DIO6199C
Synchronous Boost Converter with Ultra-Low Quiescent Current

Features

- Operating input voltage range: 0.9 V to 5.5 V
- Adjustable output voltage range: 1.8 V to 4.8 V
- Ultra−low quiescent current (VOUT pin): 800 nA
- Ultra−low quiescent current (VIN pin): 600 nA
- Switch peak current limit
- Regulated output voltage in Down mode
- True disconnection during shutdown
- Up to 93% efficiency from 10 mA to 300 mA load
- Packages: DFN2*2-6 and SOT23-6

Applications

- Portable products
- Battery powered systems
- Low power wireless applications
- Wearable applications
- Memory LCD bias
- Optical heart rate monitor LED bias

Descriptions

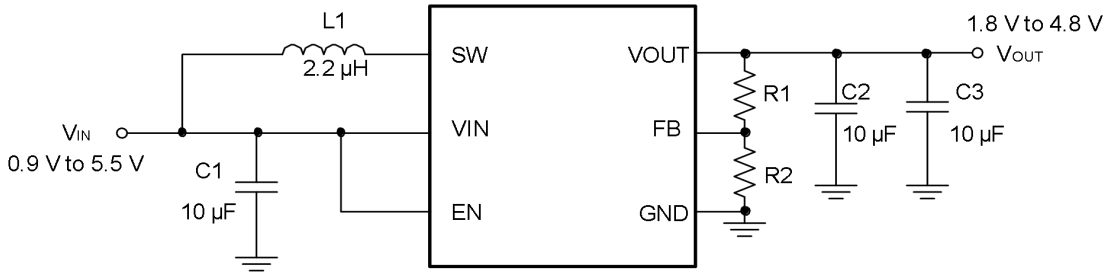
The DIO6199C is a synchronous boost converter with 2 μA ultra-low quiescent current. It can operate efficiently under light load conditions, which is essential to prolong the service life of batteries.

The DIO6199C boost converter adopts Constant Off Time (COT) control topology, which can achieve the highest efficiency with the lowest quiescent current. The device consumes only 2 μA quiescent current under light load.

The DIO6199C can also provide Down mode and Pass-Through mode for different applications. In Down mode, even if the input voltage is higher than the output voltage, the output voltage can be adjusted to the target value. In Pass-Through mode, the output voltage varies with the input voltage. When V_{IN} > V_{OUT} + 0.5 V, DIO6199C exits the Down mode and transfers to Pass-Through mode.

The DIO6199C can disconnect the load from the input power supply when it is disabled, thus realizing the real shutdown thus reducing the current consumption. The device is packaged in DFN2*2-6 and SOT23-6.

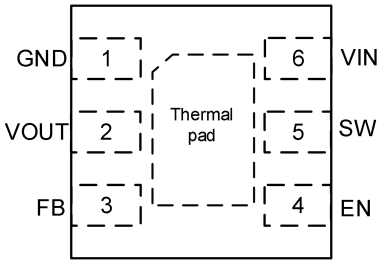
Typical Application



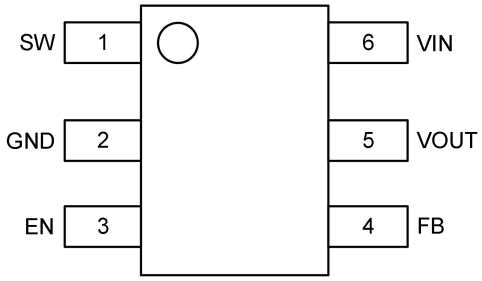
Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T_A	Package	
DIO6199CDN6	FA9C	3	Green	-40 to 85°C	DFN2*2-6	Tape & Reel, 3000
DIO6199CST6	WA9C	3	Green	-40 to 85°C	SOT23-6	Tape & Reel, 3000

Pin Assignment



DFN2*2-6



SOT23-6

Figure 1. Top view

Pin Descriptions

Pin Name	Type	Description
VIN	I	IC power supply input.
SW	PWR	Switch pin of the converter. It is connected to the inductor.
EN	I	Enable logic input. Logic high voltage enables the device; logic low voltage disables the device. Do not leave it floating.
GND	PWR	Ground.
VOUT	PWR	Boost converter output.
FB	I	Voltage feedback of adjustable output voltage. Connect to the center tap of a resistor divider to program the output voltage.
Thermal pad	NC	Not connected internally. Can be connected to GND.

Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Rating” 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) (VIN, SW, VOUT, FB, EN)		-0.3 to 6.0	V
T_J	Operating junction temperature		-40 to 150	°C
T_{STG}	Storage temperature		-65 to 150	°C
$R_{\theta JA}$	Junction-to-ambient thermal resistance	SOT23-6	150	°C/W
		DFN2*2-6	71.7	°C/W
ESD	Human-body model (HBM)		±2000	V
	Charged-device model (CDM)		±2000	V

Note:

(1) All voltage values are with respect to network ground terminal.

Recommend Operating Conditions

Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. DIOO does not recommend exceeding them or designing to absolute maximum ratings.

Symbol	Parameter	Min	Typ	Max	Unit
V_{IN}	Input voltage range	0.9		5.5	V
V_{OUT}	Output voltage range	1.8		4.8	V
L	Inductor	0.7	2.2	2.86	μH
C_{IN}	Input capacitor	1.0	10		μF
C_{OUT}	Output capacitor	10	20	100	μF
T_J	Operating virtual junction temperature	-40		85	°C

Electrical Characteristics

T_J = -40°C to 85°C and V_{IN} = 0.9 V to 5.5 V. Typical values are at V_{IN} = 3.7 V, T_J = 25°C, unless otherwise noted.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Power supply							
V_{IN}	Input voltage range			0.9		5.5	V
V_{UVLO}	Input undervoltage lockout threshold	V_{IN} rising			0.7	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			0.6	1.5	μA
	Quiescent current into V_{OUT} pin	IC enabled, no load, no switching, boost or Down mode T_J = -40°C to 85°C			0.8	2.0	μA
I_{SD}	Shutdown current into V_{IN} pin	IC disabled, V_{IN} = 3.7 V, V_{OUT} = 0 V	T_J = 25°C		0.4		μA
			T_J = 85°C		0.9		μA
Output							
V_{OUT}	Output voltage range			1.8		4.8	V
V_{REF}	Feedback reference voltage	V_{IN} < V_{OUT}, PWM mode		0.98	1.00	1.02	V
		V_{IN} < V_{OUT}, PFM mode			1.03		V
V_{OVP}	Output overvoltage protection threshold	V_{OUT} rising		5.6	5.8	6.0	V
	OVP hysteresis				200	400	mV
I_{FB_LKG}	Leakage current into FB pin	V_{FB} = 1.0 V			10	50	nA
Power switch							
$R_{DS(on)\_LS}$	Low side switch on resistance	V_{OUT} = 3.3 V			300		mΩ
		V_{OUT} = 2.0 V			400		
$R_{DS(on)\_HS}$	Rectifier on resistance	V_{OUT} = 3.3 V			350	450	mΩ
		V_{OUT} = 2.0 V			500	750	
f_{SW}	Operation frequency				1		MHz
I_{LIM}	Current limit threshold	V_{OUT} ≥ 2.5 V, boost operation		0.75	1.0	1.3	A
		V_{OUT} < 2.5 V, boost operation		0.4	0.75		A
I_{SW_LKG}	Leakage current into SW pin (from SW pin to GND)	V_{SW} = 5.0 V, no switch, T_J = -40°C to 85°C				200	nA
Control logic							
V_{IL}	EN input low voltage threshold	V_{IN} ≤ 1.5 V				0.2 × V_{IN}	V
V_{IH}	EN input high voltage threshold	V_{IN} ≤ 1.5 V		0.8 × V_{IN}			V
V_{IL}	EN input low voltage threshold	V_{IN} > 1.5 V				0.4	V

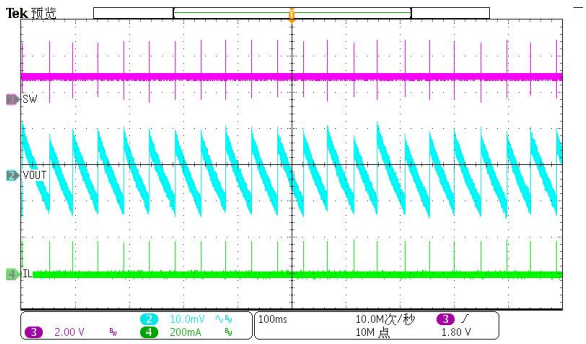
V_{IH}	EN input high voltage threshold	V_{IN} > 1.5 V	1.2			V
I_{EN_LKG}	Leakage current into EN pin	V_{EN} = 5.0 V			50	nA
	Overtemperature protection			150		°C
	Overtemperature hysteresis			25		°C

Note:

(1) Specifications subject to change without notice.

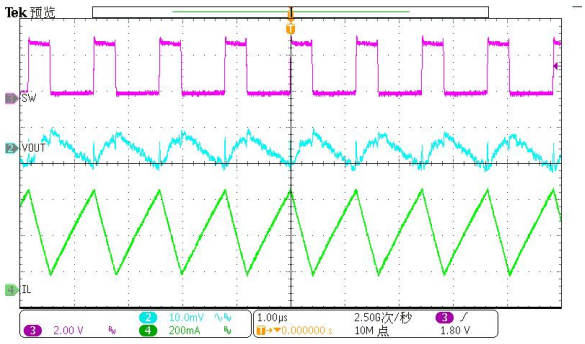
Typical Performance Characteristics

V_{IN} = 1.2 V, V_{OUT} = 3.3 V, C_{IN} = C_{OUT} = 10 μF, L = 2.2 μH, T_A = 25°C, unless otherwise specified.



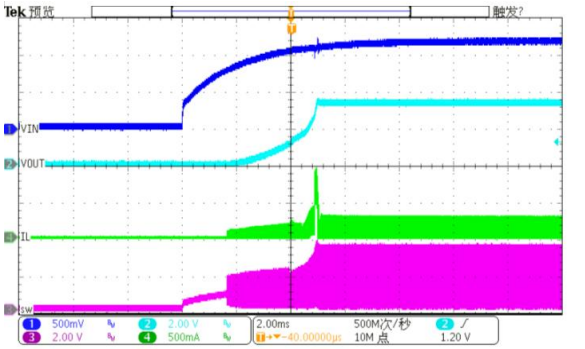
V_{IN} = 1.2 V, V_{OUT} = 3.3 V, No load

Figure 2. Switching waveform at light load



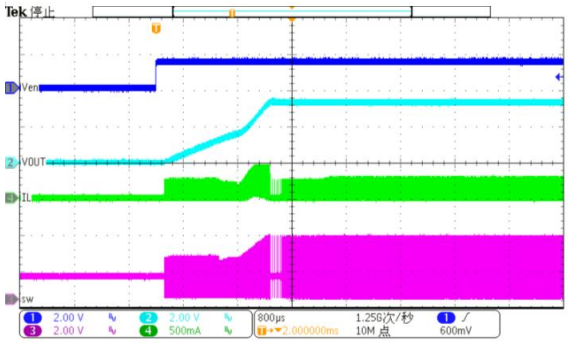
V_{IN} = 1.2 V, V_{OUT} = 3.3 V, Load = 100 mA

Figure 3. Switching waveform at heavy load



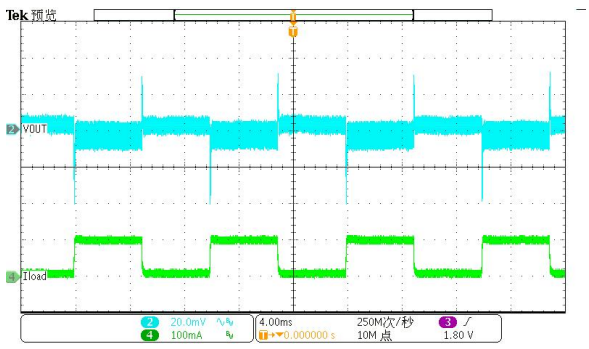
V_{IN} = 1.2 V, V_{OUT} = 3.3 V, Load = 40 mA

Figure 4. Startup by VIN



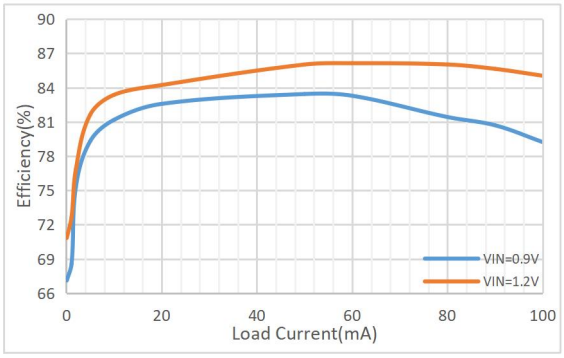
V_{IN} = 1.2 V, V_{OUT} = 3.3 V, Load = 30 mA

Figure 5. Startup by EN



V_{IN} = 1.2 V, V_{OUT} = 3.3 V, Load = 0 ~ 100 mA

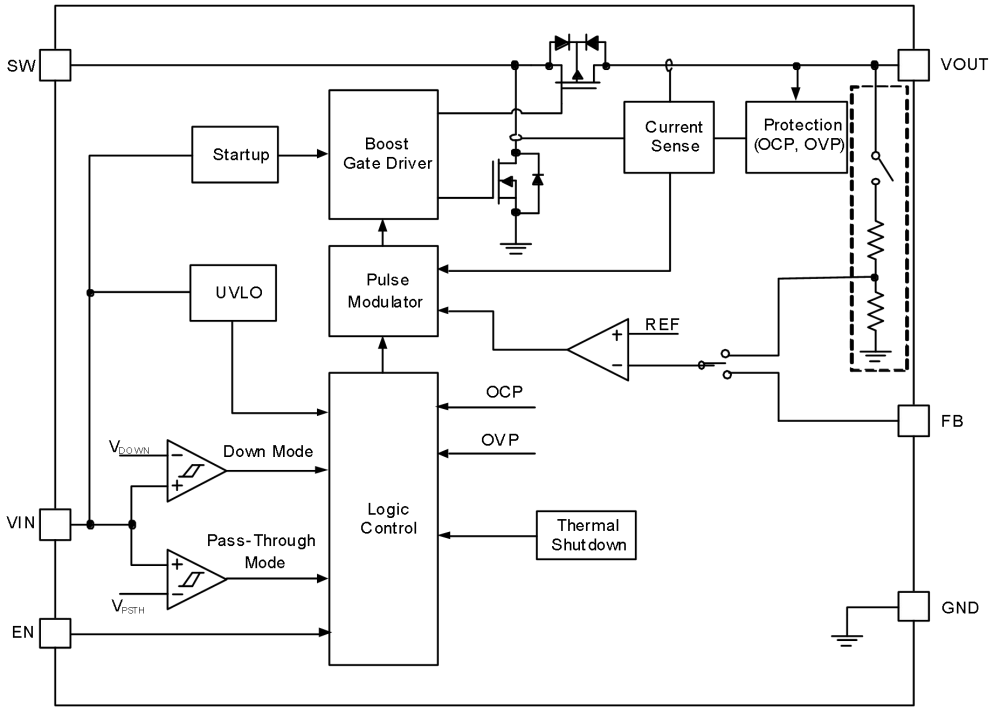
Figure 6. Load transient



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

Figure 7. Efficiency vs. Load current

Block Diagram



Detailed Description

Overview

The DIO6199C synchronous step-up converter is designed for alkaline battery, coin-cell battery, Li-ion or Li-polymer battery powered systems, which requires long battery running time and tiny solution size. The DIO6199C can operate with a wide input voltage from 0.9 V to 5.5 V. It only consumes 2 μA quiescent current and can achieve high efficiency under light load condition.

The DIO6199C operates in a Constant Off Time (COT) control scheme with typical 1 A peak switch current limit. The DIO6199C provides the true shutdown function and the load is completely disconnected from the input so as to minimize the leakage current. It also adopts Down mode and Pass-Through operation when input voltage is close to or higher than the regulated output voltage.

Function Description

Boost controller operation

The DIO6199C 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 light load condition.

To achieve high efficiency, the power stage is realized as a synchronous boost topology. The output voltage V_{OUT} is monitored via an external or internal feedback network which is connected to the voltage error amplifier. 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.

Undervoltage lockout

An undervoltage lockout (UVLO) circuit stops the operation of the converter when the input voltage drops below the typical UVLO threshold of 0.5 V. A hysteresis of 200 mV is added so that the device cannot be enabled again until the input voltage goes up to 0.7 V. This function is implemented in order to prevent malfunctioning of the device when the input voltage is between 0.5 V and 0.7 V.

Enable and disable

When the input voltage is above UVLO rising threshold and the EN pin is pulled to high voltage, the DIO6199C is enabled. When the EN pin is pulled to low voltage, the DIO6199C goes into shutdown mode. In shutdown mode, the device stops switching and the rectifying PMOS fully turns off, providing the completed disconnection between input and output. Less than 0.4 μA input current is consumed in shutdown mode.

Soft start

After the EN pin is tied to high voltage, the DIO6199C begins to startup. At the beginning, if input voltage is lower than approximately 1.6 V, 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 200 mA during this stage. When the output voltage is charged above approximately 1.6 V, the device starts the Constant Off Time (COT) mode. If input voltage is higher than approximately 1.6 V, the device starts the Constant Off Time (COT) mode directly. The current limit threshold in cot mode is reduced within 500 μs. In this way, the soft start function reduces the inrush current during startup. After V_{OUT} reaches the target value, soft start stage ends and the peak current is now determined by the output of an internal error amplifier which compares the feedback of the output voltage and the internal reference voltage.

Current limit operation

The DIO6199C employs 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 so as to stop further increase of the input current. In this case the output voltage will decrease until the power balance between input and output is achieved. If the output drops below the input voltage, the DIO6199C enters into Down mode. The peak current is still limited by I_{LIM} cycle-by-cycle in Down mode. If the output drops below 1.6 V, the DIO6199C enters into startup process again. In Pass-Through operation, current limit function is not enabled.

Output short-to-ground protection

If input voltage is below 1.6 V, the DIO6199C starts to limit the switch current to 200 mA when the output voltage is below 1.6 V. If input voltage is higher than 1.6 V, the DIO6199C gets into hiccup mode when the output voltage is below 0.1 × V_{OUT}. In hiccup mode, the DIO6199C operates 2 ms for every 8 ms. Once the short circuit is released, the DIO6199C goes back to soft start again and regulates the output voltage.

Overvoltage protection

The DIO6199C has an output overvoltage protection (OVP) to protect the device in case that the external feedback resistor divider is wrongly populated. When the output voltage of the DIO6199C exceeds the OVP threshold of 5.8 V, the device stops switching. Once the output voltage falls 0.2 V below the OVP threshold, the device starts operating again.

Down mode regulation and Pass-Through operation

The DIO6199C features Down mode and Pass-Through operation when input voltage is close to or higher than output voltage.

In the Down mode, output voltage is regulated at 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 ground. In this way, the voltage drop across the PMOS is increasing 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 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 DIO6199C goes into Down mode first when V_{IN} > V_{OUT} - 50 mV. It stays in Down mode until V_{IN} > V_{OUT} + 0.5 V and then goes automatically into Pass-Through operation. In the Pass-Through operation, output voltage follows input voltage. The DIO6199C 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 input voltage falls 100 mV below the output voltage, returning to Boost operation.

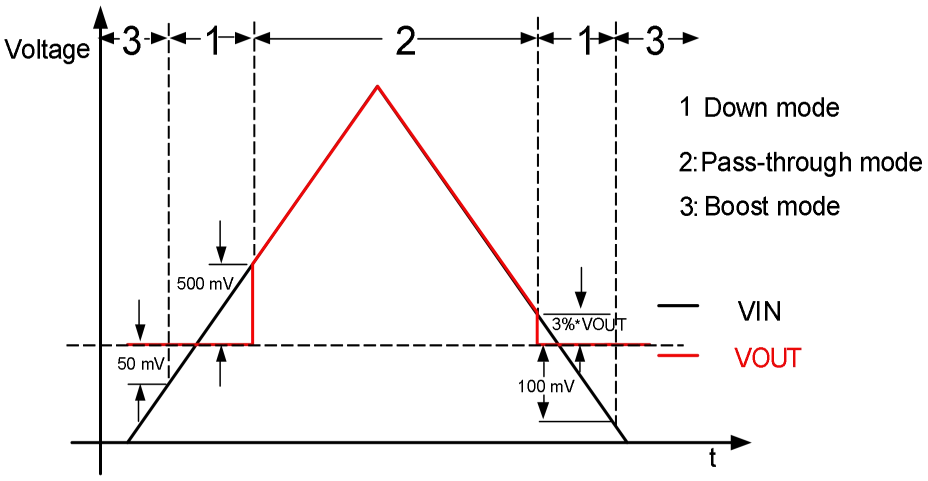


Figure 8. Down mode and Pass-Through operation

Thermal shutdown

The DIO6199C has a built-in temperature sensor which monitors the internal junction temperature in boost mode operation. If the junction temperature exceeds the threshold 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.

Adjustable output voltage

An external resistor divider is used to set the output voltage. The output voltage of the switching regulator (V_{OUT}) is determined by the following equation:

$$V_{OUT} = V_{FB} \times \left(1 + \frac{R_1}{R_2}\right)$$

Device Functional Modes

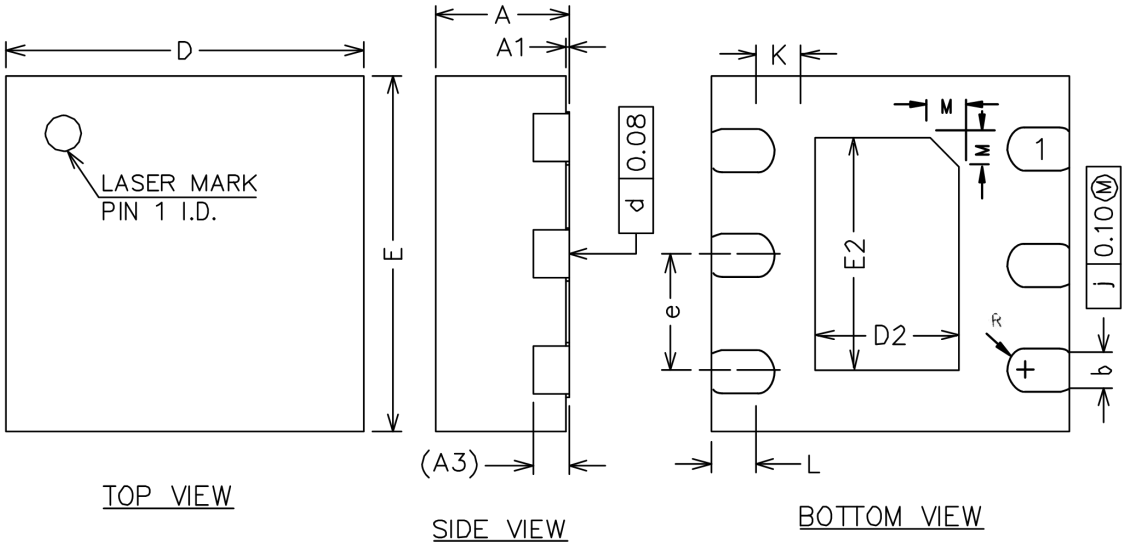
Burst mode operation under light load condition

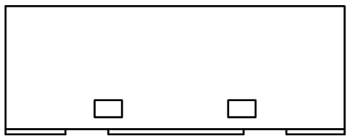
The boost converter of DIO6199C enters into Burst mode operation under light load condition. Refer to Boost Controller Operation for details.

Down mode regulation and Pass-Through mode operation

The boost converter of DIO6199C automatically enters into Down mode or Pass-Through mode operation when input voltage is higher than the target output voltage. Refer to Down mode Regulation and Pass-Through Operation for details.

Physical Dimensions: DFN2*2-6

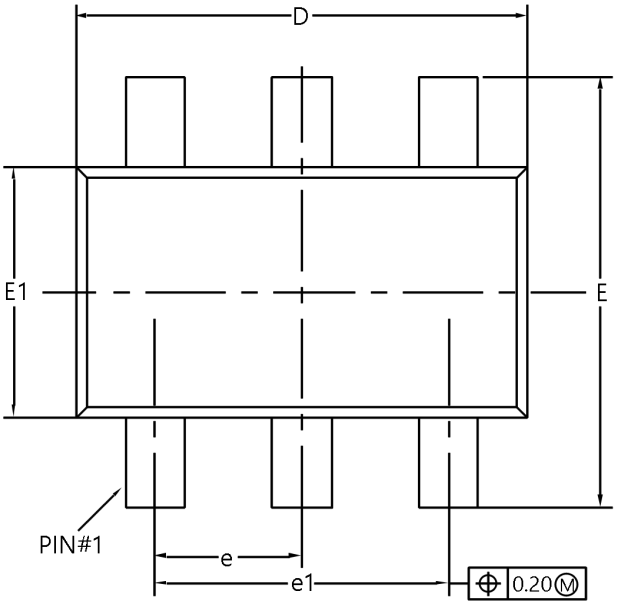


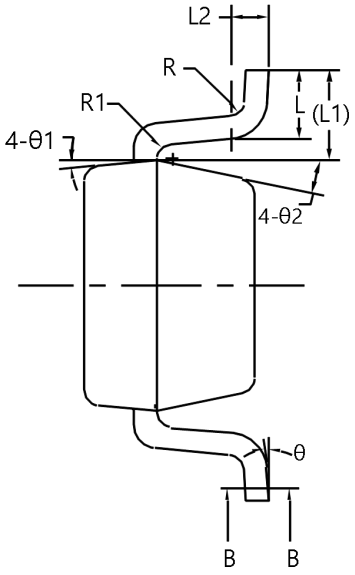


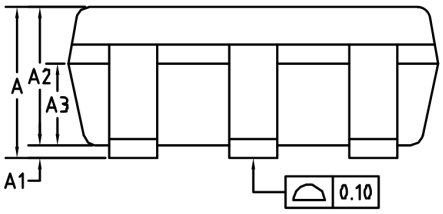
SIDE VIEW

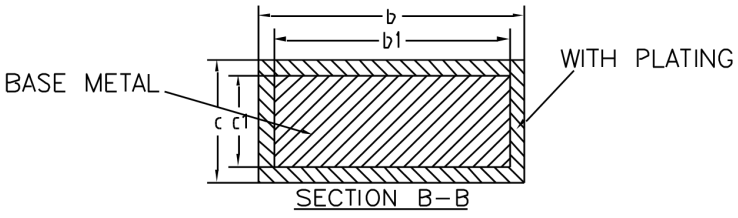
Common Dimension (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.20 REF	
b	0.20	0.25	0.30
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D2	0.70	0.80	0.90
E2	1.20	1.30	1.40
e	0.55	0.65	0.75
K	0.15	0.25	0.35
L	0.30	0.35	0.40
M		0.25 REF	
R		0.13 REF	

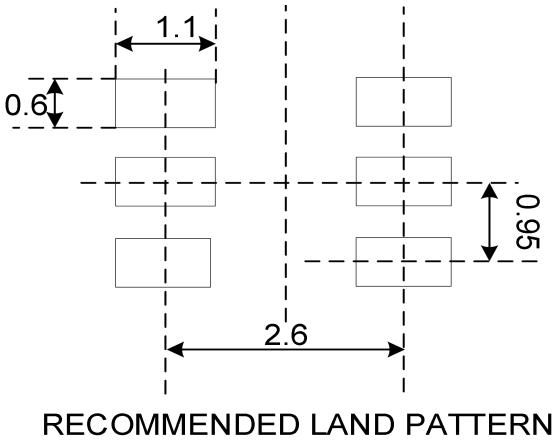
Physical Dimensions: SOT23-6











RECOMMENDED LAND PATTERN

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	0.34	-	0.45
b1	0.34	0.38	0.41
c	0.12	-	0.20
c1	0.12	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.700
e	0.90	0.95	1.00
e1	1.80	1.90	2.00
L	0.30	0.40	0.60
L1	0.59 REF		
L2	0.25 BSC		
R	0.05	-	0.20
R1	0.05	-	0.20
θ	0°	-	8°
θ1	8°	10°	12°
θ2	10°	12°	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.