

1.2MHz, Fixed Frequency White LED Driver

FFEATURES

- High Efficiency: Up to 90%
- 1.2MHz Constant Frequency Operation
- Integrated internal Power MOSFET
- Drives up to 7 Series WLEDs
- Low 104mV Feedback Voltage
- Soft-start/Dimming with wide Frequency Range
- UVLO, Thermal Shutdown
- Internal Current limit
- Over Voltage Protection
- Small LC Filter
- Minimize the External Component
- <math><1\mu\text{A}</math> Shutdown Current
- Tiny TSOT23-6/SOT23-6 Package

APPLICATIONS

- Camera Flash White LED
- Mobile Phone, Smart Phone LED Backlight
- PDA LED Backlight
- Digital Still Cameras
- Camcorder

GENERAL DESCRIPTION

The MT9284 is a step-up converter designed for driving up to 7 series white LEDs from a single cell Lithium Ion battery. The MT9284 uses current mode, fixed frequency architecture to regulate an LED current, which is measured through an external current sense resistor. Its low 104mV feedback voltage reduces power loss and improves efficiency.

The MT9284 includes under-voltage lockout, current limiting and thermal overload protection preventing damage in the event of an output overload.

Optimized operation frequency can meet the requirement of small LC filters value and low operation current with high efficiency. Internal soft start function can reduce the inrush current. Tiny package type provide the best solution for PCB space saving and total BOM cost.

Typical Application

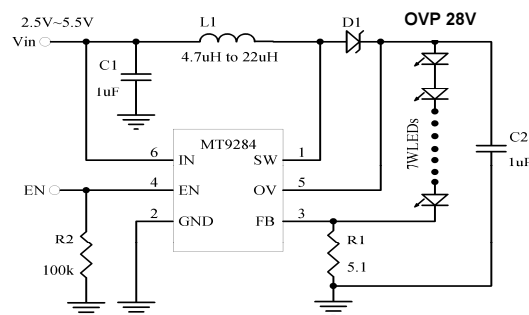


Figure 1. Typical Application Circuit

Efficiency vs. Input Voltage

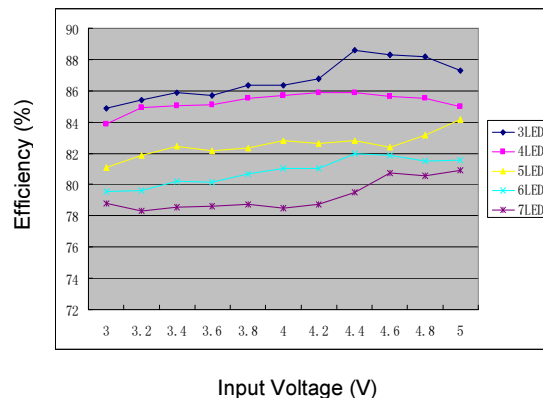
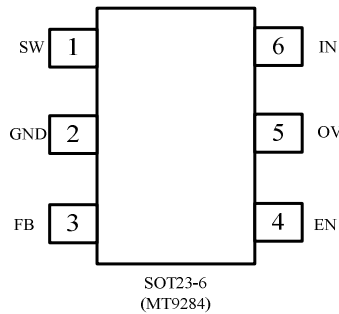


Figure 2. Efficiency vs. Vin

Absolute Maximum Ratings (Note 1)

Input Supply Voltage -0.3V to 6V	Operating Temperature Range ... -40°C to +85°C
EN, FB Voltages..... -0.3V to 6V	Junction Temperature(Note2) 125°C
SW Voltage ...-0.3V to 30V	Storage Temperature Range -65°C to 150°C
Peak SW Sink and Source Current... 1.8A	Lead Temperature(Soldering, 10s)+300°C

Package/Order Information



Part Number	OVP Voltage	Switching Frequency	Temperature Range	Package Type
MT9284-15J	15V	1.2MHz	-40°C to +85°C	TSOT23-6/ SOT23-6
MT9284-20J	20V	1.2MHz	-40°C to +85°C	TSOT23-6/ SOT23-6
MT9284-28J	28V	1.2MHz	-40°C to +85°C	TSOT23-6/ SOT23-6

Pin Description

PIN	NAME	FUNCTION
1	SW	Switching Node. It is the switch node connection to Inductor.
2	GND	Ground Pin
3	FB	Output Voltage Feedback Pin.
4	EN	Chip Enable Pin. Drive EN above 1.5V to turn on the part. Drive EN below 0.4V to turn it off. Do not leave EN floating.
5	OV	Over Voltage Input. OV measures the output voltage for open circuit protection. Connect OV to the output at the top of the LED string.
6	IN	Power Supply Input. Must be closely decoupled to GND with a 1µF or greater ceramic capacitor.

Electrical Characteristics (Note 3)

($V_{IN}=V_{EN}=3.7V$, $T_A = 25^{\circ}C$, unless otherwise noted.)

Parameter	Conditions	MIN	TYP	MAX	unit
Input Voltage Range		2.5		5.5	V
UVLO Threshold			2.2	2.45	V
Under Voltage Lockout Hysteresis			100		mV
Shutdown Current	$V_{EN}<0.4V$		0.1	1	μA
Quiescent Current	$V_{FB}=0.15V$, No switching		200	300	μA
Supply Current	$V_{FB}=0V$, switching		0.6	1	mA
Regulated Feedback Voltage		94	104	114	mV
Oscillation Frequency			1.2		MHz
ON Resistance of NMOS			0.5		Ω
Peak Current Limit	$V_{IN}= 4.2V$, Duty cycle=50%		1.5		A
EN Shutdown Voltage				0.4	V
EN Enable Voltage		1.5			V
EN Leakage Current			± 0.01	± 1.0	μA
OVP Threshold	Vov Rising		15 20 28		V

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + (P_D) \times (250^{\circ}C/W)$.

Note3: 100% production test at $+25^{\circ}C$. Specifications over the temperature range are guaranteed by design and characterization.

Note 4: Dynamic supply current is higher due to the gate charge being delivered at the switching frequency

OPERATION

The MT9284 uses a constant frequency, peak current mode boost regulator architecture to regulate the series string of white LEDs. At the start of each oscillator cycle the FET is turned on through the control circuitry. To prevent sub-harmonic oscillations at duty cycles greater than 50 percent, a stabilizing ramp is added to the output of the current sense amplifier and the result is fed into the positive input of the

PWM comparator. When this voltage equals the output voltage of the error amplifier the power FET is turned off. The voltage at the output of the error amplifier is an amplified version of the difference between the 104mV reference voltage and the feedback voltage. In this way the peak current level keeps the output in regulation. If the feedback voltage starts to drop, the output of the error amplifier increases. This results in more current flowing through the power FET, thus increasing the power delivered to the output.

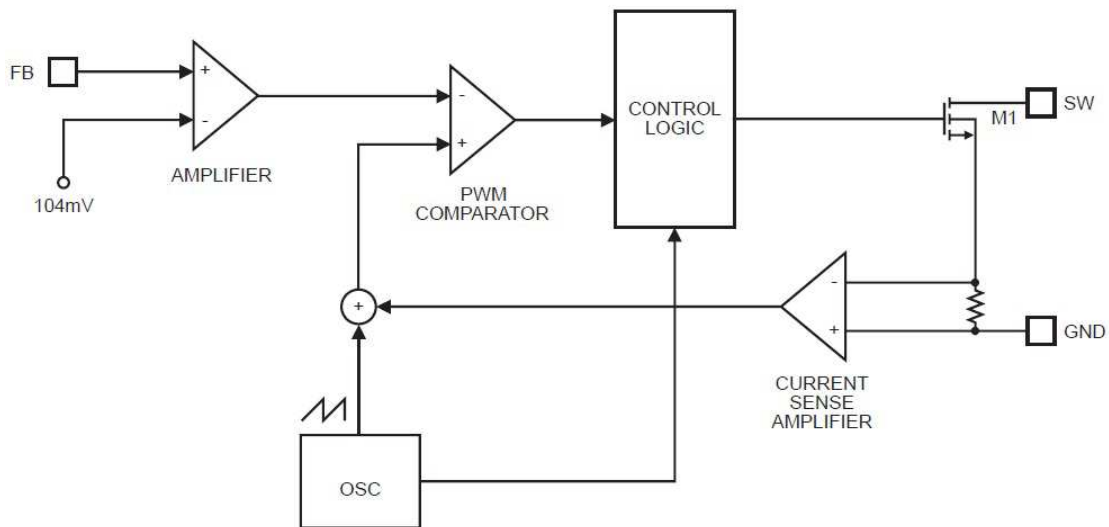
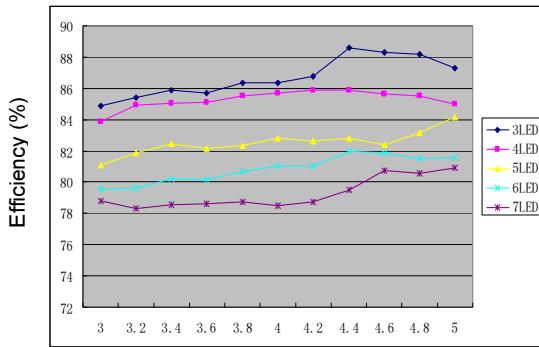


Figure 3. Functional Block Diagram

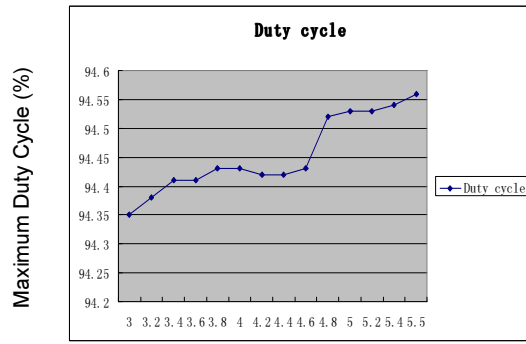
Typical Operating Characteristics

Efficiency vs. Input Voltage



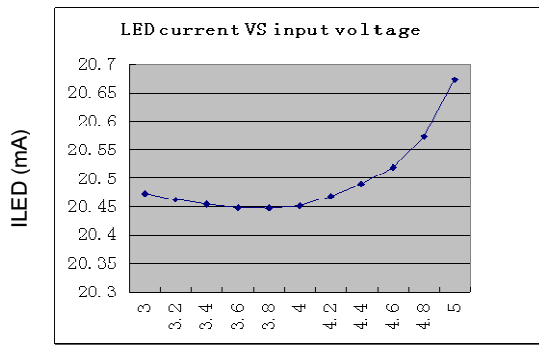
Input Voltage (V)

Maximum Duty Cycle vs. Vin



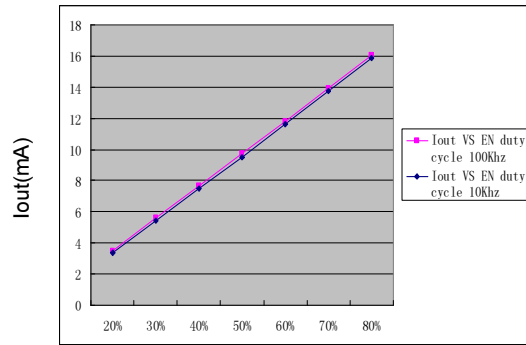
Vin (V)

LED Current vs. Input voltage



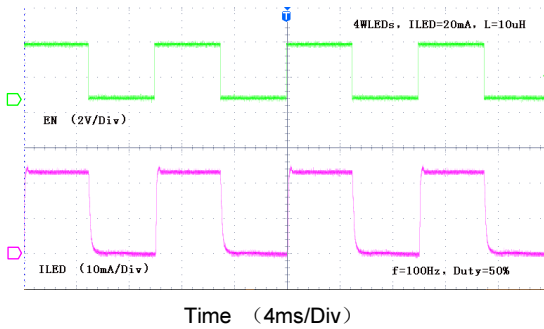
Vin (V)

Iout vs. EN Duty



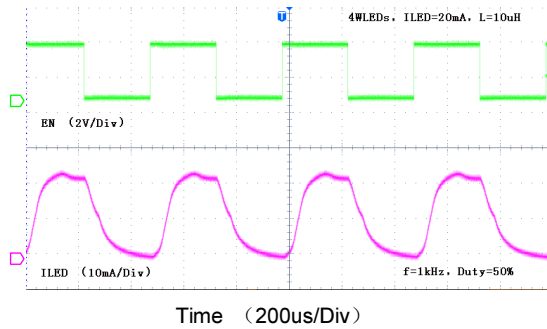
EN Duty

Dimming Operation



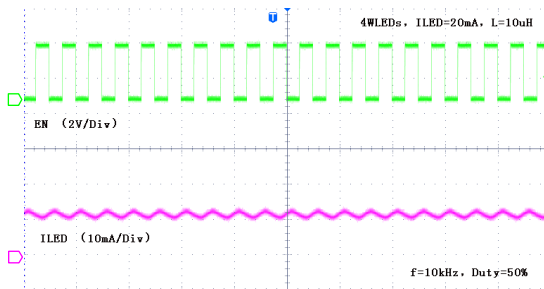
Time (4ms/Div)

Dimming Operation



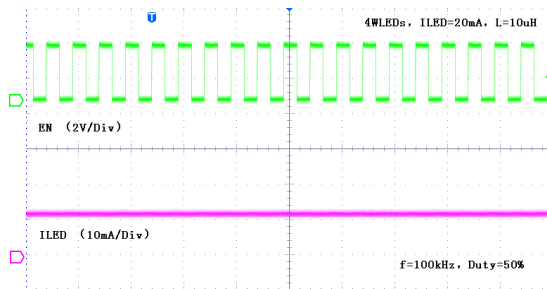
Time (200us/Div)

Dimming Operation



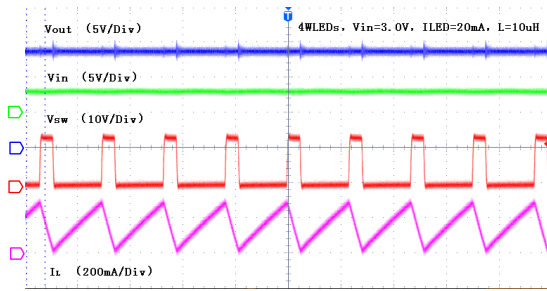
Time (400us/Div)

Dimming Operation



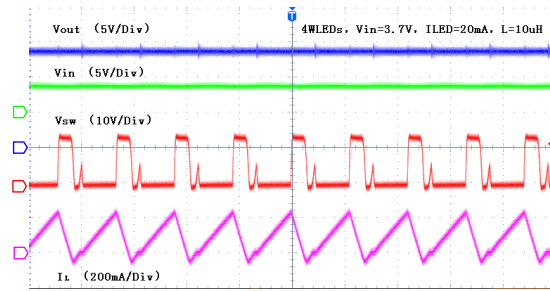
Time (20us/Div)

Normal Operation



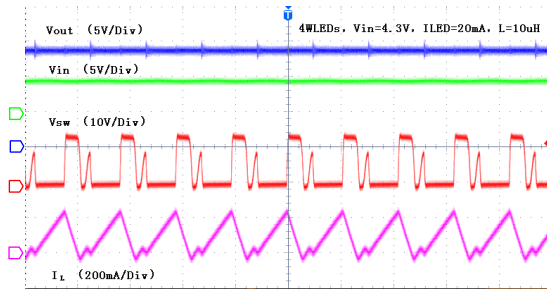
Vin=3.0V

Normal Operation



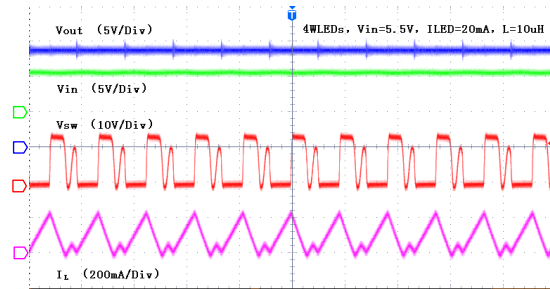
Vin=3.7V

Normal Operation



Vin=4.3V

Normal Operation



Vin=5.5V

APPLICATION INFORMATION

Setting the LED Current

The LED current is controlled by the feedback resistor, R1, in Figure 1. The current through the LEDs is given by the equation $104\text{mV}/R1$. Table 1 shows the selection of resistors for a given LED current.

Table 1— I_{LED} vs. R1

I_{LED} (mA)	R1 (Ω)
1	104
5	20.8
10	10.4
15	6.93
20	5.2

Dimming Control

a. Using a PWM Signal to EN Pin

For controlling the LED brightness, the MT9284 can perform the dimming control by applying a PWM signal to EN pin. The internal soft start and the wide range dimming frequency can eliminate inrush current and audio noise when dimming. The average LED current is proportional to the PWM signal duty cycle. The magnitude of the PWM signal should be higher than the maximum enable voltage of EN pin, in order to let the dimming control perform correctly for preventing the flicker issue, the suggested PWM frequency is $\geq 1\text{kHz}$ or $\leq 200\text{Hz}$.

b. Using a DC Voltage

Using a variable DC voltage to adjust the brightness is a popular method in some applications. According to the Superposition Theorem, as the DC voltage increases, the voltage contributed to V_{FB} increases and the voltage drop on R2 decreases, i.e. the LED current decreases. For example, if the V_{DC} range is from 0V to 2.8V, the selection of resistors sets in Figure 4 sets dimming control of LED current from 20mA to 0mA.

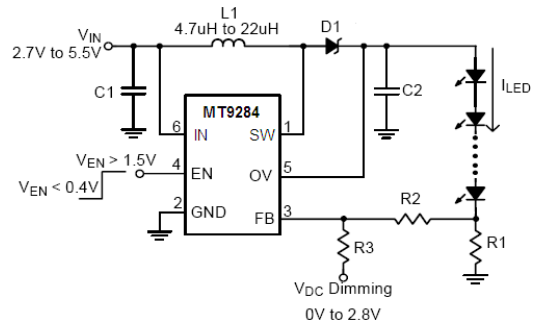


Figure 4. Dimming Control Using a DC Voltage for MT9284

The LED current can be calculated by the following equation:

$$I_{LED} = \frac{V_{FB} - \frac{R_2 \times (V_{DC} - V_{FB})}{R_3}}{R_1}$$

c. Using a Filtered PWM signal

Another common application is using a filtered PWM signal as an adjustable DC voltage for LED dimming control. A filtered PWM signal acts as the DC voltage to regulate the output current. The recommended application circuit is shown in the Figure 5. In this circuit, the output ripple depends on the frequency of PWM signal. For smaller output voltage ripple ($< 100\text{mV}$), the recommended frequency of 2.8V PWM signal should be above 2kHz. To fix the frequency of PWM signal and change the duty cycle of PWM signal can get different output current. Figure 6. shows the relationship between LED current and PWM duty cycle.

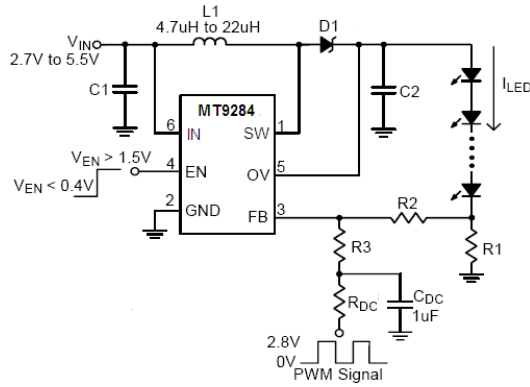


Figure 5. Filtered PWM Signal for LED Dimming Control of MT9284

The LED current can be calculated by the following equation:

$$I_{LED} = \frac{V_{FB} - \frac{R_2 \times (V_{PWM} \times Duty - V_{FB})}{R_3 + R_{DC}}}{R_1}$$

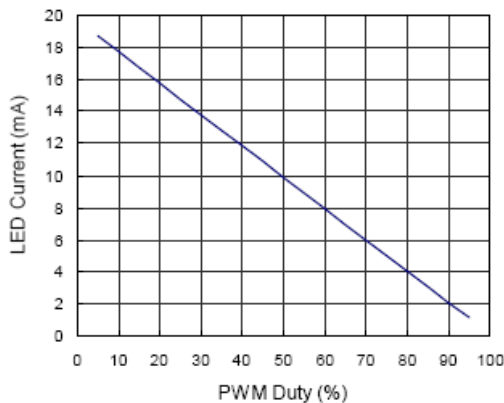


Figure 6. LED Current Vs. PWM Duty Cycle

Inductor Selection

The recommended value of inductor are 4.7 to 22μH. Small size and better efficiency are the major concerns for portable device, such as MT9284 used for mobile phone. The inductor should have low core loss at 1.2MHz and low DCR for better efficiency. To avoid inductor saturation current rating should be considered.

Capacitor Selection

Input and output ceramic capacitors of 1μF are recommended for MT9284 applications. For better voltage filtering, ceramic capacitors with low ESR are recommended. X5R and X7R types are suitable because of their wider voltage and temperature ranges.

Diode Selection

Schottky diode is a good choice for MT9284 because of its low forward voltage drop and fast reverse recovery. Using Schottky diode can get better efficiency. The high speed rectification is also a good characteristic of Schottky diode for high switching frequency. Current rating of the diode must meet the root mean square of the peak current and output average current multiplication as following :

$$I_D (RMS) = \sqrt{I_{OUT} \times I_{PEAK}}$$

The diode's reverse breakdown voltage should be larger than the output voltage.

Layout Consideration

For best performance of the MT9284, the following guidelines must be strictly followed.

- Input and Output capacitors should be placed close to the IC and connected to ground plane to reduce noise coupling.
- The GND should be connected to a strong ground plane for heat sinking and noise protection.
- Keep the main current traces as possible as short and wide.
- SW node of DC-DC converter is with high frequency voltage swing. It should be kept at a small area.
- Place the feedback components as close as possible to the IC and keep away from the noisy devices.

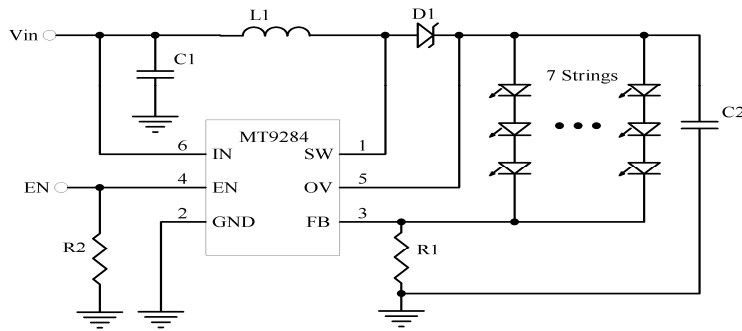


Figure 7. Typical Application Circuit for Driving 21 WLEDs

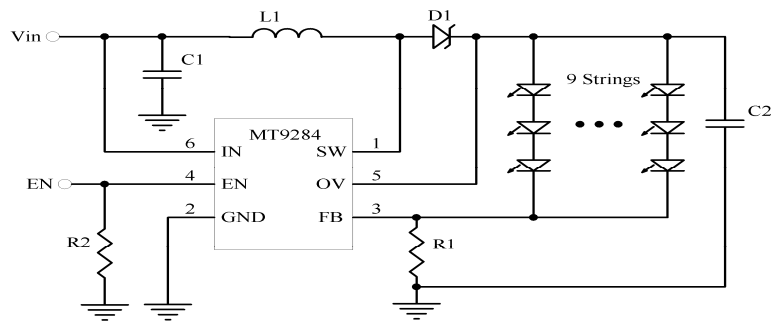


Figure 8. Typical Application Circuit for Driving 27 WLEDs

Package Description

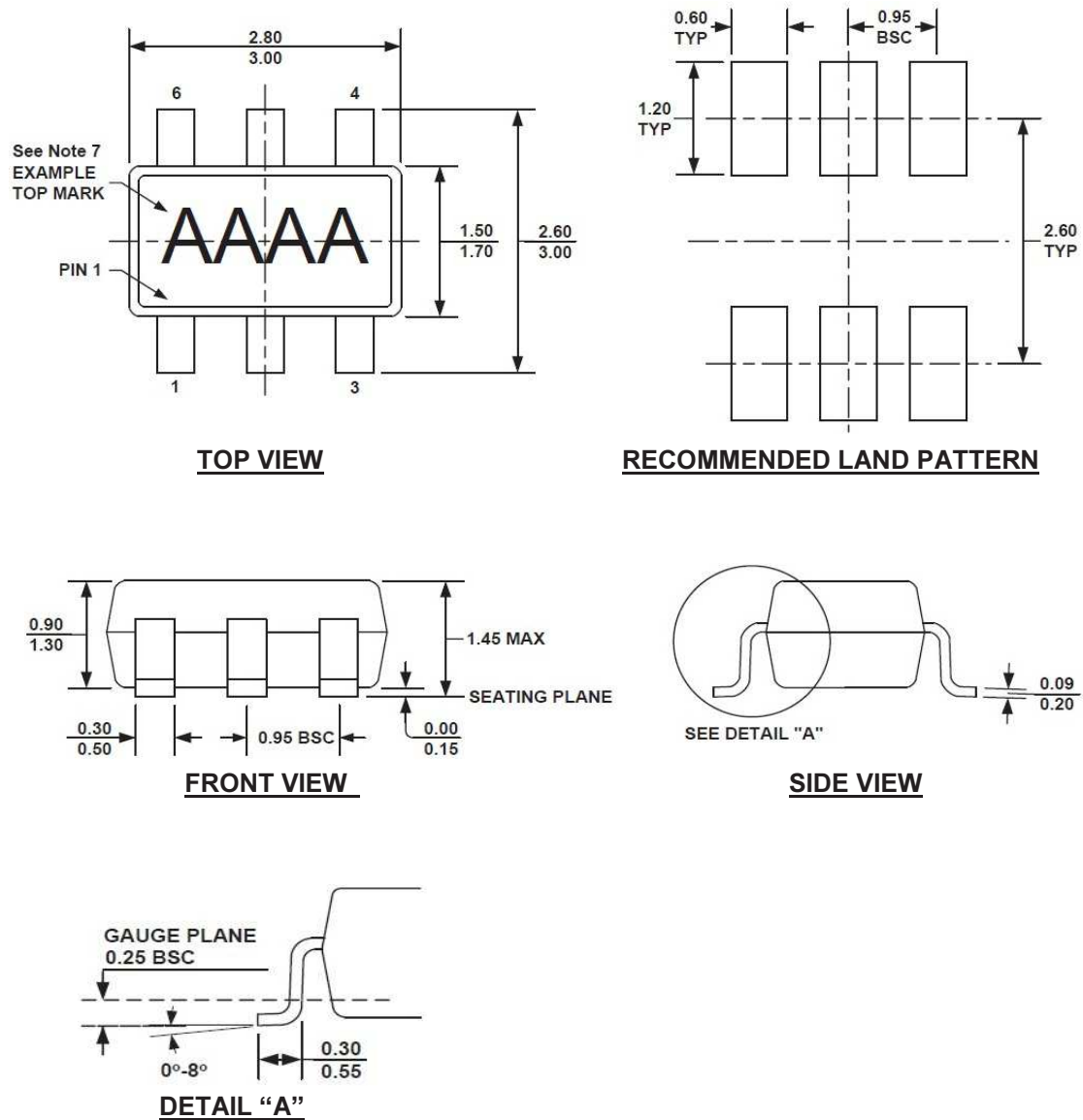


Figure 9. TSOT23-6/SOT23-6 Physical Dimensions

NOTE:

- 1) ALL DIMENSIONS ARE IN MILLIMETERS.
- 2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURR.
- 3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION.
- 4) LEAD COPLANARITY (BOTTOM OF

LEADS AFTER FORMING) SHALL BE 0.10 MILLIMETERS MAX.

- 5) DRAWING CONFORMS TO JEDEC MO-193, VARIATION AB.
- 6) DRAWING IS NOT TO SCALE.
- 7) PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT, (SEE EXAMPLE TOP MARK)