DIO6197

Synchronous Boost Converter with Ultra-Low Quiescent Current

Features

- Operating Input Voltage Range: 0.9V to 3.8V
- Output Voltage: 3.3V
- Ultra−Low Quiescent Current (V_{OUT} Pin): 1uA
- Ultra−Low Quiescent Current (V_{IN} Pin): 1uA
- Switch Peak Current Limit
- Bypass from input to load during shutdown
- Up to 93% Efficiency from 10mA to 300mA Load
- Package: SOT23-5

Applications

- Portable Products
- Battery Powered Systems
- Low Power Wireless Applications
- Wearable Applications
- Memory LCD Bias
- Optical Heart Rate Monitor LED Bias

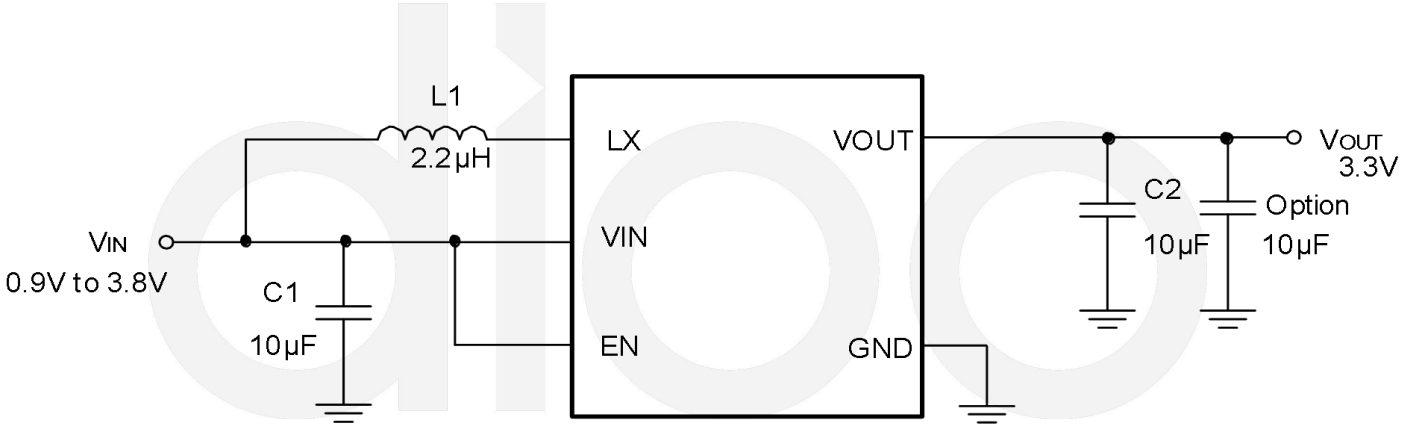
Descriptions

DIO6197 is a synchronous boost converter with a 1μA ultra-low quiescent current. It can operate efficiently under a light load condition, which is essential to prolonging the service life of batteries.

DIO6197 boost converter adopts hysteresis control topology, which can achieve the highest efficiency with the lowest quiescent current. The device consumes only 1μA quiescent current under light load.

DIO6197 has a bypass function that provides a direct connection from input to load when the device is disabled. The device is packaged in SOT23-5.

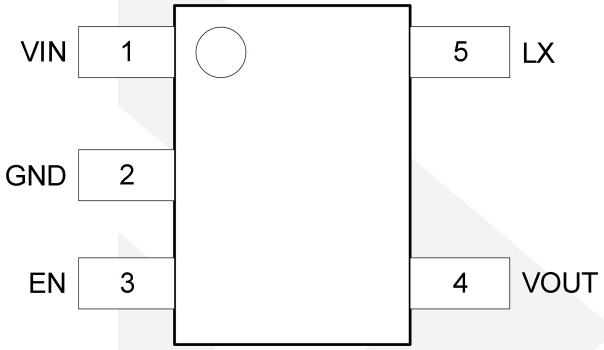
Typical Application



Ordering Information

Order Part Number	Top Marking		T_A	Package	
DIO6197ST5	W19G	Green	-40 to 85°C	SOT23-5	Tape & Reel,3000

Pin Assignment



SOT23-5

Figure 1. Top View

Pin Descriptions

Pin Name	Description
VIN	IC power supply input.
GND	Ground.
EN	Enable logic input. Logic high voltage enables the device; logic low voltage disables the device. Do not leave it floating.
LX	Switch pin of the converter. It is connected to the inductor.
VOUT	Boost converter output.

Absolute Maximum Ratings

Stresses beyond those listed under the Absolute Maximum Rating table may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition 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.

Symbol	Parameter		Rating	Unit
	Voltage range at terminals (1) (V_{IN}, V_{OUT}, EN)		-0.3 to 6.0	V
	Voltage range at LX	Pulsed<10ns	-3.0 to 9.0	V
		DC	-0.3 to 6.0	
T_J	Operating junction temperature		-40 to 150	°C
T_{STG}	Storage Temperature		-65 to 150	°C
ESD	Human Body Model (HBM)		±2000	V
	Charged Device Model (CDM)		±500	V

Note: 1. All voltage values are with respect to network ground terminal.

Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended Operating conditions are specified to ensure optimal performance to the datasheet specifications.

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{IN}	Input voltage range	0.9		3.8	V
V_{OUT}	Output voltage range	3.2	3.3	3.4	V

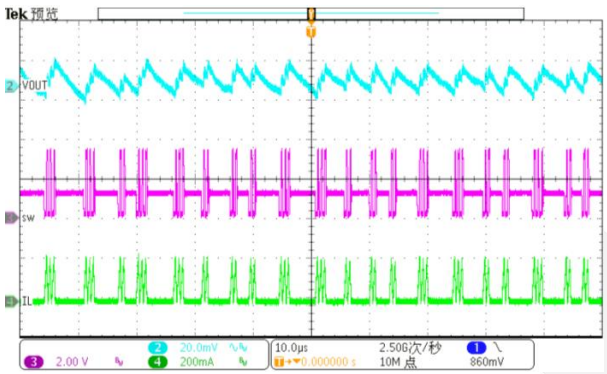
Electrical Characteristics

T_J = -40°C to 150°C and V_{IN} = 0.9V to 3.8V. Typical values are at V_{IN} = 1.2V, T_J = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Power Supply						
V_{IN}	Input voltage range		0.9		3.8	V
V_{UVLO}	Input under voltage lockout threshold	V_{IN} rising		0.75	0.9	V
	UVLO hysteresis			200		mV
I_Q	Quiescent current into V_{IN} pin	IC enabled, no Load, no Switching T_J = -40°C to 85°C		1	3	μA
	Quiescent current into V_{OUT} pin	IC enabled, no Load, no Switching, Boost or Down Mode T_J = -40°C to 85°C		1	3	μA
I_{SD}	Shutdown current into V_{IN} pin	IC disabled, V_{IN} = 3.7V, T_J = -40°C to 85°C		0.5	1.6	μA
I_{No_Load}	Quiescent current from Supply	IC enabled, no Load, Switching, T_J = -40°C to 85°C		2.5	10	μA
Output						
V_{OUT}	Output voltage range	V_{IN} = 1.2V, I_{OUT} = 30mA	3.2	3.3	3.4	V
Power Switch						
$R_{DS(on)\_LS}$	Low side switch on resistance	V_{OUT} = 3.3V		300		mΩ
$R_{DS(on)\_HS}$	Rectifier on resistance	V_{OUT} = 3.3V		350	450	mΩ
	Bypass switch on resistance	V_{IN} = 1.2V, I_{OUT} = 100mA		2.5		Ω
F_{LX}	Operation frequency			1		MHz
I_{LIM}	Current limit threshold	V_{OUT} = 3.3V, boost operation		0.9		A
I_{LX_LKG}	Leakage current into LX pin (from LX pin to GND)	V_{LX} = 5.0V, no switch, T_J = -40°C to 85°C			200	nA
Control logic						
V_{IL}	EN input low voltage threshold	T_J = 25°C			0.53	V
		T_J = -10°C to 70°C			0.486	V
		T_J = -40°C to 85°C			0.471	V
V_{IH}	EN input high voltage threshold	T_J = 25°C	0.745			V
		T_J = -10°C to 70°C	0.787			V
		T_J = -40°C to 85°C	0.821			V
I_{EN_LKG}	Leakage current into EN pin	EN = 0 V or EN = V_{IN}		0.01	0.1	uA
	Over temperature protection			150		°C
	Over temperature hysteresis			25		°C

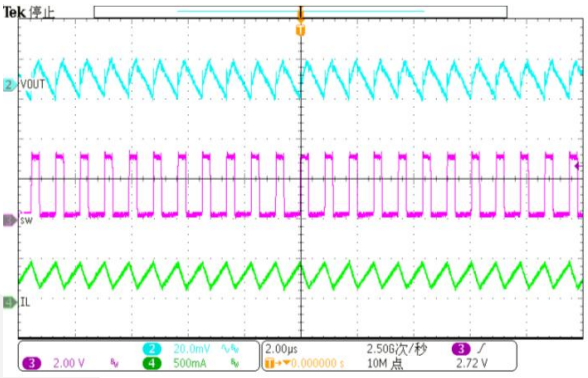
Typical Performance Characteristics

V_{IN}=1.2V, V_{OUT}=3.3V, C_{IN}=10uF, C_{OUT}=10uF, L=2.2uH



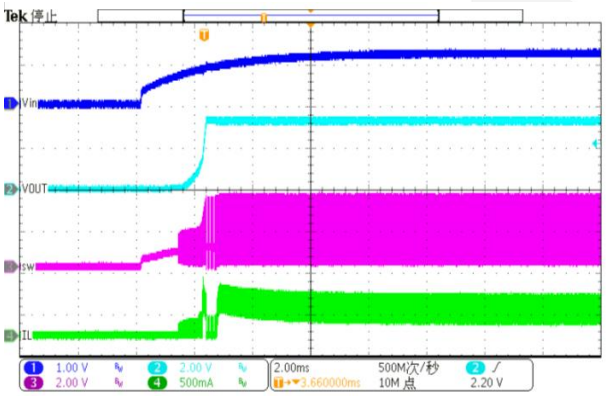
V_{IN}=1.2V, V_{OUT}=3.3V, Load=10mA

Figure 2. Switching Waveform at Light Load



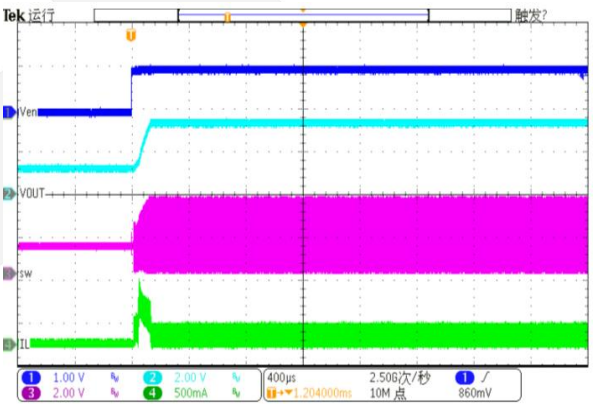
V_{IN}=1.2V, V_{OUT}=3.3V, Load=100mA

Figure 3. Switching Waveform at Heavy Load



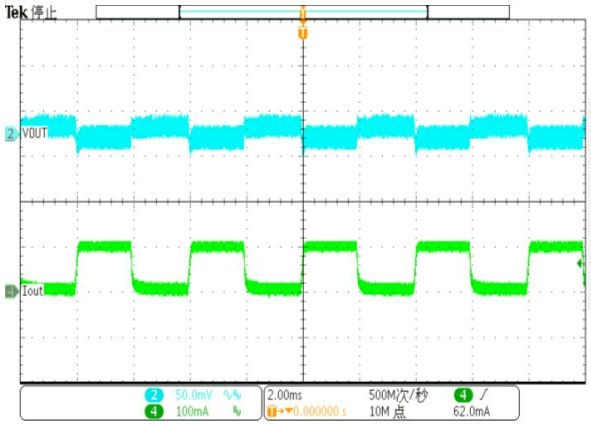
V_{IN}=1.2V, V_{OUT}=3.3V, Load=100mA

Figure 4. Starup by V_{IN}



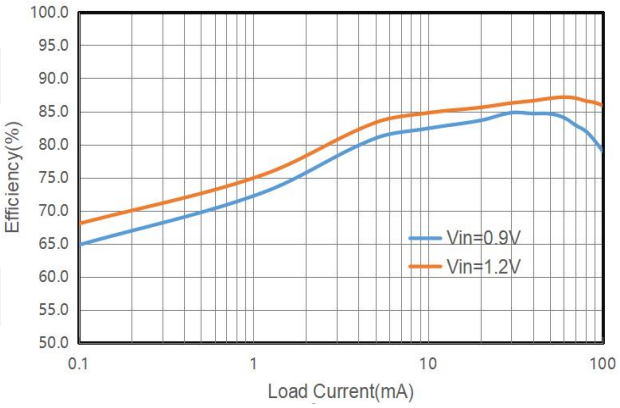
V_{IN}=1.2V, V_{OUT}=3.3V, Load=10mA

Figure 5. Starup by EN



V_{IN}=1.2V, V_{OUT}=3.3V, Load=5mA-100mA

Figure 6. Load Transient



V_{IN}=0.9V/1.2V, V_{OUT}=3.3V

Figure 7. Efficiency vs. Load Current

Block Diagram

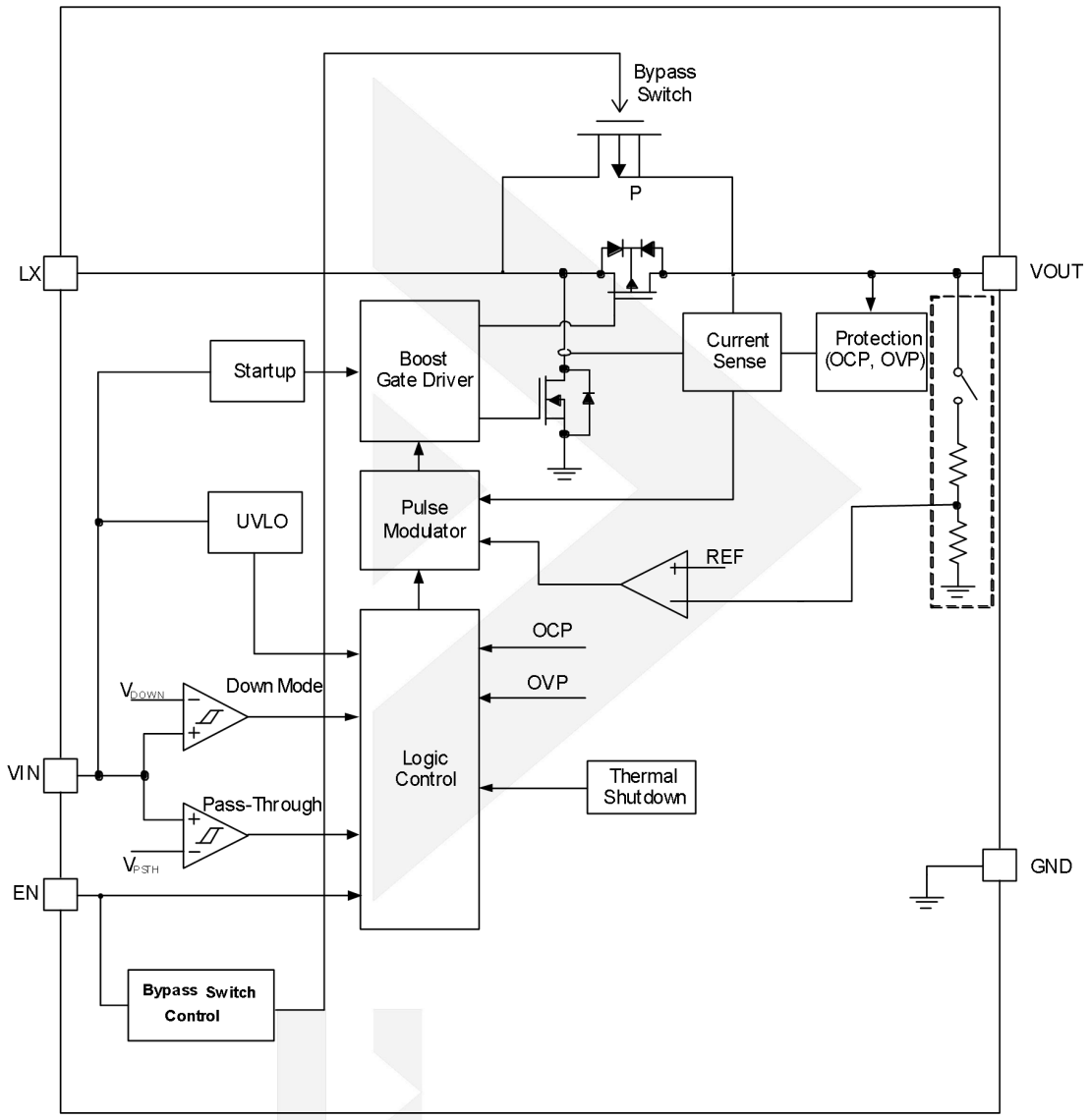


Figure 8. Block Diagram

Detailed Description

Overview

The DIO6197 synchronous step-up converter is designed for alkaline batteries, coin-cell batteries, and Li-ion or Li-polymer battery-powered systems, which require a long battery running time and tiny solution size. The DIO6197 can operate with a wide input voltage from 0.9V to 3.8V. It only consumes 1μA quiescent current and can achieve high efficiency under a light load condition.

The DIO6197 operates in a hysteretic control scheme with a typical 1A peak switch current limit. The DIO6197 provides the bypass function, this function allows the device to maintain a direct connection from input to load when the DIO6197 is on shutdown mode.

Boost Controller Operation

The DIO6197 boost converter is controlled by a Constant Off Time (COT) controller. This controller regulates the output voltage by keeping the off time constant according to input and output voltage and adjusting the peak inductor current depending on the output load. Since COT is a PFM control mode, the switching frequency is not fixed and is determined by the operation condition. If the required current is lower than the minimum CCM inductor current, the inductor current goes discontinuously to keep the efficiency high under a light load condition. To achieve high efficiency, the power stage is realized as a synchronous boost topology. To regulate the output voltage, the voltage error amplifier compares this feedback voltage to the internal voltage reference and adjusts the required offset of the inductor current accordingly.

Under-Voltage Lockout

An under-voltage lockout (UVLO) circuit stops the operation of the converter when the input voltage drops below the typical UVLO threshold of 0.55V. A hysteresis of 200mV is added so that the device cannot be enabled again until the input voltage goes up to 0.75V. This function is implemented in order to prevent the malfunctioning of the device when the input voltage is between 0.55V and 0.75V.

Device Enable and Shutdown Mode

The device is enabled when EN is set high and shuts down when EN is low. During a shutdown, the converter stops switching and all internal control circuitry is turned off.

Bypass Switch

The DIO6197 contains a P-channel MOSFET (Bypass Switch) in parallel with the synchronous rectifying MOSFET. When the IC is enabled (V_{EN} > V_{IH}), the Bypass Switch is turned off to allow the IC to work as a standard boost converter. When the IC is disabled (V_{EN} < V_{IL}) the Bypass Switch is turned on to provide a direct, low impedance connection from the input voltage (at the L pin) to the load (VOUT). The Bypass Switch is not impacted by Undervoltage lockout, Overvoltage, or Thermal shutdown.

Soft Start

After the EN pin is tied to high voltage, the DIO6197 begins to startup. In the beginning, if the input voltage is lower than approximately 1.6V, the device operates at the boundary of Discontinuous Conduction Mode (DCM) and Continuous Conduction Mode (CCM), and the inductor peak current is limited to around 200mA during this stage. If the input voltage is higher than approximately 1.6V, the device starts the Constant Off Time (COT) Mode directly. The current limit threshold in cot mode is 0.7×I_{LIM} within 500μs. In this way, the soft start function reduces the inrush current during startup.

Current Limit Operation

The DIO6197 employs a cycle-by-cycle over-current protection (OCP) function. If the inductor peak current reaches the current limit threshold I_{LIM}, the main switch turns off to stop the further increase of the input current. If the output drops below the input voltage, the DIO6197 enters into Down Mode. The peak current is also limited by I_{LIM} cycle-by-cycle in Down Mode.

Down Mode Regulation and Pass-Through Operation

The DIO6197 features Down Mode and Pass-Through operation when the input voltage is close to or higher than the output voltage.

In the Down Mode, the output voltage is regulated at the target value even when V_{IN}>V_{OUT}. The control circuit changes the behavior of the rectifying PMOS by pulling its gate to input voltage instead of to the ground. In this way, the voltage drop across the PMOS is increased as high as to regulate the output voltage. The power loss also increases in this mode, which needs to be taken into account for thermal consideration.

In the Pass-Through operation, the boost converter stops switching. The rectifying PMOS constantly turns on and the low side switch constantly turns off. The output voltage is the input voltage minus the voltage drop across the dc resistance (DCR) of the inductor and the on-resistance of the rectifying PMOS.

With V_{IN} ramping up, the DIO6197 goes into Down Mode first when V_{IN}>V_{OUT} -50mV. It stays in Down Mode until V_{IN}>V_{OUT} +0.5V and then goes automatically into Pass-Through operation. The DIO6197 exits Pass-Through Mode and goes back to Down Mode when V_{IN} ramps down to 103% of the target output voltage. It stays in Down Mode until the input voltage falls 100mV below the output voltage, returning to Boost operation.

Thermal Shutdown

The DIO6197 has a built-in temperature sensor that monitors the internal junction temperature in boost mode operation. If the junction temperature exceeds the threshold of 150°C, the device stops operating. As soon as the junction temperature drops below the shutdown temperature minus the hysteresis, typically 125°C, it starts operating again.

Device Functional Modes

Burst Mode Operation under Light Load Condition

The boost converter of DIO6197 enters into Burst Mode operation under a light load condition. Refer to Boost Controller Operation for details.

Down Mode Regulation and Pass-Through Mode Operation

The boost converter of DIO6197 automatically enters into Down Mode or pass-through mode operation when the input voltage is higher than the output voltage.

PCB Layout Recommendation

Proper layout of the switching power supplies is very important, and sometimes critical to make it work properly. Especially, for the high switching frequencies converter, If the layout is not carefully done, the regulator could show stability issues as well as EMI issues. Therefore, use wide and short traces for the main current path and for the power ground tracks. The input and output capacitor, as well as the inductor should be placed as close as possible to the IC, as shown in Figure 9.

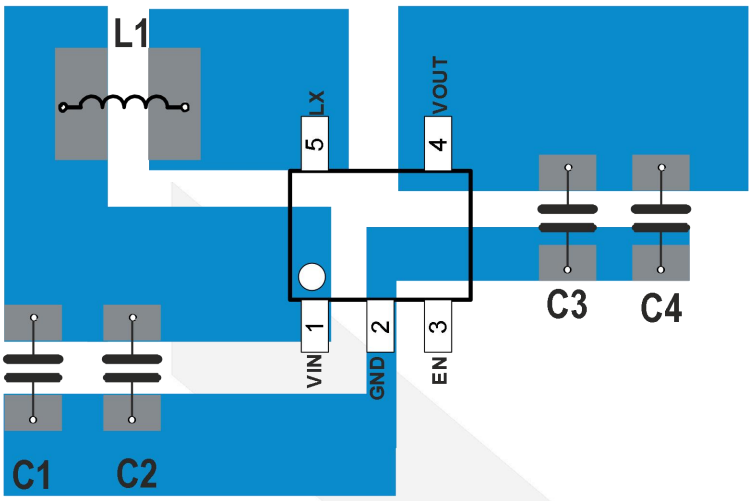
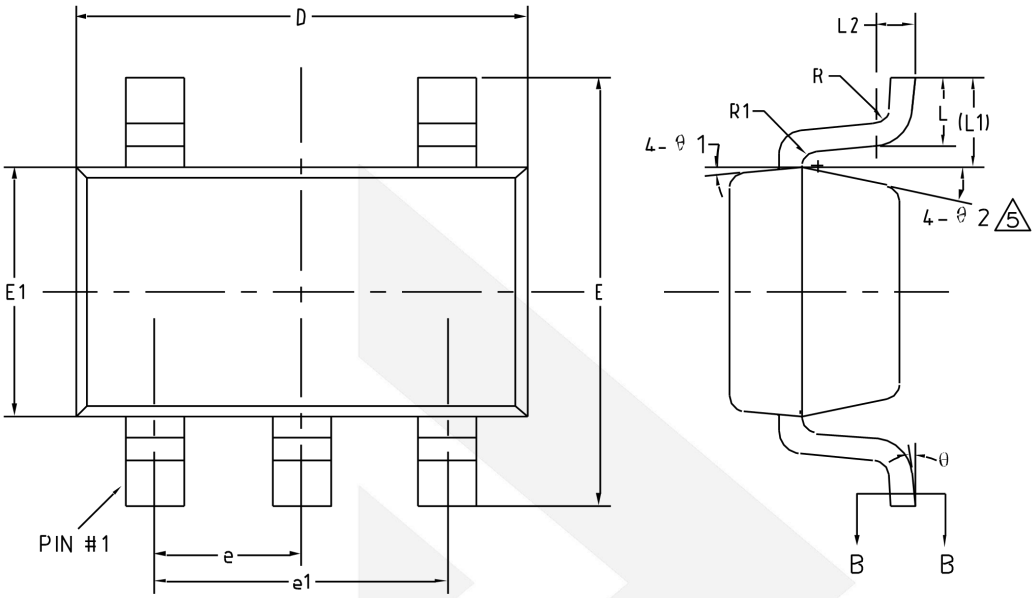
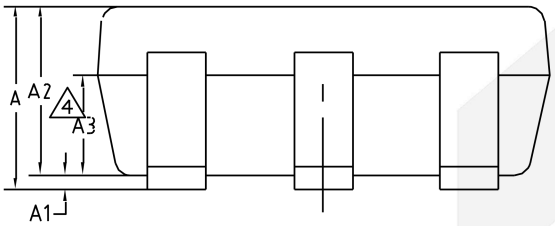
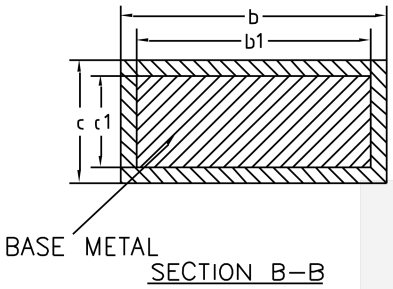


Figure 7. PCB Layout Guide

Physical Dimensions: SOT23-5







COMMON DIMENSIONS (UNITS OF MEASURE=MILLIMETER)			
Symbol	**MIN**	**NOM**	**MAX**
A	-	-	1.25
A1	0	-	0.15
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.36	-	0.50
b1	0.36	0.38	0.45
c	0.14	-	0.20
c1	0.14	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.726
e	0.90	0.95	1.00
e1	1.80	1.90	2.00
L	0.35	0.45	0.60
L1	0.59REF		
L2	0.25BSC		
R	0.10	-	-
R1	0.10	-	0.25
Θ	0°	-	8°
Θ1	3°	5°	7°
Θ2	6°	-	14°

CONTACT US

Dioo is a professional design and sales corporation for high-quality and performance analog semiconductors. The company focuses on industry markets, such as, cell phone, handheld products, laptop, and medical equipment and so on. Dioo's product families include analog signal processing and amplifying, LED drivers and charger IC. Go to http://www.dioo.com for a complete list of Dioo product families.

For additional product information, or full datasheet, please contact with our Sales Department or Representatives.