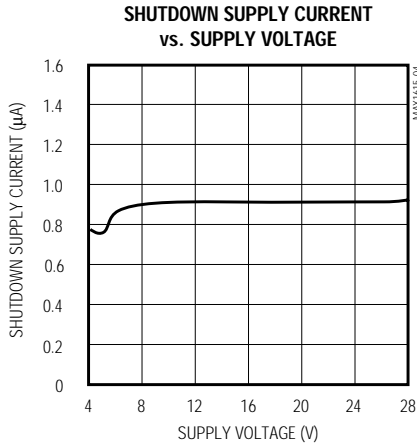
High-Voltage, Low-Power Linear Regulators for Notebook Computers

_____Pin Description

PIN		NAME	FUNCTION
MAX1615	MAX1616		
1	1	IN	Positive Input Voltage. Connect to a +4V to +28V supply.
2	2	GND	Ground
3	3	OUT	Regulator Output
4	—	5/$\overline{3}$	Preset Output Voltage Select. Connect to GND for 3.3V output or to OUT for 5.0V output.
—	4	FB	Feedback Input. Regulates to 1.24V nominally.
5	5	$\overline{SHDN}$	Shutdown, active low input. Connect to IN for automatic start up.

MAX1615/MAX1616

Figure 1. Functional Diagram

The MAX1615's output voltage is fed back through an internal resistor voltage divider connected to OUT. Set the output voltage to either 3.3V or 5.0V with the 5/$\overline{3}$ pin.

Select the 5V output by connecting 5/$\overline{3}$ to OUT, or the 3.3V output by connecting 5/$\overline{3}$ to GND.

The MAX1616 uses external feedback, allowing the output voltage to be set by external resistors (see *Setting the MAX1616 Output Voltage* section). The typical FB threshold is at 1.24V.

Shutdown
The device enters shutdown mode when $\overline{SHDN}$ is low. In shutdown mode, the pass transistor, control circuit, reference, and all biases turn off, reducing the supply current to below 1µA. Connect $\overline{SHDN}$ to IN for automatic start-up.

Current Limit
Output current is limited to 100mA (typical). The current limit exceeds the 30mA (max) safe operating limit. The output can be shorted to ground for 30 seconds without damaging the part.

Thermal-Overload Protection
When the junction temperature exceeds T_J = +150°C, the thermal sensor sends a signal to the shutdown logic, turning off the pass transistor and allowing the IC to cool. The thermal sensor turns the pass transistor on again after the IC's junction temperature cools by +20°C (typical), resulting in a pulsating output during continuous thermal-overload conditions.

Operating Region and Power Dissipation
Maximum power dissipation depends on the thermal resistance of the case and circuit board, the temperature difference between the die junction and ambient air, and the rate of air flow. The device's power dissipa-

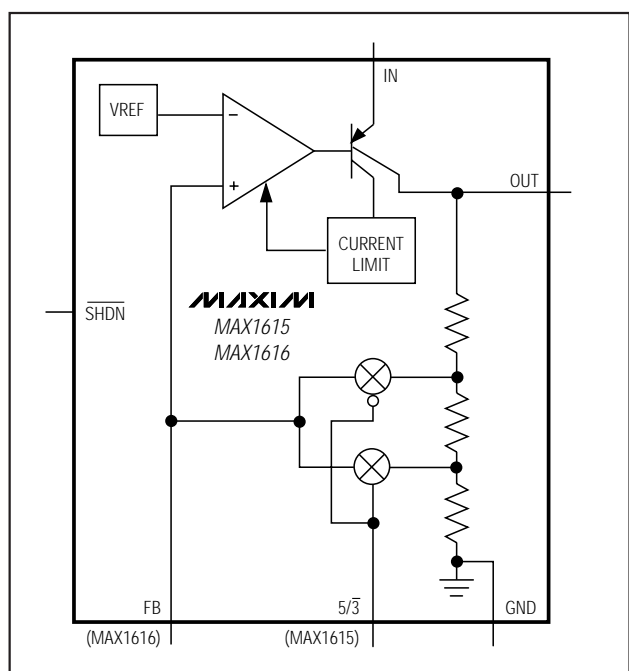_____Detailed Description

The MAX1615/MAX1616 low-quiescent-current linear regulators are designed primarily for high input voltage applications. The MAX1615 supplies a preselected 3.3V or 5.0V output for loads up to 30mA. The MAX1616 provides an adjustable voltage from 1.24V to 28V. The maximum output current is a function of the package's maximum power dissipation for a given temperature. A 5µA load is required to maintain output regulation.

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High-Voltage, Low-Power Linear Regulators for Notebook Computers

MAX1615/MAX1616

tion is $P = I_{OUT} (V_{IN} - V_{OUT})$. The power dissipation at +70°C ambient is 571mW (see *Absolute Maximum Ratings*). The thermal resistance junction-to-case of the SOT23-5 package is 81°C/W, and the maximum safe junction temperature is +150°C.

The GND pin performs the dual function of providing an electrical connection to ground and channeling heat away. Connect GND to ground using a large pad or ground plane.

_____Applications Information

Setting the MAX1616 Output Voltage
Set the MAX1616's output voltage with two resistors, R1 and R2 (Figure 2). Choose R2 = 250kΩ to maintain a 5µA minimum load and calculate R1 using the following equation:

$$R1 = R2 \left(\frac{V_{OUT}}{V_{FBT}} - 1 \right)$$

where $V_{FBT} = 1.24V$ (typical).

Capacitor Selection
Use a 0.1µF minimum capacitor on the input. Higher values will improve line-transient response.

Use 1µF minimum on the output, or 4.7µF for the full 30mA load current (6.8µF, MAX1616). Otherwise, use 1µF plus 0.125µF/mA (0.2µF/µA, MAX1616). For output voltages less than 3.3V, use 15µF instead of 6.8µF. The output capacitor's effective series resistance (ESR) must be less than 1Ω for stable operation.

Output Voltage Noise
The MAX1615/MAX1616 typically exhibit 5mVp-p of noise during normal operation. This is negligible in most applications. In applications that include analog-to-digital converters (ADCs) of more than 12 bits, consider the ADC's power-supply-rejection specifications.

Transient Response
The *Typical Operating Characteristics* show the MAX1615/MAX1616's load-transient response. Two of the output response's components can be observed on the load-transient graph: a DC shift from the output impedance due to the different load currents, and the transient response. Typical step changes in the load current from 10mA to 20mA produce 50mV transients. Increasing the output capacitor's value attenuates transient spikes.
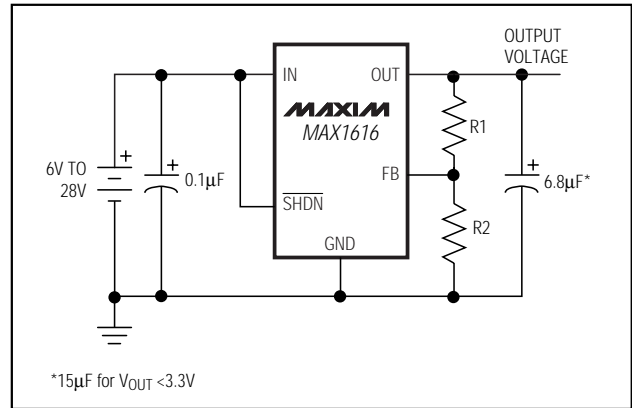
Figure 2. MAX1616 Typical Application Circuit

Table 1. Surface-Mount Capacitor Manufacturers

TYPE	MANUFACTURER	CAPACITOR
Electrolytic	AVX	TPS series
	Matsuo	267 series
	Sprague	593D, 595 series
Ceramic	AVX	X7R
	Matsuo	X7R

Table 2. Component Suppliers

SUPPLIER	PHONE	FAX
AVX	(803) 946-0690	(803) 626-3123
Matsuo	(714) 969-2491	(714) 960-6492
Sprague	(603) 224-1961	(603) 224-1430

_____Chip Information

TRANSISTOR COUNT: 386

High-Voltage, Low-Power Linear Regulators
for Notebook Computers

_____*Tape-and-Reel Information*

MAX1615/MAX1616

NOTE: DIMENSIONS ARE IN MM.
AND FOLLOW EIA481-1 STANDARD.

A_0	3.200	±0.102
B_0	3.099	±0.102
D	1.499	+0.102 +0.000
D_1	0.991	+0.254 +0.000

E	1.753	±0.102
F	3.505	±0.051
K_0	1.397	±0.102
P	3.988	±0.102

P_0	3.988	±0.102
$P_0$10	40.005	±0.203
P_2	2.007	±0.051
t	0.254	±0.127
W	8.001	+0.305 -0.102

5 SOT23-5

MAXIM _____ **7**

High-Voltage, Low-Power Linear Regulators for Notebook Computers

MAX1615/MAX1616
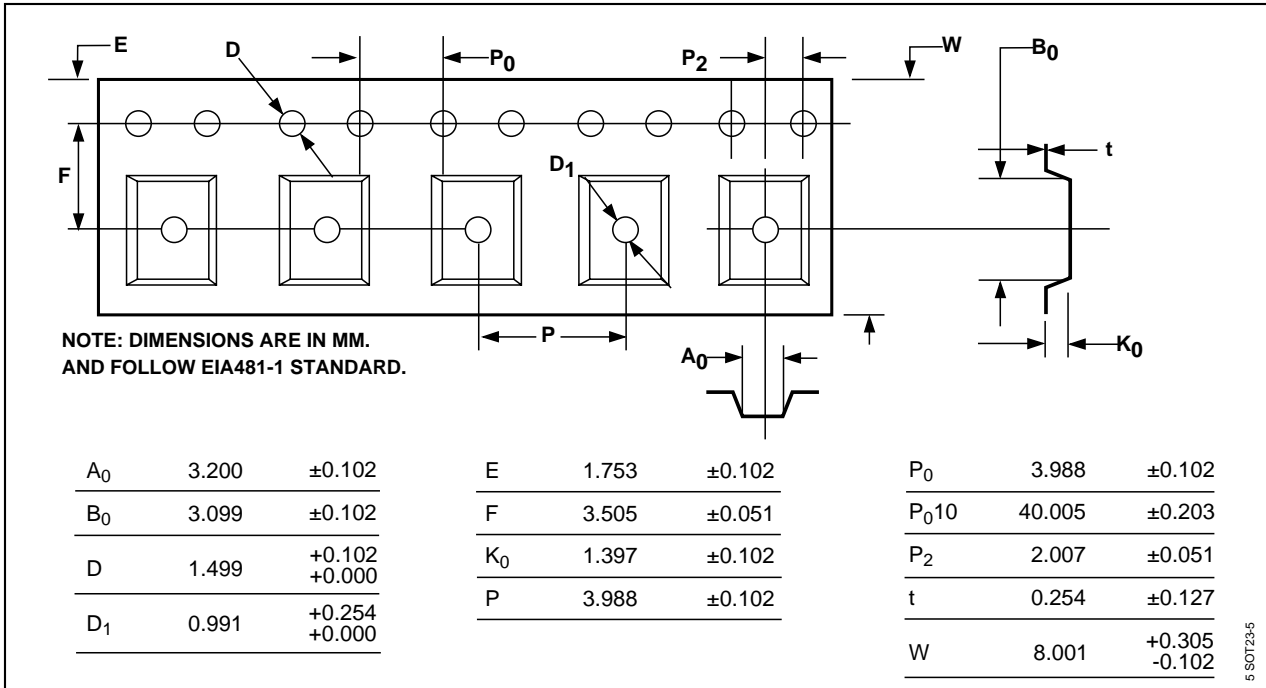
Package Information

(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**.)

SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.35	0.50
C	0.08	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.35	0.60
L1	0.60	REF
e	0.95	BSC.
e1	1.90	BSC.
α	0°	8°

SOT-23 5L.EPS

TOP VIEW

SIDE VIEW

FRONT VIEW

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25 MM.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. MEETS JEDEC MO178, VARIATION AA.
6. LEADS TO BE COPLANAR WITHIN 0.10 mm.
7. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.

DALLAS SEMICONDUCTOR /VI/IXI/VI

PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, SOT-23, 5L

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0057	E	1/1