19-1225; Rev 1; 10/97

MAXIM

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

General Description

The MAX1615 is a micropower, SOT23-5 linear regulator that supplies 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 its miserly 8µA (max) no-load supply current, the MAX1615 has excellent line-transient response and AC PSRR. It provides a clean, fixed 5V or 3.3V output, 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.

Features

- **Low Cost**
- **4V to 28V Input Range**
- **8µA (max) Quiescent Supply Current**
- **<1µA Shutdown Supply Current**
- **3.3V or 5V, Pin-Selectable Output**
- **30mA Output Current**
- **±2% Initial Output Accuracy**
- **Thermal-Overload Protection**
- **5-Pin SOT23 Package**

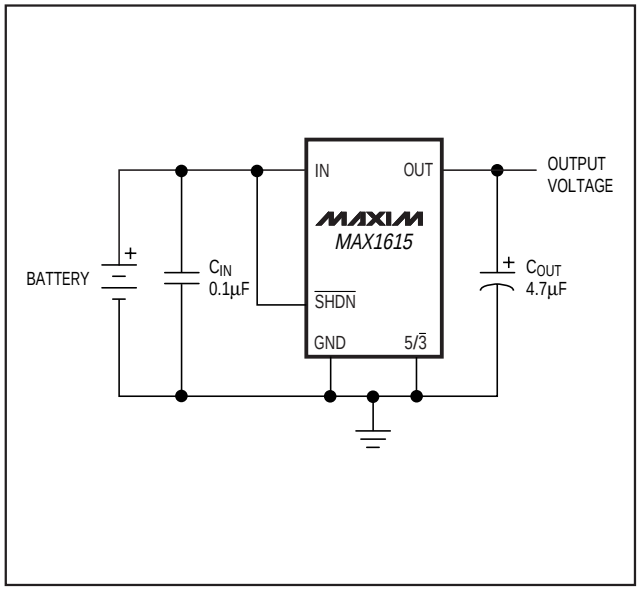
Applications

CMOS/RTC Backup Power
Microcontroller Power
Notebook Computers
Smart-Battery Packs
PDAs and Handy-Terminals
Battery-Powered Systems

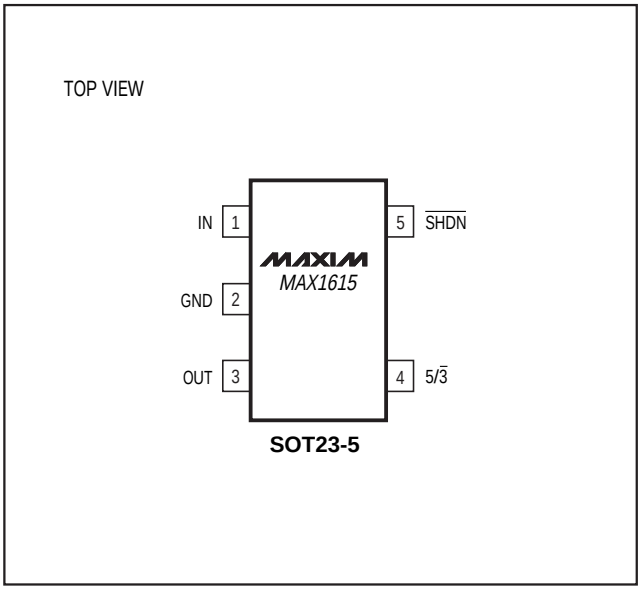
Ordering Information

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

Typical Operating Circuit



Pin Configuration



SOT23-5

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

ABSOLUTE MAXIMUM RATINGS

IN to GND .....-0.3V to 30V
Terminal Voltages to GND
  $\overline{SHDN}$ to GND.....-0.3V to (V_{IN} + 0.3V)
  5/$\overline{3}$ 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
  MAX1615EUK-T .....-40°C to +85°C
Storage Temperature Range .....-65°C to +160°C
Lead Temperature (soldering, 10sec) .....+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, $\overline{SHDN}$ = 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}	$\overline{SHDN}$ = IN, T_A = +25°C			6.2	8	µA
		$\overline{SHDN}$ = IN, V_{IN} = 6V to 28V, T_A = T_{MIN} to T_{MAX}				15	
Minimum Load Current						5	µA
Shutdown Supply Current	I_{IN}	$\overline{SHDN}$ = GND (shutdown mode)	T_A = +25°C			1.5	µA
			T_{MIN} = T_{MIN} to T_{MAX}			3	
Dropout Supply Current		3/$\overline{5}$ = OUT, V_{IN} = 4V	T_A = +25°C		55		µA
Output Voltage (Note 3)		V_{IN} = 6V to 28V, 5/$\overline{3}$ = GND, I_{LOAD} = 1mA, T_A = +25°C		3.26	3.33	3.40	V
		V_{IN} = 6V to 28V, 5/$\overline{3}$ = GND, I_{LOAD} = 5µA to 30mA, T_A = T_{MIN} to T_{MAX}		3.15		3.48	
		V_{IN} = 6V to 28V, 5/$\overline{3}$ = OUT, I_{LOAD} = 1mA, T_A = +25°C		4.95	5.05	5.15	
		V_{IN} = 6V to 28V, 5/$\overline{3}$ = OUT, I_{LOAD} = 5µA to 30mA, T_A = T_{MIN} to T_{MAX}		4.75		5.25	
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			55		µA
Capacitive Load Requirements		(Notes 5, 6)		0.16			µF/mA
Start-Up Time Response		Rising edge of IN or $\overline{SHDN}$ to OUT within specification limits, R_L = 500Ω, C_{OUT} = 4.7µF, 5/$\overline{3}$ = IN				1	ms
Start-Up Overshoot	V_{OSH}	R_L = 500Ω, C_{OUT} = 10µF within 90% of nominal output voltage			0.5		$\%V_{OUT}$
$\overline{SHDN}$ Input Threshold Voltage	V_{IL}					0.25	V
	V_{IH}			1.4			
$\overline{SHDN}$ Input Current		$V_{\overline{SHDN}}$ = 0V or 15V		-1	0.1	1	µA

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)

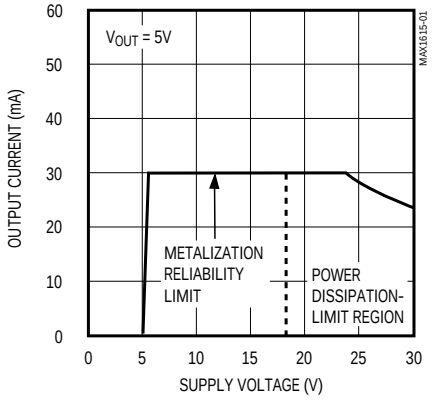
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Thermal-Shutdown Temperature	T_{SHDN}	$V_{\overline{SHDN}}$ = 0V or 15V		150		°C
Thermal-Shutdown Hysteresis	$\Delta T_{\overline{SHDN}}$	$V_{\overline{SHDN}}$ = 0V or 15V		20		°C

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 5/$\overline{3}$ = OUT. 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 for loads greater than 100µA.
Note 6: Guaranteed by design.

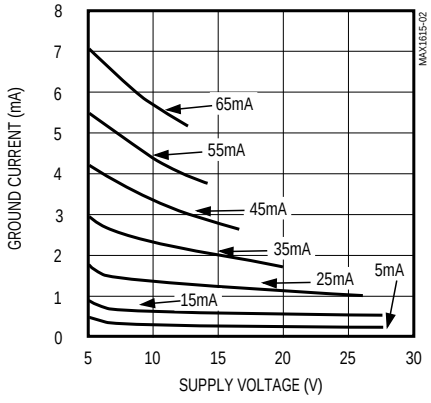
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

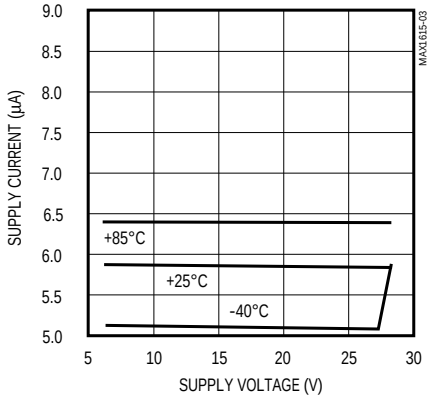
SAFE LOAD-CURRENT OPERATING AREA vs. SUPPLY VOLTAGE



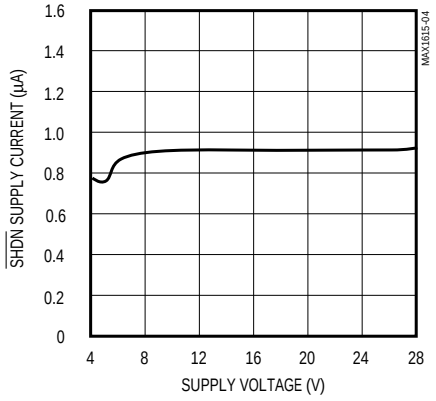
GROUND CURRENT vs. SUPPLY VOLTAGE AT VARIOUS LOADS



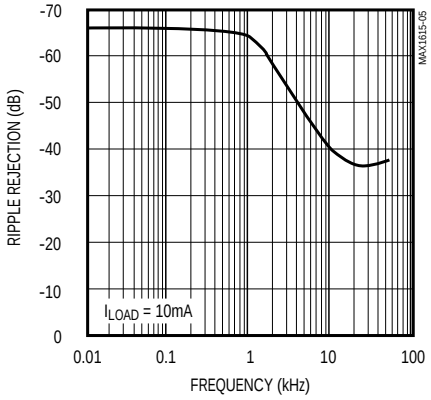
SUPPLY CURRENT vs. SUPPLY VOLTAGE



SHUTDOWN SUPPLY CURRENT vs. SUPPLY VOLTAGE



RIPPLE REJECTION vs. FREQUENCY

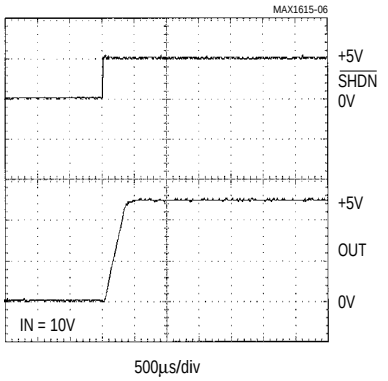


High-Voltage, Low-Power Linear Regulator for Notebook Computers

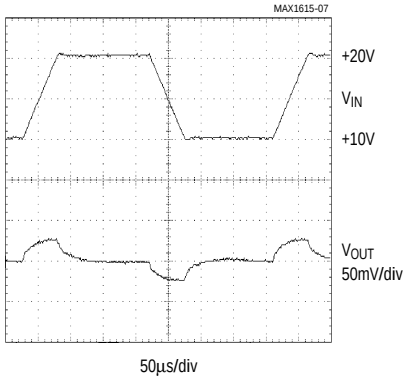
Typical Operating Characteristics (continued)

(T_A = +25°C, unless otherwise noted.)

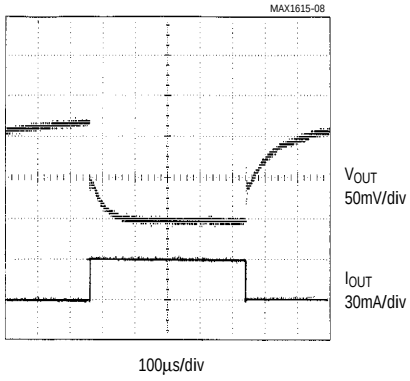
TIME TO EXIT SHUTDOWN



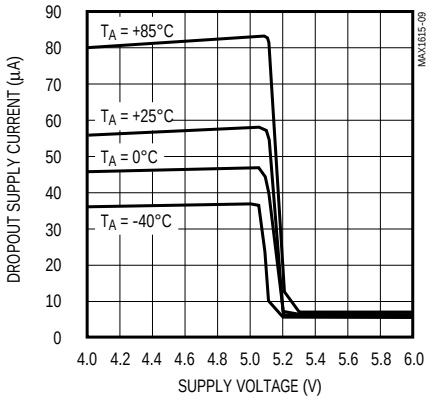
LINE-TRANSIENT RESPONSE



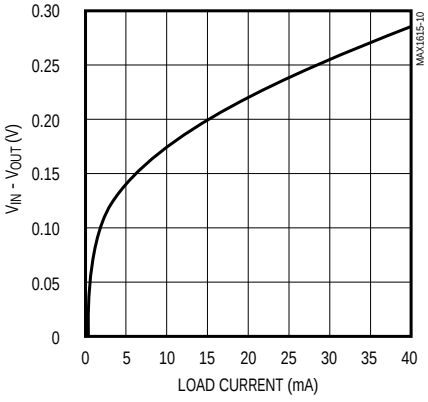
LOAD-TRANSIENT RESPONSE



DROPOUT SUPPLY CURRENT vs. SUPPLY VOLTAGE



DROPOUT VOLTAGE vs. LOAD CURRENT



Pin Description

PIN	NAME	FUNCTION
1	IN	Positive Input Voltage. Connect to a +4V to +28V supply.
2	GND	Ground
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.
5	$\overline{SHDN}$	Shutdown, active low input. Connect to IN if unused.

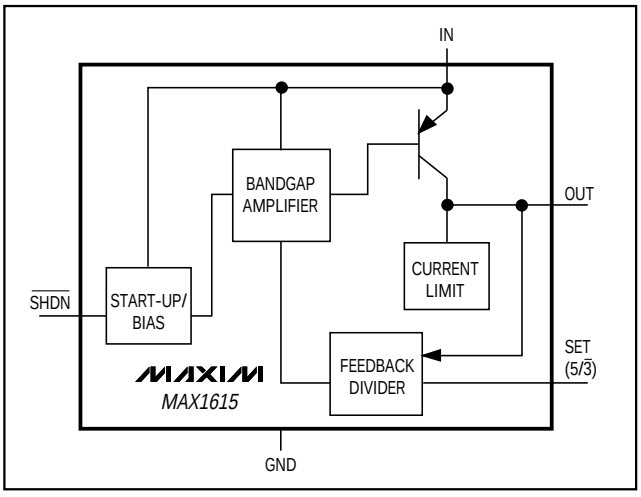


Figure 1. Block Diagram

Detailed Description

The MAX1615 low-quiescent-current linear regulator is designed primarily for high input voltage applications. It supplies a preselected 3.3V or 5.0V output for loads up to 30mA. 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.

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

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 normal operation.

Current Limit

The MAX1615 includes a current limiter that monitors and controls the pass transistor's gate voltage, estimating the output current and typically limiting it to 100mA. The current limit exceeds the 30mA (max) safe operating limit. A repetitive short-circuit condition results in reduced reliability due to electron-metal migration. The output can be shorted to ground for 30 seconds without damaging the part.

Thermal-Overload Protection

Thermal-overload protection limits total power dissipation in the MAX1615. 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 (typ), resulting in a pulsating output during continuous thermal-overload conditions.

Thermal-overload protection is designed to protect the MAX1615 in the event of fault conditions. Stressing the device with high-load currents and high input-output differential voltages (which result in die temperatures above +125°C) can cause a momentary overshoot (2% to 8% for 200ms) when the load is completely removed. Minimize this overshoot by raising the minimum load current from 5µA to 100µA. For continuous operation, do not exceed the absolute maximum junction-temperature rating of T_j = +150°C.

Operating Region and Power Dissipation

The MAX1615 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 dissipation 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 the GND pin to ground using a large pad or ground plane.

Applications Information

Capacitor Selection

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

Use 1.0µF minimum on the output, or 4.7µF for the full 30mA load current. Otherwise, use 1µF plus 0.125µF/mA. The output capacitor effective series resistance (ESR) must be less than 1Ω for stable operation.

Noise

The MAX1615 typically exhibits 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 Conditions

The *Typical Operating Characteristics* show the MAX1615'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.

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

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

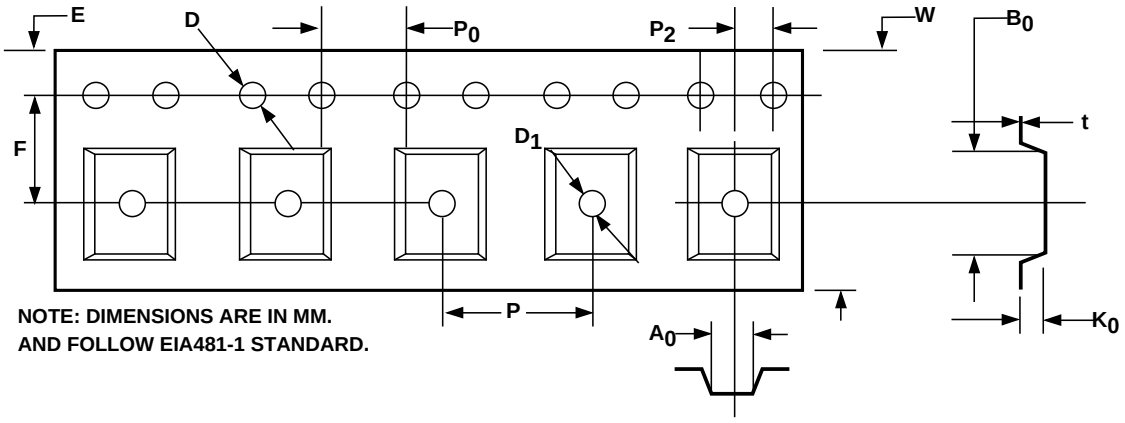
Table 2. Component Suppliers

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

Tape-and-Reel Information



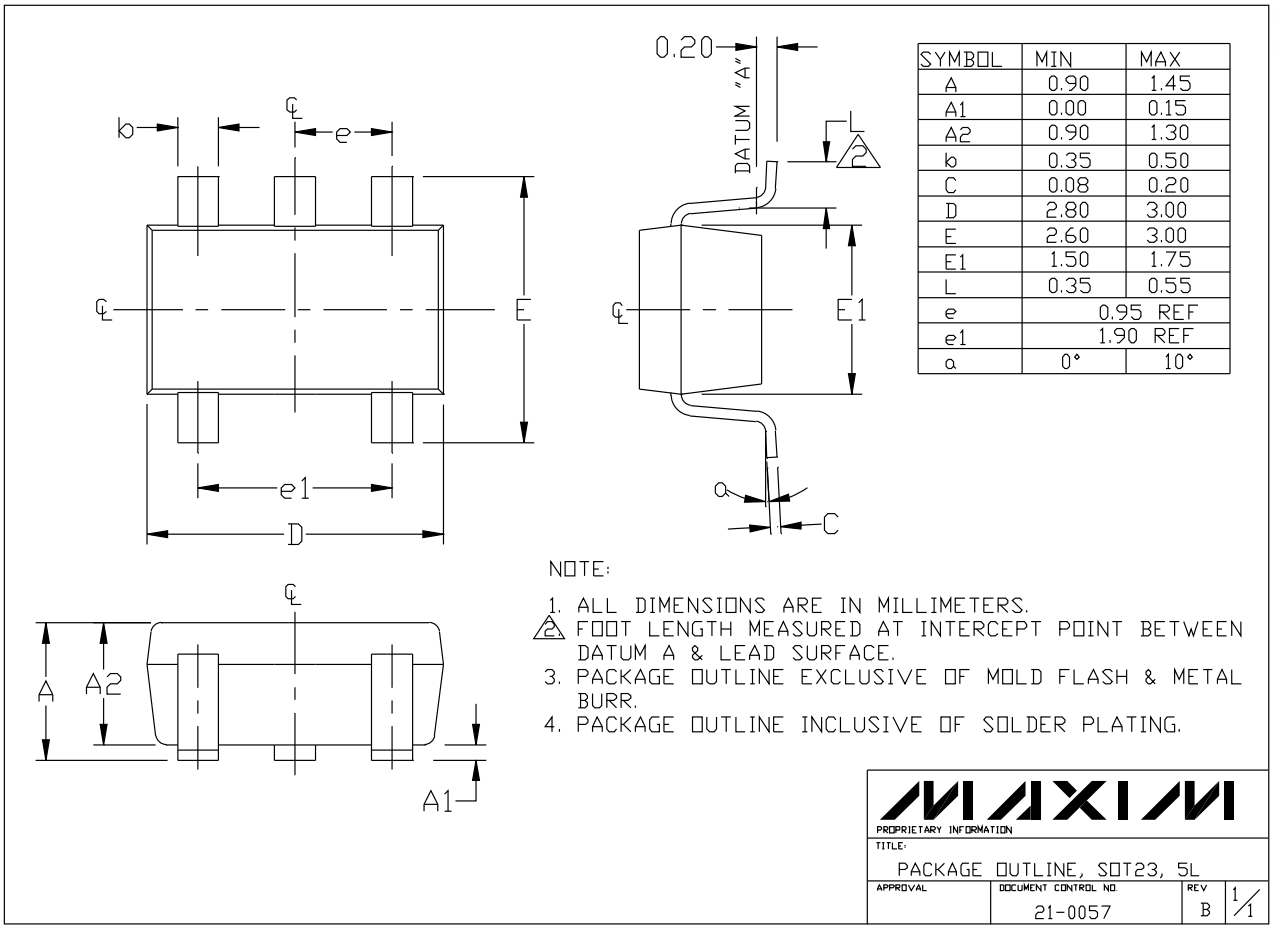
A_0	3.200	±0.102
B_0	3.099	±0.102
D	1.499	+0.102 +0.000
D_1	0.991	+0.254 +0.000

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

Package Information



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	0.55
e	0.95 REF	
e1	1.90 REF	
a	0°	10°

NOTE:

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.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.

MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, SOT23, 5L

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

NOTES