1.3A Fixed Frequency White LED Driver

FEATURES

- 2.5V to 6V input voltage Range
- On Board Power MOSFET
- Drives up to 39 White LEDs at 5V input
- Up to 92% Efficiency
- Over 1MHz Fixed Switching Frequency
- Open Load Shutdown
- Low 104mV Feedback Voltage
- Soft-Start/PWM Dimming
- UVLO, Thermal Shutdown
- Internal 1.3A Current Limit

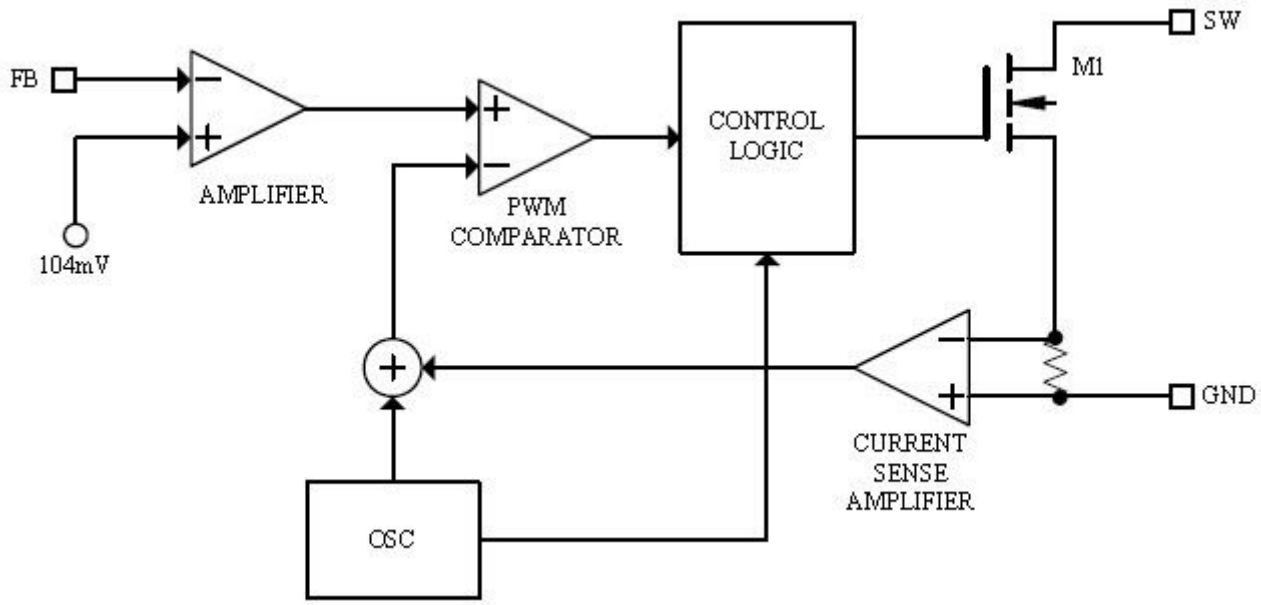
TYPICAL APPLICATIONS

- Cell Phones
- Handheld Computers and PDAs
- Digital Still Cameras
- Small LCD Displays

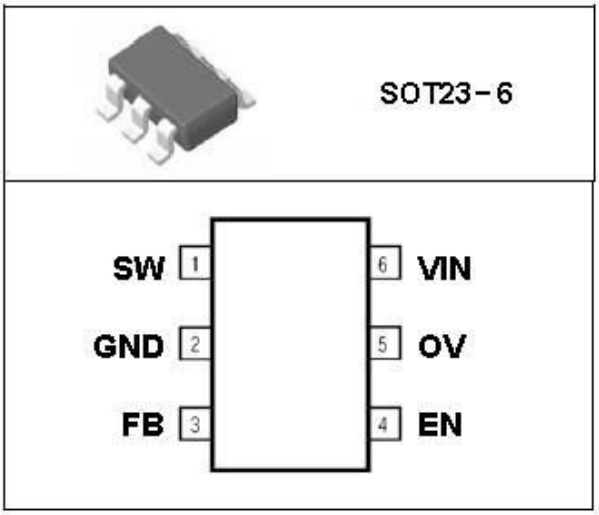
DESCRIPTION

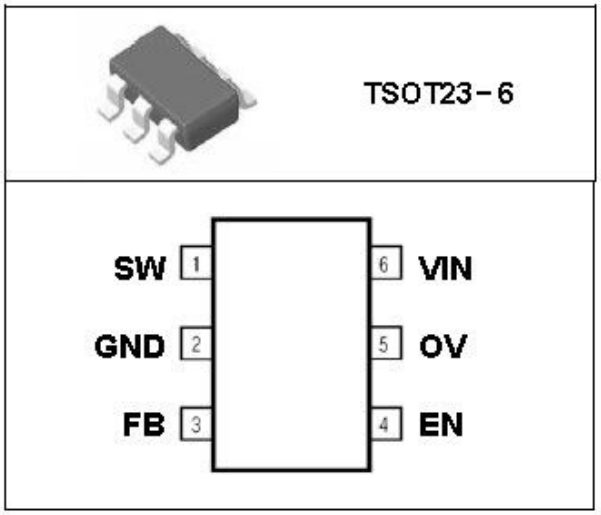
The ZL3202 is a step-up converter designed for driving up to 39 white LEDs (13 strings of 3 LEDs each) from a 5V system rail. The ZL3202 uses a current mode, fixed frequency architecture to regulate the LED current, which is measured through an external current sense resistor. Its low 104mV feedback voltage reduces power loss and improves efficiency. The OV pin monitors the output voltage and turns off the converter if an over-voltage condition is present due to an open circuit condition. The ZL3202 includes under-voltage lockout, current limiting and thermal overload protection preventing damage in the event of an output overload.

Block Diagram



PIN CONNECTION





PIN DESIGNATIONS

Number	Name	Description
1	SW	Power Switch Output. SW is the drain of the internal MOSFET switch. Connect the power inductor and output rectifier to SW. SW can swing between GND and 25V.
2	GND	Ground
3	FB	Feedback Input. The ZL3202 regulates the voltage across the current sense resistor between FB and GND. Connect a current sense resistor from the bottom of the LED string to GND. Connect the bottom of the LED string to FB. The regulation voltage is 104mV.
4	EN	Regulator On/Off Control Input. A high input at EN turns on the converter, and a low input turns it off. When not used, connect EN to the input source for automatic startup. The EN pin cannot be left 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	Input Supply Pin. Must be locally bypassed.
7	NC	No Connect

ABSOLUTE MAXIMUM RATINGS

Number	Parameter	Absolute Maximum Ratings
1	SW Pin	- 0.5V to +28.5V
2	All Other Pins	- 0.3V to +6.5V
3	Storage Temperature	- 55°C to +150°C

Recommended Operating Conditions

Number	Parameter	Range
1	VIN Supply Voltage	2.5V to 6V
2	Output Voltage	VIN to 25V
3	Operating Temperature	-40℃ to +85℃

Electrical Characteristic

VIN = VEN = 5V, TA = +25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
VIN	Operating Input Voltage		2.5		6	V
	Supply Current (Shutdown)	VEN = 0V		0.1	1	μA
	Supply Current (Quiescent)	VFB = 0.15V		690	750	μA
fSW	Switching Frequency		1.0	1.3	1.5	MHZ
	Maximum Duty Cycle	VFB = 0V	85	92		%
Under Voltage Lockout						
UVLO	IN Under Voltage Lockout	VIN Rising		2.25	2.45	V
	Under Voltage Lockout Hysteresis			92		mV
VOV	Open Lamp Shutdown Threshold	VOV Rising		28		V
Enable						
	EN Threshold	VEN Rising, VIN=5V	1.0	1.35	1.6	V
	EN Threshold	VEN Rising, VIN = 2.5V	0.8			V
	EN Hysteresis			90		mV
	EN Input Bias Current	VEN = 0V, 5V			1	uA
Feedback						
	FB Voltage		94	104	114	mV
	FB Input Bias Current	VFB = 0.1V	-600	-300		nA
Output Switch						
RON	SW On-Resistance			0.5		Ω
	SW Current Limit	Duty Cycle = 60%		1.33		A
	Thermal Shutdown			160		°C

OPERATION

The ZL3202 uses a constant frequency, peak current mode boost regulator architecture to regulate the series string of white LEDs. Refer to the block diagram in Figure 1 for details.

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 %, 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.

Analog and Digital Dimming

There are three methods to control dimming for the ZL3202 during normal operation. The first method uses DC voltage to control the feedback voltage. This is shown in Figure 1. As the DC voltage increases, current starts flowing down R1, R2 and R3. The loop will continue to regulate the feedback voltage to 104mV. Thus the current has to decrease through the LEDs by the same amount of current as is being injected from the DC voltage source. With a VDC from 0V to 2V, the resistor values shown for R2 and R3 can control the LED current from 0mA to 20mA.

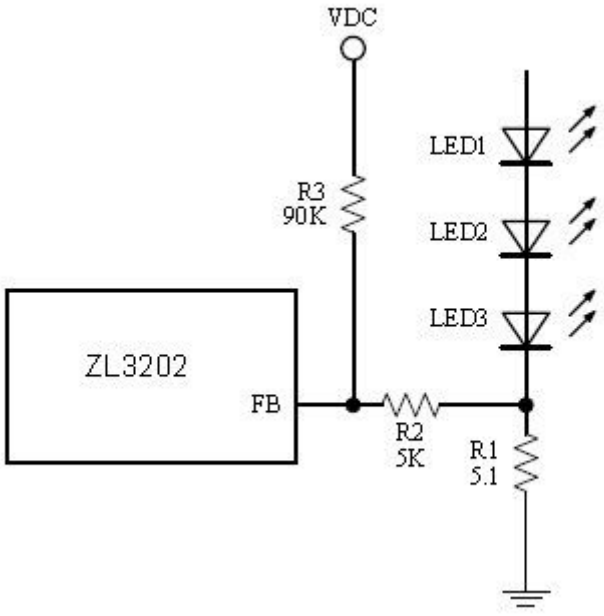


Figure 1 Dimming Control Using a DC Voltage

Other applications require a logic signal to control dimming. This can be seen in Figure 2. The PWM signal is applied to the EN pin of the ZL3202. T he LEDs will switch between full load to completely shut off. The average current through the LEDs will increase proportionally to the duty cycle of the PWM signal. The PWM signal used in Figure 2 should be 1KHz or below due to the soft-start function.

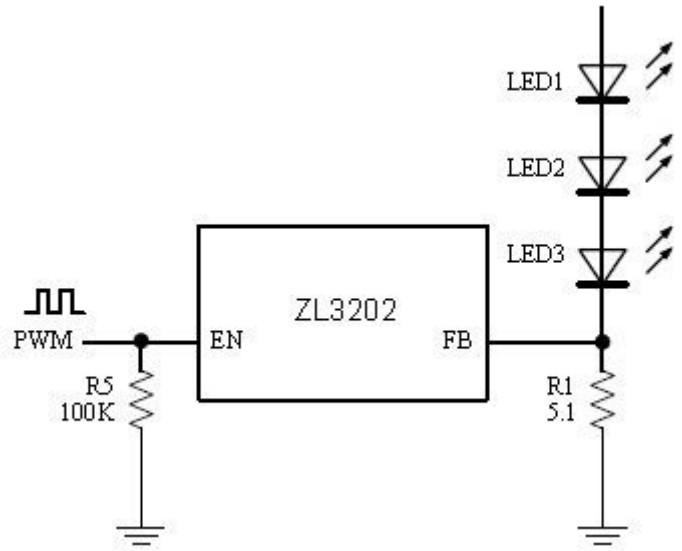


Figure 2 PWM Dimming Control Using a Logic Signal

If the PWM signal is above 1KHz, dimming can be achieved by using the circuit shown in Figure 3.

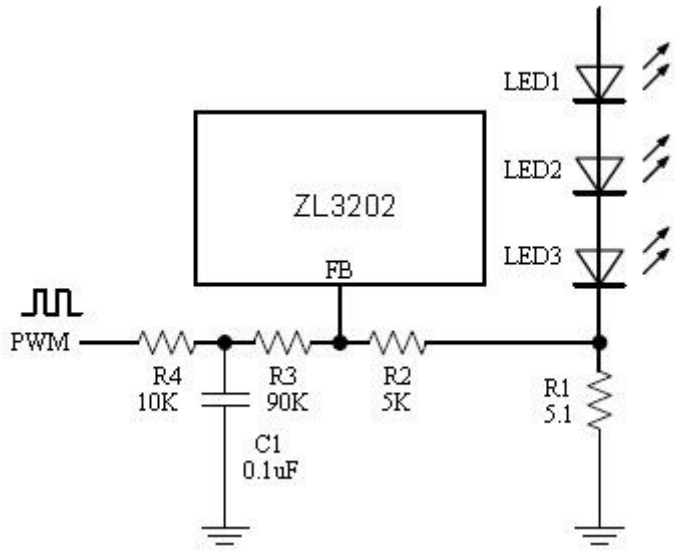


Figure 3 Dimming Control Using a Filtered PWM Signal

Open Load Protection

Open Load protection will shut off the ZL3202 if the output voltage rises too high when the OV pin is tied to the output. In some cases an LED may fail, this will result in the feedback voltage always remaining zero.

The part will run at maximum duty cycle boosting the output voltage higher and higher. By tying the OV pin to the top of the LED string the ZL3202 can check for this condition, if the output exceeds 28V. the ZL3202 will shut down. The part will not switch again until the power is recycled.

APPLICATION INFORMATION

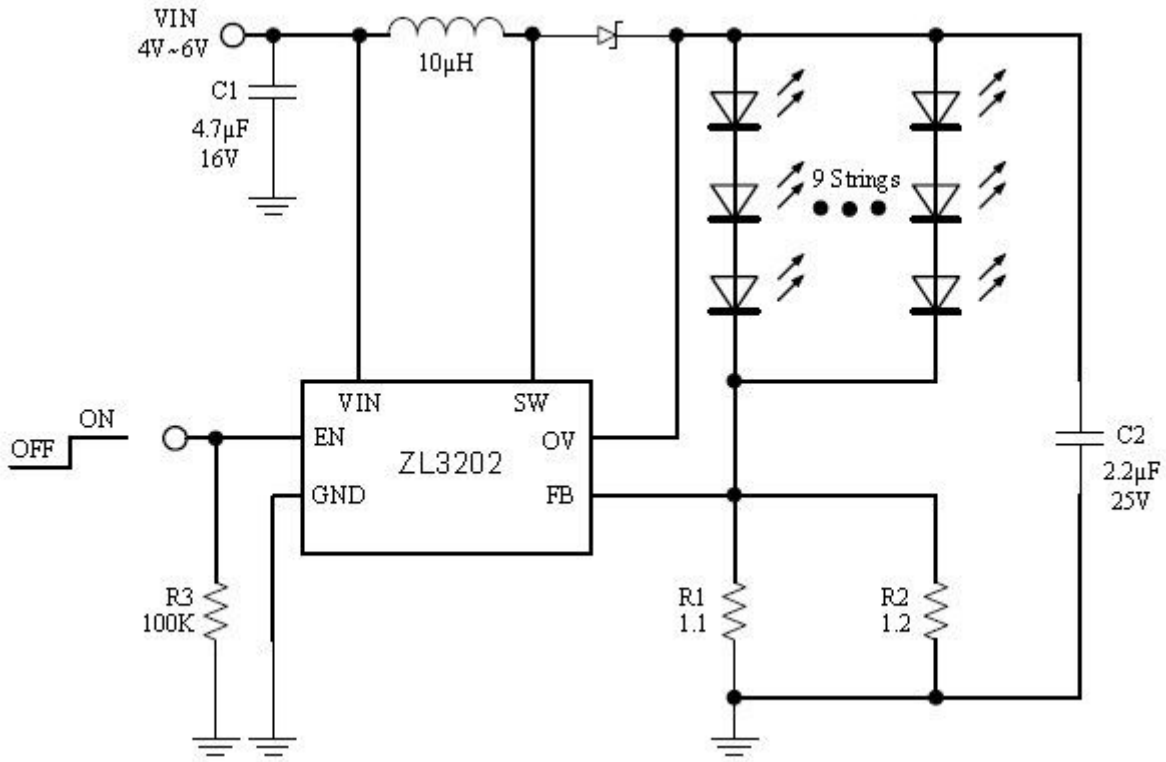


Figure 4 Circuit for Driving 27 WLEDs

A typical application circuit can be seen in Figure 2. The 27 white LEDs can be driven from a voltage supply range of 4V to 6V at a total current of 180mA. A 2.2μF output capacitor is sufficient for most applications but up to 1μF may be used. A 10μH inductor with low DCR (Inductor resistance) is recommended to improve efficiency. A 4.7μF ceramic capacitor is recommended for the input capacitance in the real system. Schottky diodes with fast recovery and a low forward voltage and are recommended. Schottky diodes rated with 500mA rating are sufficient for the ZL3202.The ZL3202 has internal soft-start to limit the amount of overshoot on the output. The current limit is increased by a fourth every 40μs giving a total soft-start time of 120μs.The ramped voltage added to the current sense amplifier reduces the current output as the duty cycle increases. As more LEDs are added, the output voltage rises but the current that can be delivered to the load is reduced as well.

Setting the LED Current

The LED current is controlled by the feedback resistor R1 and R2, as shown in Figure 2.The current through the LEDs is given by the equation:

$$I_{LED} = 104mV \frac{R1 + R2}{R1 \times R2}$$

Table 1 shows the selection of resistors for a given LED current.

Table 1—I_{LED} vs. R1

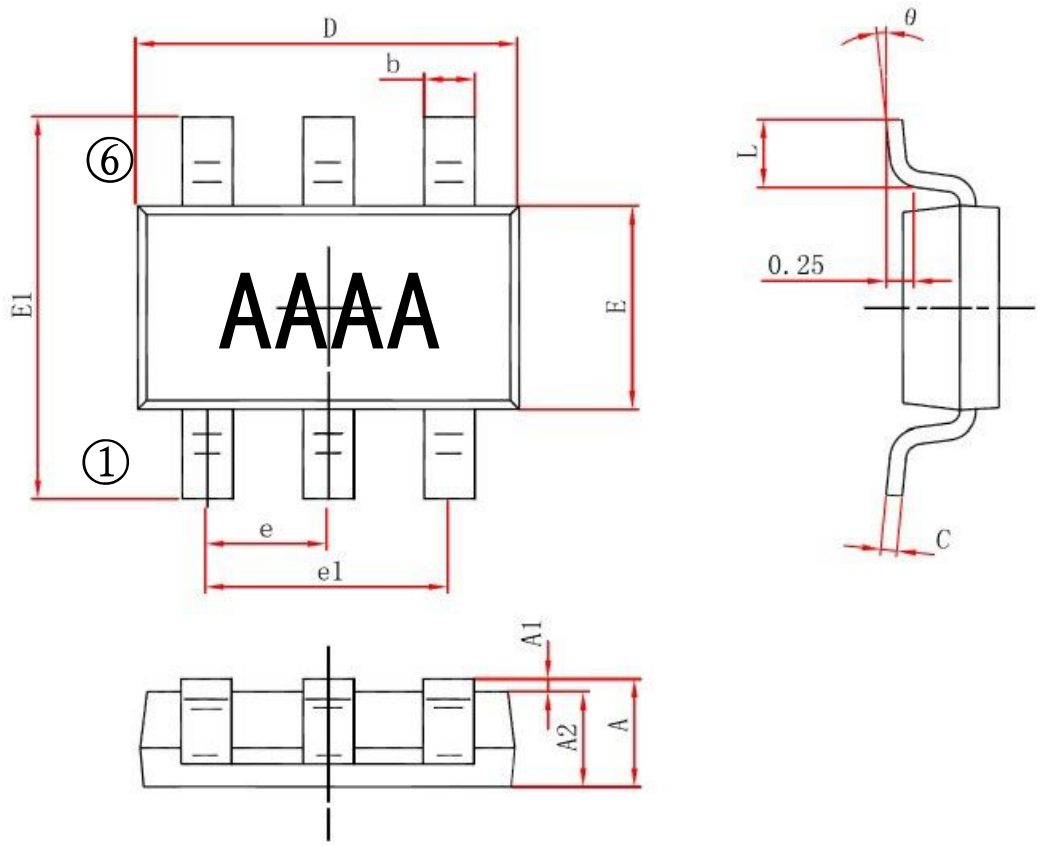
I_{LED} (mA)	R1 (Ω)	R2 (Ω)
10	10.4	N/A
50	2.08	N/A
100	1.04	N/A
150	1.5	1.3
200	1.2	1.1

Layout Considerations

Careful attention must be paid to the PCB board layout and component placement. Proper layout of the high frequency switching path is critical to prevent noise. Due to the high frequency switching, the length and area of all the traces connected to the switch node should be minimized.

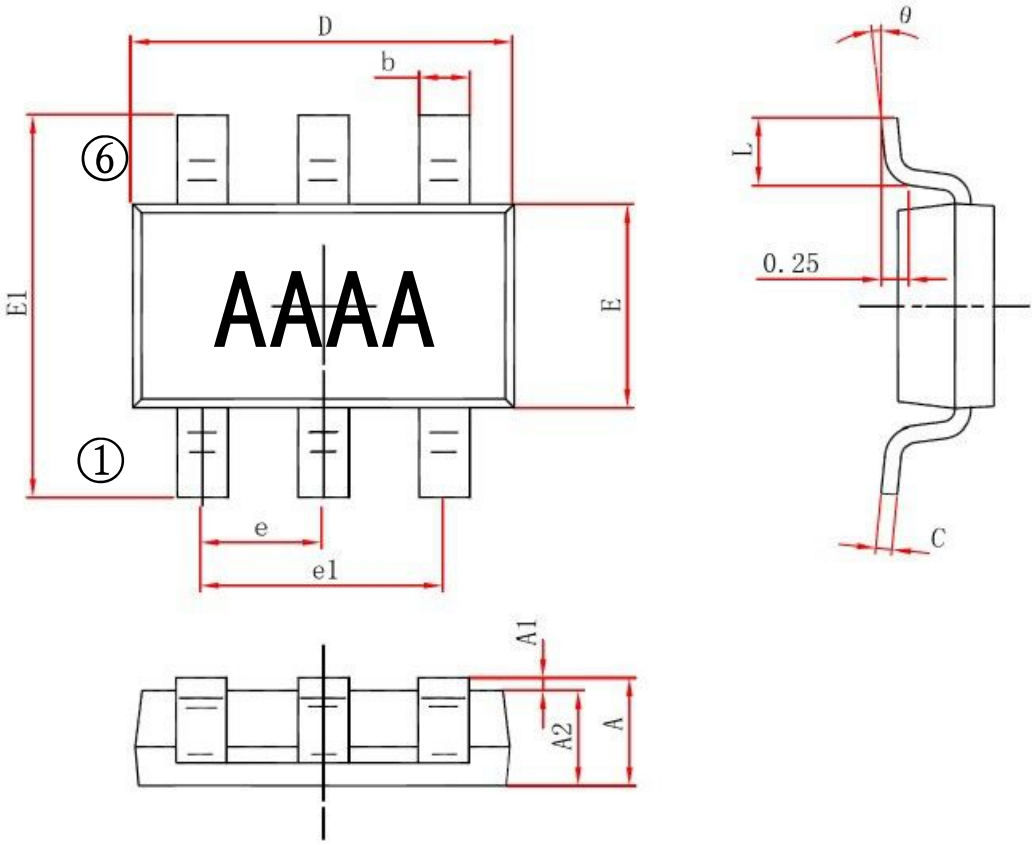
PACKAGE INFORMATION

SOT23-6



Symbol	mm		inches	
	MIN.	MAX.	MIN.	MAX.
A	1.070	1.200	0.042	0.047
A1	0.000	0.100	0.000	0.004
A2	1.070	1.130	0.042	0.044
b	0.350	0.500	0.014	0.020
c	0.080	0.200	0.003	0.008
D	2.820	3.020	0.111	0.119
E	1.600	1.700	0.063	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.900(BSC)		0.075(BSC)	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

TSOT23-6



Symbol	mm		inches	
	MIN.	MAX.	MIN.	MAX.
A	0.700	0.900	0.028	0.035
A1	0.000	0.100	0.000	0.004
A2	0.700	0.800	0.028	0.031
b	0.350	0.500	0.014	0.020
c	0.080	0.200	0.003	0.008
D	2.820	3.020	0.111	0.119
E	1.600	1.700	0.063	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
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