

### **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)

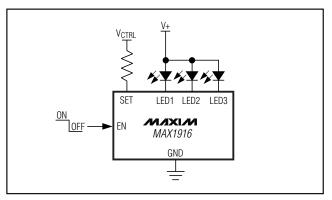
### **Applications**

**Next-Generation Wireless Handsets** PDAs, Palmtops, and Handy Terminals Digital Cameras, Camcorders Battery-Powered Equipment

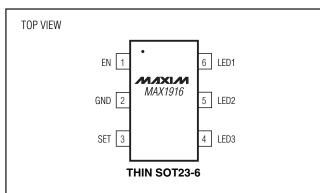
### **Ordering Information**

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

### **Typical Operating Circuit**



## **Pin Configuration**



### **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	C) 727mW

Operating Temperature Range	40°C to +85°C
Storage Temperature Range	65°C to +150°C
Lead Temperature (soldering, 1	0s) 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**

(VEN = 3.3V, VLED1 = VLED2 = VLED3 = 1V, TA = -40°C to +85°C, unless otherwise noted. Typical values are at TA = +25°C.) (Note 1)

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

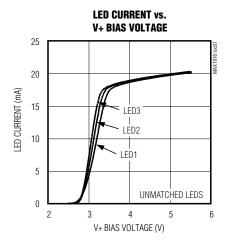
**Note 1:** Limits are 100% production tested at  $T_A = +25^{\circ}C$ . Limits over the operating temperature range are guaranteed through correlation using statistical quality control (SQC) methods.

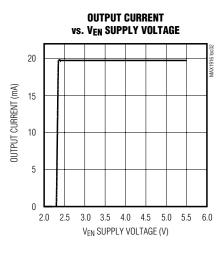
Note 2: Dropout Voltage is defined as the LED\_ to GND voltage at which current sink into LED\_ drops 20% from the value at VLED = 1V.

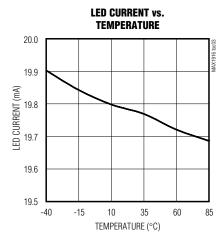
**Note 3:** Dropout Voltage is defined as the LED\_ to GND voltage at which current sink into LED\_ drops 10% from the value at  $V_{LED} = 1V$ .

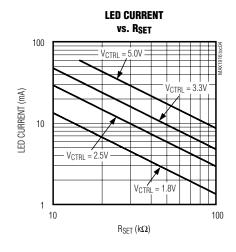
## \_Typical Operating Characteristics

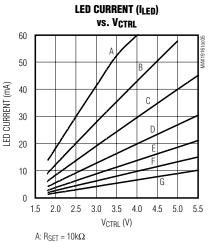
(VEN = 3.3V, VCTRL = 3.3V, RSET = 24.9k $\Omega$ , V+ = 5V, TA = +25°C, unless otherwise noted.) (Circuit of Figure 1)

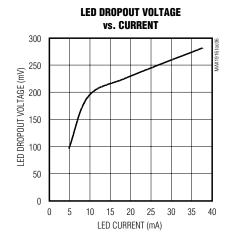








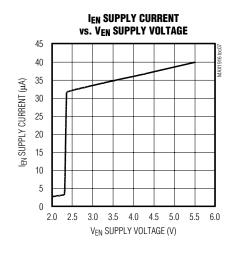


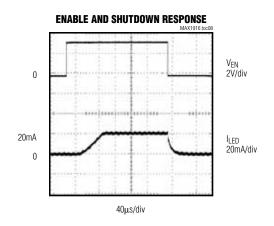


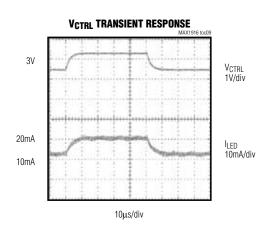
A: RSET = 10KΩ B: RSET = 15kΩ C: RSET = 22kΩ D: RSET = 33kΩ E: RSET = 47kΩ F: RSET = 68kΩ G: RSET = 100kΩ

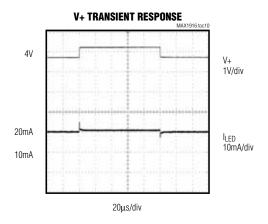
## \_Typical Operating Characteristics (continued)

(VEN = 3.3V, VCTRL = 3.3V, RSET =  $24.9k\Omega$ , V+ = 5V, TA =  $+25^{\circ}$ C, unless otherwise noted.) (Circuit of Figure 1)









### **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 ILED_= 230 x ISET. VSET 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.		

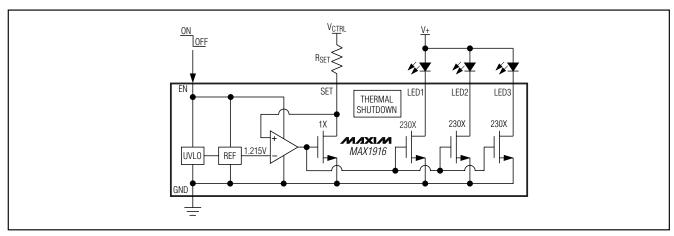


Figure 1. MAX1916 Simplified Functional Diagram

### **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 40 $\mu$ A in normal operation and 0.05 $\mu$ A 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  $40\mu$ A to power the IC. Driving EN low forces LED1, LED2, LED3, and SET into a high-impedance state.

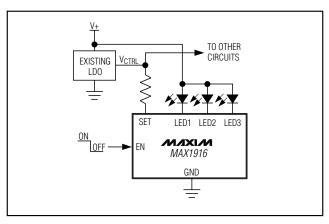


Figure 2. Very Low-Cost, High-Efficiency Solution

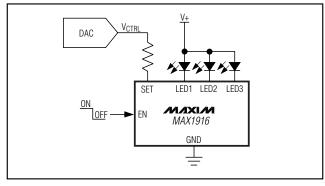


Figure 3. Brightness Adjust Using DAC

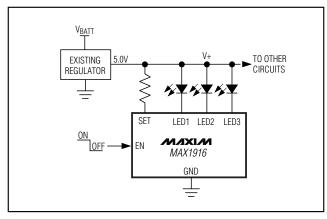


Figure 4. Existing 5V Supply Circuit

#### **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).

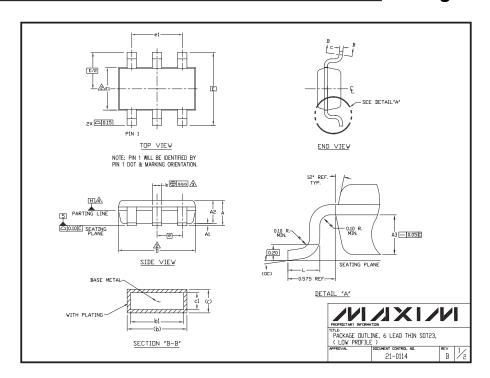
## **Applications Information**

- 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 VCTRL.
- 2) Brightness Adjustment Using a DAC (Figure 3). A DAC is used as V<sub>CTRL</sub> 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 VCTRL.

**Chip Information** 

TRANSISTOR COUNT: 220 PROCESS: BICMOS

### **Package Information**



#### NOTES:

- 1. ALL DIMENSIONS ARE IN MILLIMETERS.
- "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.
- 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.
- AT THE BOTTOM OF PARTING LINE.
- 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.
- 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	N□M	MAX		
Α	-	-	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		
С	0.15	-	0.20		
⊂1	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				
е	0.95 BSC				
œ	0-	4-	8-		
aaa	0.20				



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