19-2067; Rev 0; 7/01

Low-Dropout, Constant-Current Triple White LED Bias Supply

MAX1916

General Description

The MAX1916 low-dropout bias supply for white LEDs is a high-performance alternative to the simple ballast resistors used in conventional white LED designs. The MAX1916 uses a single resistor to set the bias current for three LEDs, which are matched to 0.3%. The MAX1916 consumes only 40μA of supply current when enabled and 0.05μA when disabled.

The MAX1916's advantages over ballast resistors include significantly better LED-to-LED bias matching, much lower bias variation with supply voltage variation, significantly lower dropout voltage, and in some applications, significantly improved efficiency. The MAX1916 requires a 200mV dropout at a 9mA load on each output to match the LED brightness.

The MAX1916 is available in a space-saving 6-pin Thin SOT23 package.

Features

- ♦ **Low 200mV Dropout at 9mA**
- ♦ **Up to 60mA/LED Bias Current**
- ♦ **0.3% LED Current Matching**
- ♦ **Simple LED Brightness Control**
- ♦ **Low 40μA Supply Current**
- ♦ **Low 0.05μA Shutdown Current**
- ♦ **2.5V to 5.5V Supply Voltage Range**
- ♦ **Thermal Shutdown Protection**
- ♦ **Tiny 6-Pin Thin SOT23 Package (1mm High)**

Applications

Next-Generation Wireless Handsets

PDAs, Palmtops, and Handy Terminals

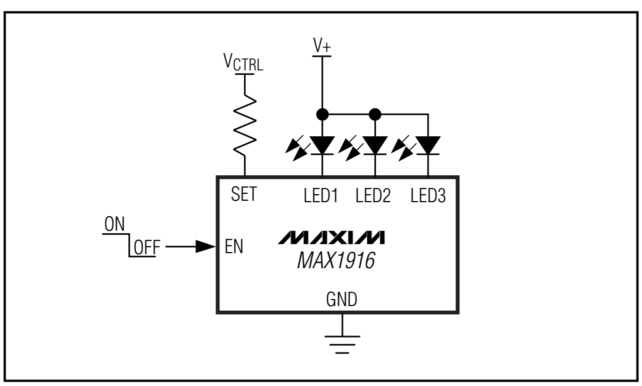
Digital Cameras, Camcorders

Battery-Powered Equipment

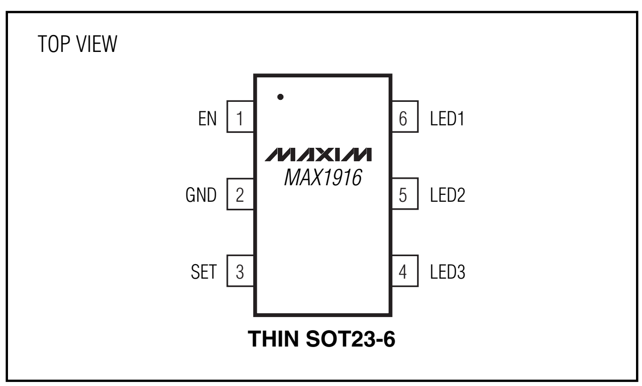
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	TOP MARK
MAX1916EZT	-40°C to +85°C	6 Thin SOT23	AAAG

Typical Operating Circuit



Pin Configuration



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ABSOLUTE MAXIMUM RATINGS

EN, SET, LED1, LED2, LED3 to GND .... -0.3V to +6V
Continuous Power Dissipation (T_A = +70°C)
6-Pin Thin SOT23 (derate 9.1mW/°C above +70°C) ... 727mW
Operating Temperature Range .... -40°C to +85°C
Storage Temperature Range .... -65°C to +150°C
Lead Temperature (soldering, 10s).................................. 300°C

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_{EN} = 3.3V, V_{LED1} = V_{LED2} = V_{LED3} = 1V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

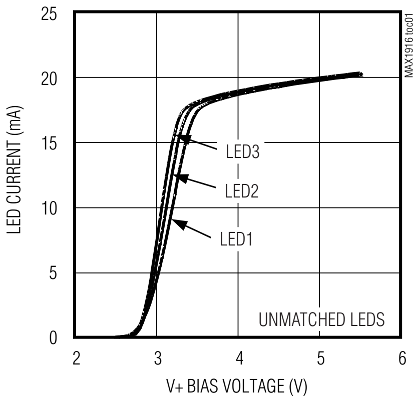
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Operating Voltage Range	V_{EN}	EN is the power-supply input		2.5		5.5	V
Undervoltage Lockout Threshold	V_{UVLO}	V_{EN} rising		2.2		2.47	V
		Hysteresis			85		mV
SET Input Current Range	I_{SET}			5		260	µA
SET to LED_ Current Ratio		I_{LED}/I_{SET}, I_{SET} = 42µA		207	230	253	A/A
SET Bias Voltage	V_{SET}	I_{SET} = 42µA		1.154	1.215	1.276	V
SET Leakage Current in Shutdown		EN = GND, V_{SET} = 3.3V	T_A = -40°C to +25°C		0.01	1	µA
			T_A = -40°C to +85°C			5	
LED_-to-LED_ Current Matching		I_{SET} = 42µA			0.3	5	%
Maximum LED_ Sink Current	$I_{LED\_}$	Each LED_		60			mA
LED_ Dropout Voltage		I_{SET} = 22µA (Note 2)			100	180	mV
		I_{SET} = 42µA (Note 3)			200	360	
		I_{SET} = 84µA (Note 3)			230	410	
LED_ Leakage Current in Shutdown		V_{LED1} = V_{LED2} = V_{LED3} = 5.5V, EN = GND, each LED_	T_A = +25°C		0.01	1	µA
Input High Voltage	V_{IH}	V_{EN} > V_{IH} for enable		2.5			V
Input Low Voltage	V_{IL}	V_{EN} < V_{IL} for disable				2.2	
EN Input Bias Current	I_{EN}	V_{EN} = 2.5V to 5.5V, EN is the power-supply input			40	100	µA
		V_{EN} = 0.4V	T_A = +25°C		0.05	1	
Thermal Shutdown Temperature					170		°C
Thermal Shutdown Hysteresis					10		°C

Note 1: Limits are 100% production tested at T_A = +25°C. Limits over the operating temperature range are guaranteed through correlation using statistical quality control (SQC) methods.
Note 2: Dropout Voltage is defined as the LED_ to GND voltage at which current sink into LED_ drops 20% from the value at V_{LED} = 1V.
Note 3: Dropout Voltage is defined as the LED_ to GND voltage at which current sink into LED_ drops 10% from the value at V_{LED} = 1V.

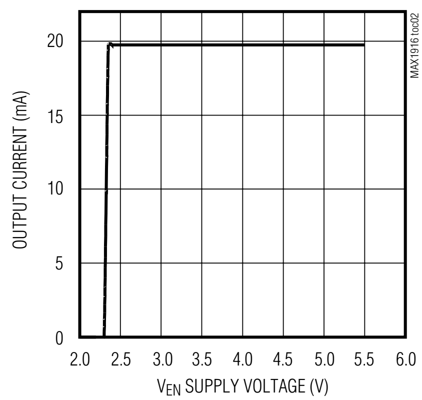
Typical Operating Characteristics

(V_{EN} = 3.3V, V_{CTRL} = 3.3V, R_{SET} = 24.9kΩ, V+ = 5V, T_A = +25°C, unless otherwise noted.) (Circuit of Figure 1)

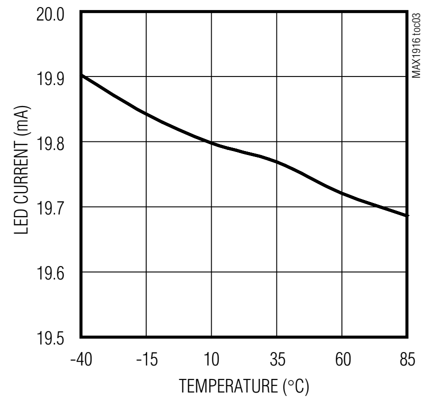
LED CURRENT vs. V+ BIAS VOLTAGE



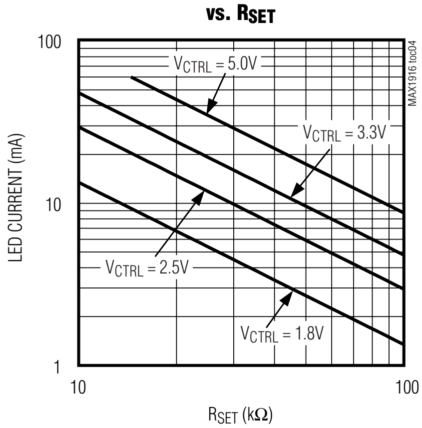
OUTPUT CURRENT vs. V_{EN} SUPPLY VOLTAGE



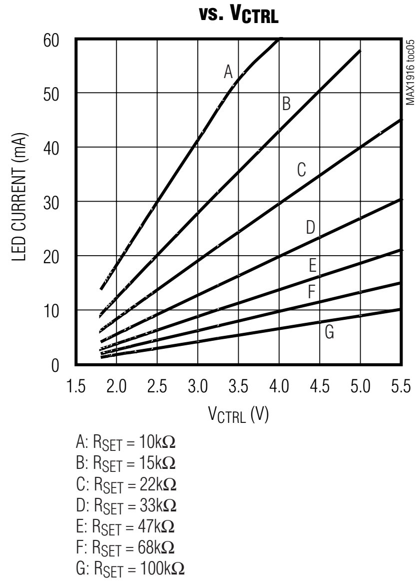
LED CURRENT vs. TEMPERATURE



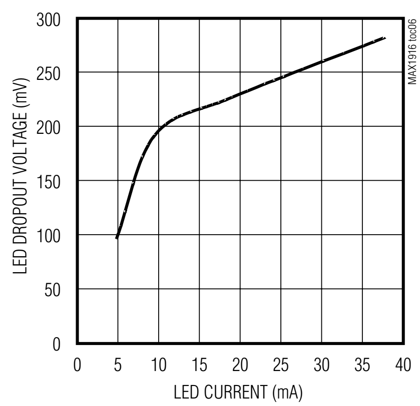
LED CURRENT vs. R_{SET}



LED CURRENT (I_{LED}) vs. V_{CTRL}



LED DROPOUT VOLTAGE vs. CURRENT

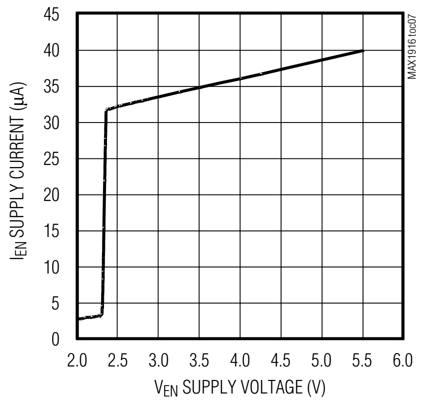


Low-Dropout, Constant-Current Triple White LED Bias Supply

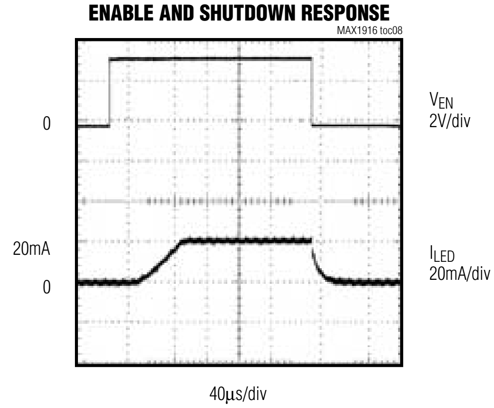
Typical Operating Characteristics (continued)

(V_{EN} = 3.3V, V_{CTRL} = 3.3V, R_{SET} = 24.9kΩ, V+ = 5V, T_A = +25°C, unless otherwise noted.) (Circuit of Figure 1)

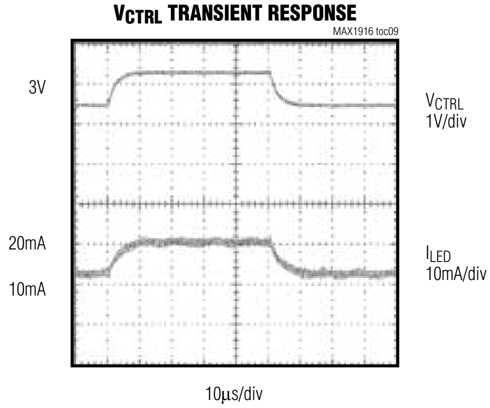
I_{EN} SUPPLY CURRENT vs. V_{EN} SUPPLY VOLTAGE



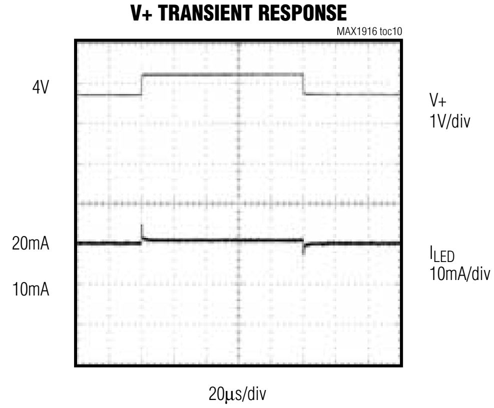
ENABLE AND SHUTDOWN RESPONSE



V_{CTRL} TRANSIENT RESPONSE



V+ TRANSIENT RESPONSE



Pin Description

PIN	NAME	FUNCTION
1	EN	Enable Input/Power Input. Drive high (> 2.5V) to enable; drive low (< 2.2V) to disable. When disabled, SET, LED1, LED2, and LED3 are high impedance. When enabled, EN is the power input for the MAX1916.
2	GND	Ground
3	SET	Bias Current Set Input. The current flowing into SET sets the bias current into each LED by $I_{LED\_} = 230 \times I_{SET}$. V_{SET} is internally biased to 1.215V. SET is high impedance when EN is low.
4	LED3	LED 3 Cathode Connection. Current flowing into LED3 is 230 times the current flowing into SET. LED3 is high impedance when EN is low.
5	LED2	LED 2 Cathode Connection. Current flowing into LED2 is 230 times the current flowing into SET. LED2 is high impedance when EN is low.
6	LED1	LED 1 Cathode Connection. Current flowing into LED1 is 230 times the current flowing into SET. LED1 is high impedance when EN is low.

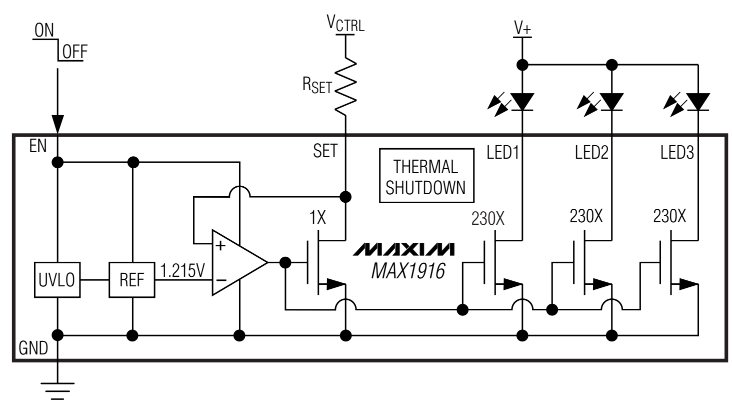


Figure 1. MAX1916 Simplified Functional Diagram

Detailed Description

The MAX1916 provides constant-current bias supply for white LED designs. The MAX1916 uses a single resistor to set the bias current for up to three LEDs. LED bias currents are matched to 0.3% by the MAX1916's unique current-matching architecture (Figure 1). Supply current (I_{EN}) is a low 40µA in normal operation and 0.05µA when disabled.

The MAX1916 offers several advantages over using ballast resistors, such as improved LED-to-LED brightness matching, lower bias variation with supply voltage changes, significantly lower dropout voltage, and in some applications, significantly improved efficiency.

The MAX1916 achieves a 200mV dropout with a 9mA load on each output.

For circuits requiring only one or two LEDs, leave unused LED outputs unconnected.

Enable Input

EN powers the input of the MAX1916. Drive EN high (> 2.5V) to enable the device; drive EN low (< 2.2V) to disable the device. When driven high, EN draws 40µA to power the IC. Driving EN low forces LED1, LED2, LED3, and SET into a high-impedance state.

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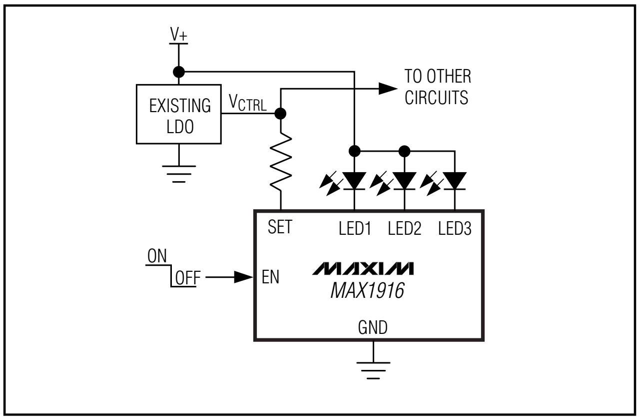


Figure 2. Very Low-Cost, High-Efficiency Solution

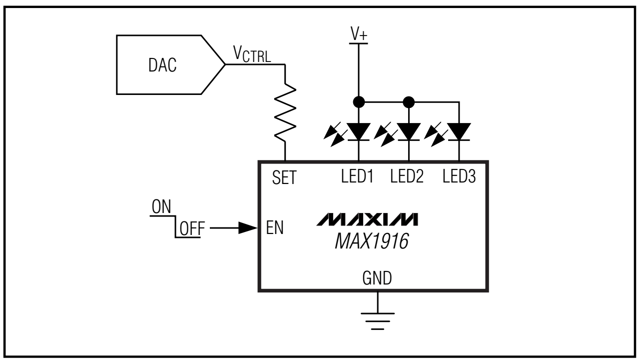


Figure 3. Brightness Adjust Using DAC

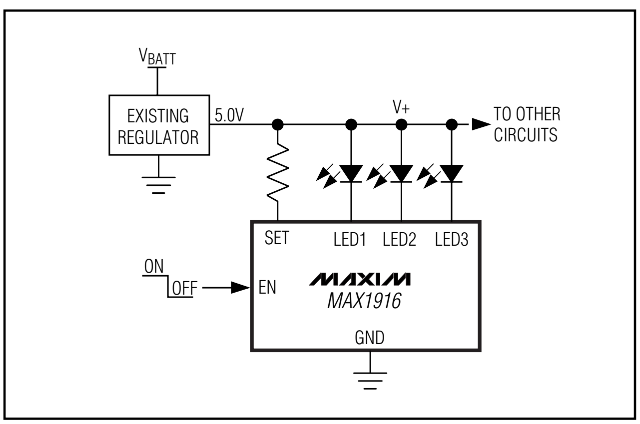


Figure 4. Existing 5V Supply Circuit

Setting the Output Current

SET controls the LED bias current. Current flowing into LED1, LED2, and LED3 is 230 times greater than the current flowing into SET. Set the output current as follows:

$$I_{LED\_} = 230 \frac{(V_{CTRL} - V_{SET})}{R_{SET}}$$

where V_{SET} = 1.215V, V_{CTRL} is an external voltage between 1.8V and 5.5V, and R_{SET} is the resistor connected between V_{CTRL} and SET (Figure 1).

Applications Information

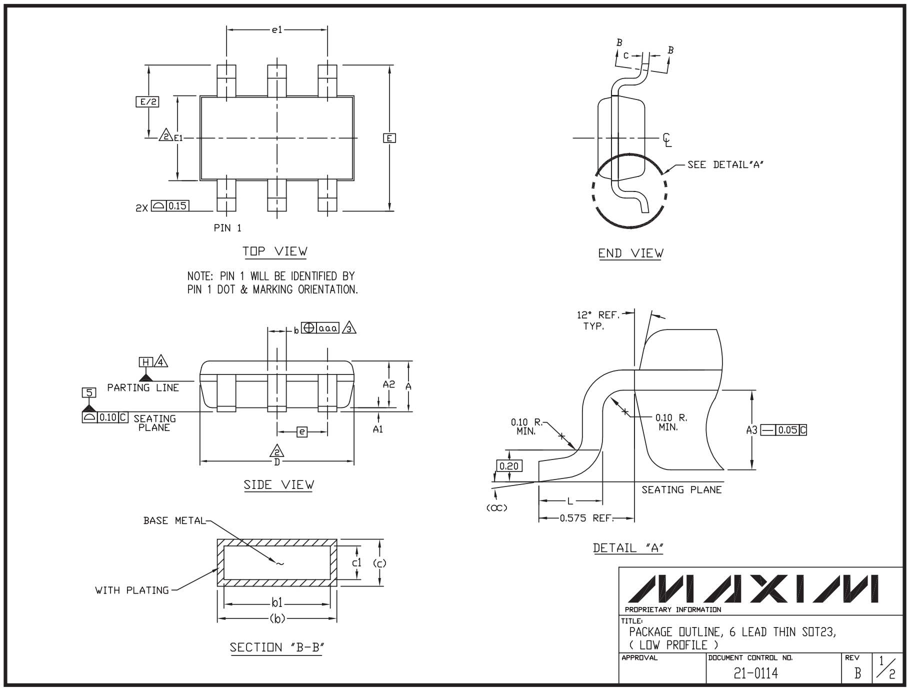
1) Very Low-Cost, High-Efficiency Solution (Figure 2). A battery (single Li+ or three NiMH cells) powers the LEDs directly. This is the least expensive and most efficient architecture. Due to the high forward voltage of white LEDs (3.3V), the LED brightness may dim slightly at the end of battery life. The MAX1916's current-regulating architecture and low dropout greatly minimize this effect compared to using simple ballast resistors. The enable function of the MAX1916 turns on and off the LEDs. An existing low-dropout regulator is used as V_{CTRL}.
2) Brightness Adjustment Using a DAC (Figure 3). A DAC is used as V_{CTRL} such that the LED brightness may be dynamically adjusted to eliminate factory calibration. A battery (single Li+ or three NiMH cells) or a regulated power source drives the LEDs.
3) Existing 5V Supply (Figure 4). Use an existing system regulator, such as the MAX684, to provide the required LED voltage and provide power to other circuits. Due to the high forward voltage of white LEDs (3.3V), use a 3.6V to 5.5V regulated supply to provide enough voltage headroom such that the LEDs will maintain constant brightness for any battery voltage. Use the existing regulated supply as V_{CTRL}.

Chip Information

TRANSISTOR COUNT: 220

PROCESS: BiCMOS

Package Information



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. "D" AND "E1" ARE REFERENCE DATUM AND DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS, AND ARE MEASURED AT THE BOTTOM PARTING LINE. MOLD FLASH OR PROTRUSION SHALL NOT EXCEED 0.15mm ON "D" AND 0.25mm ON "E" PER SIDE.
3. THE LEAD WIDTH DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.07mm TOTAL IN EXCESS OF THE LEAD WIDTH DIMENSION AT MAXIMUM MATERIAL CONDITION.
4. DATUM PLANE "H" LOCATED AT MOLD PARTING LINE AND COINCIDENT WITH LEAD, WHERE LEAD EXITS PLASTIC BODY AT THE BOTTOM OF PARTING LINE.
5. THE LEAD TIPS MUST LINE WITHIN A SPECIFIED TOLERANCE ZONE. THIS TOLERANCE ZONE IS DEFINED BY TWO PARALLEL LINES. ONE PLANE IS THE SEATING PLANE, DATUM [-C-]; AND THE OTHER PLANE IS AT THE SPECIFIED DISTANCE FROM [-C-] IN THE DIRECTION INDICATED. FORMED LEADS SHALL BE PLANAR WITH RESPECT TO ONE ANOTHER WITH 0.10mm AT SEATING PLANE.
6. THIS PART IS COMPLIANT WITH JEDEC SPECIFICATION MO-193 EXCEPT FOR THE "e" DIMENSION WHICH IS 0.95mm INSTEAD OF 1.00mm. THIS PART IS IN FULL COMPLIANCE TO EIAJ SPECIFICATION SC-74.

SYMBOLS			
	MIN	NOM	MAX
A	-	-	1.10
A1	0.05	0.075	0.10
A2	0.85	0.88	0.90
A3	0.50 BSC		
b	0.30	-	0.45
b1	0.25	0.35	0.40
c	0.15	-	0.20
c1	0.12	0.127	0.15
D	2.80	2.90	3.00
E	2.75 BSC		
E1	1.55	1.60	1.65
L	0.30	0.40	0.50
e1	1.90 BSC		
e	0.95 BSC		
α	0°	4°	8°
aaa	0.20		

MAXIM
PROPRIETARY INFORMATION
TITLE: PACKAGE OUTLINE, 6 LEAD THIN SOT23, (LOW PROFILE)
APPROVAL | DOCUMENT CONTROL NO. 21-0114 | REV B | 2/2