DIO6095

Synchronous Boost Converter with Ultra-Low Quiescent Current

Features

- Operating Input Voltage Range: 0.9V to 5.5V
- Output Voltage : 5V
- Ultra−Low Quiescent Current (V_{OUT} Pin): 600nA
- Ultra−Low Quiescent Current (V_{IN} Pin): 400nA
- Switch Peak Current Limit
- Regulated Output Voltage in Down Mode
- True Disconnection During Shutdown
- Up to 93% Efficiency from 10mA to 300mA Load
- Package: DFN2*2-6, WLCSP-6

Applications

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

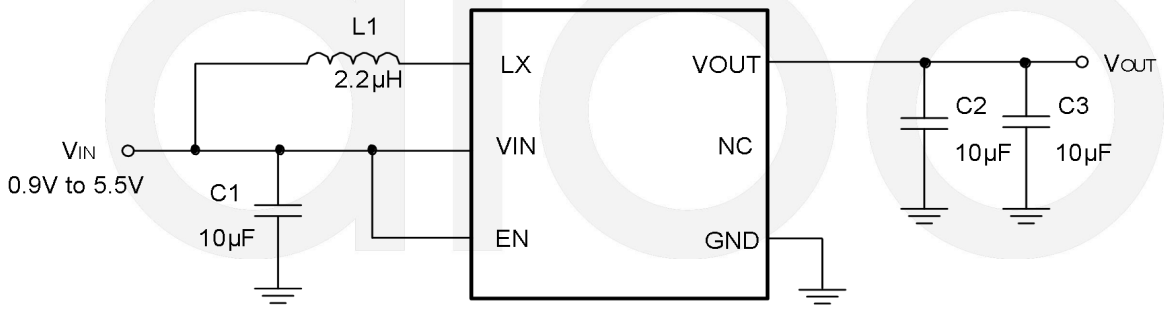
Descriptions

DIO6095 is a synchronous boost converter with 1μA ultra-low quiescent current. It can operate efficiently under light load conditions, which is essential to prolong the service life of batteries.

DIO6095 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.

DIO6095 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 WLCSP-6.

Typical Application

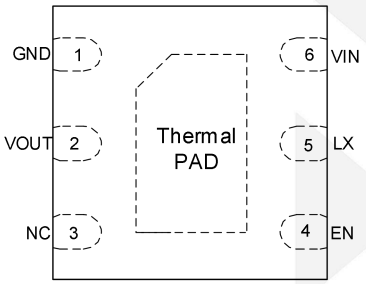


Ordering Information

Order Part Number	Top Marking		T_A	Package	
DIO6095DN6	DFV5	Green	-40 to 85°C	DFN2*2-6	Tape & Reel, 3000
DIO6095WL6	DFV5	Green	-40 to 85°C	WLCSP-6	Tape & Reel, 3000

Pin Assignment

DFN2*2-6



WLCSP-6

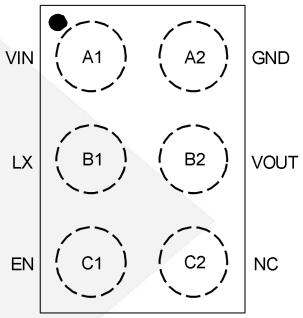


Figure 1 Top View

Pin Descriptions

Pin Name	Description
GND	Ground.
VOUT	Boost converter output.
NC	No Connect. Floating or connect to GND.
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.
VIN	IC power supply input.
Thermal PAD	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, VOUT, 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		5.5	V
V_{OUT}	Output voltage range	4.9	5.0	5.1	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		125	°C

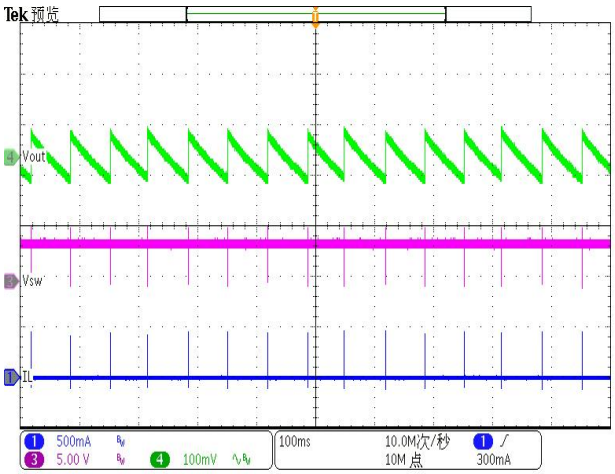
Electrical Characteristics

T_J = -40°C to 125°C and V_{IN} = 0.9V to 5.5V. Typical values are at V_{IN} = 3.7V, T_J = 25°C, unless otherwise noted.

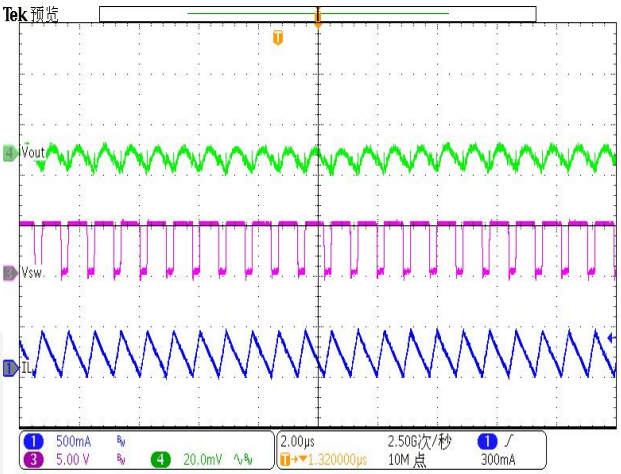
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Power Supply						
V_{IN}	Input voltage range		0.9		5.5	V
V_{UVLO}	Input under voltage lockout threshold	V_{IN} rising		0.75	0.9	V
	UVLO hysteresis			200		mV
I_Q	Quiescent current into V_{IN} pin	IC enabled, no Load, no Switching T_J = -40°C to 85°C		0.4	1.1	μA
	Quiescent current into V_{OUT} pin	IC enabled, no Load, no Switching, Boost or Down Mode T_J = -40°C to 85°C		0.6	1.5	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		4.9	5.0	5.1	V
V_{OVP}	Output overvoltage protection threshold	V_{OUT} rising	5.6	5.8	6.0	V
	OVP hysteresis			100	200	mV
Power Switch						
$R_{DS(on)\_LS}$	Low side switch on resistance	V_{OUT} = 5.0V		250		mΩ
$R_{DS(on)\_HS}$	Rectifier on resistance	V_{OUT} = 5.0V		300	350	mΩ
F_{LX}	Operation frequency			1		MHz
I_{LIM}	Current limit threshold	V_{OUT} = 5V, 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	V_{IN} ≤ 1.5V	0.2 x V_{IN}			V
V_{IH}	EN input high voltage threshold	V_{IN} ≤ 1.5V			0.8 x V_{IN}	V
V_{IL}	EN input low voltage threshold	V_{IN} > 1.5V	0.4			V
V_{IH}	EN input high voltage threshold	V_{IN} > 1.5V			1.2	V
I_{EN_LKG}	Leakage current into EN pin	V_{EN} = 5.0V			50	nA
	Over temperature protection			150		°C
	Over temperature hysteresis			25		°C

Typical Characteristics

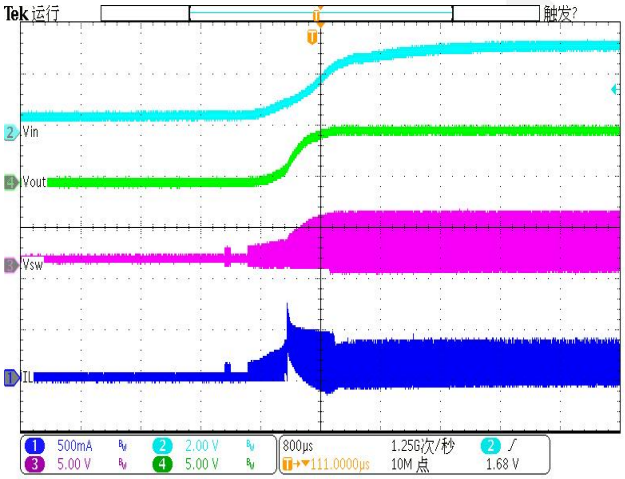
Vin=3.7V, No Load at Light Load



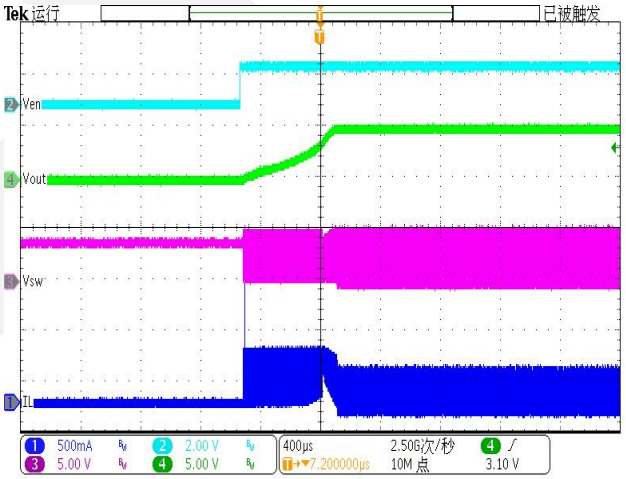
Vin=3.7V, Load=100mA at Heavy Load



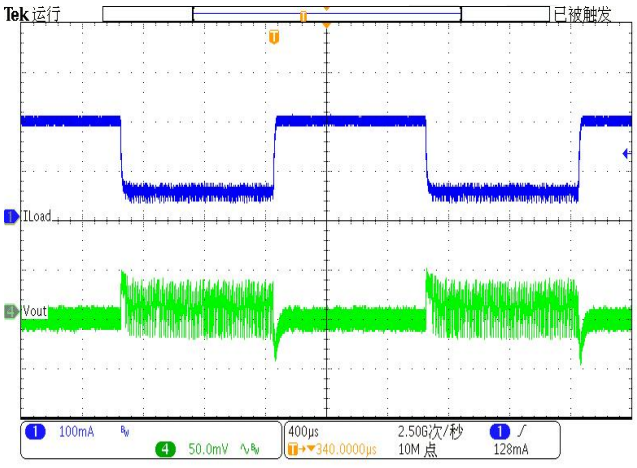
Vin=3.7V, Load=50mA start up by Vin



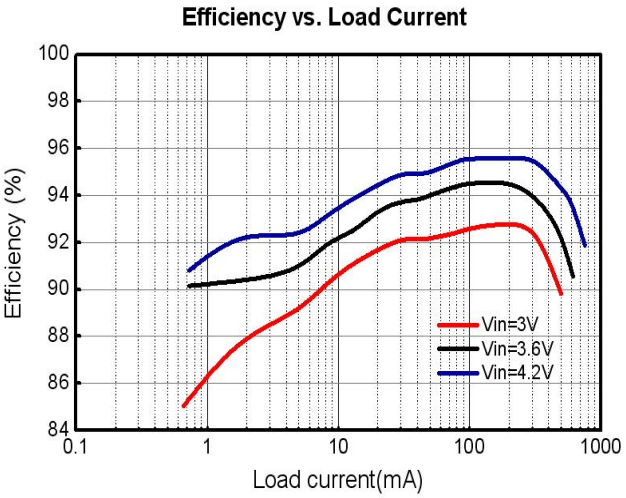
Vin=3.7V, Load=50mA start up by En



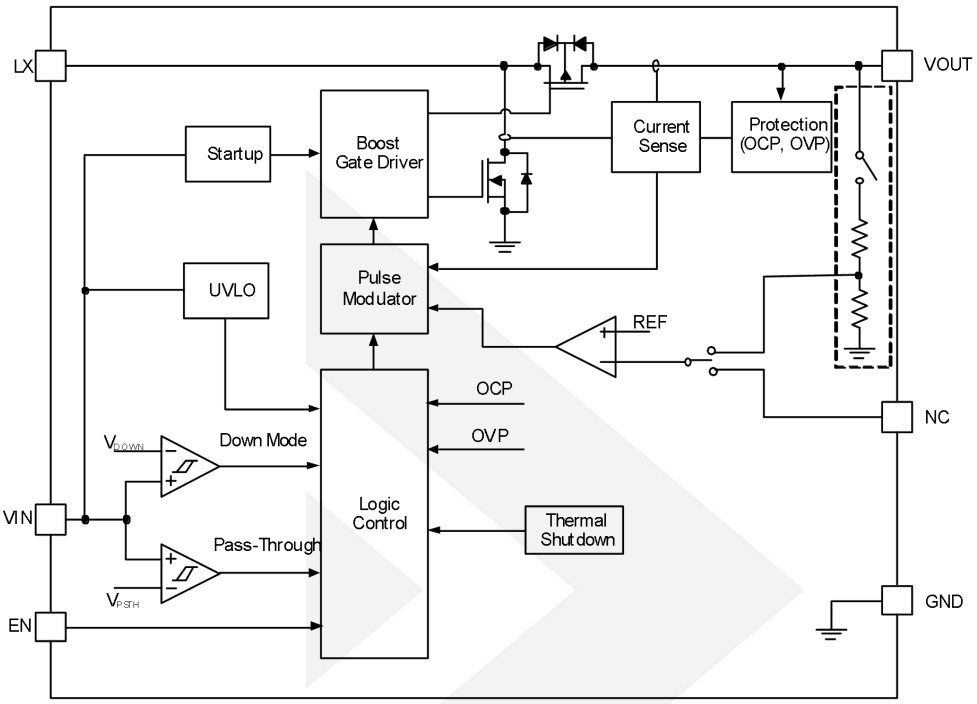
Vin=3.7V, Vout=5V, Load=50mA to 200mA



Vin=3V/3.6/4.2V, Vout=5V



Block Diagram



Detailed Description

Overview

The DIO6095 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 DIO6095 can operate with a wide input voltage from 0.9V to 5.5V. It only consumes 1μA quiescent current and can achieve high efficiency under light load condition.

The DIO6095 operates in a hysteretic control scheme with typical 1A peak switch current limit. The DIO6095 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.

Feature Description

Boost Controller Operation

The DIO6095 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 an 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. 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 0.5V. 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 malfunctioning of the device when the input voltage is between 0.5V and 0.75V.

Enable and Disable

When the input voltage is above UVLO rising threshold and the EN pin is pulled to high voltage, the DIO6095 is enabled. When the EN pin is pulled to low voltage, the DIO6095 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 0.5μA input current is consumed in shutdown mode.

Soft Start

After the EN pin is tied to high voltage, the DIO6095 begins to startup. At the beginning, if 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 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 $0.7\times I_{LIM}$ within 500μs. In this way, the soft start function reduces the inrush current during startup.

Current Limit Operation

The DIO6095 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. If the output drops below the input voltage, the DIO6095 enters into Down Mode. The peak current is still limited by I_{LIM} cycle-by-cycle in Down Mode.

Down Mode Regulation and Pass-Through Operation

The DIO6095 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 DIO6095 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 DIO6095 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 100mV below the output voltage, returning to Boost operation.

Thermal Shutdown

The DIO6095 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.

Device Functional Modes

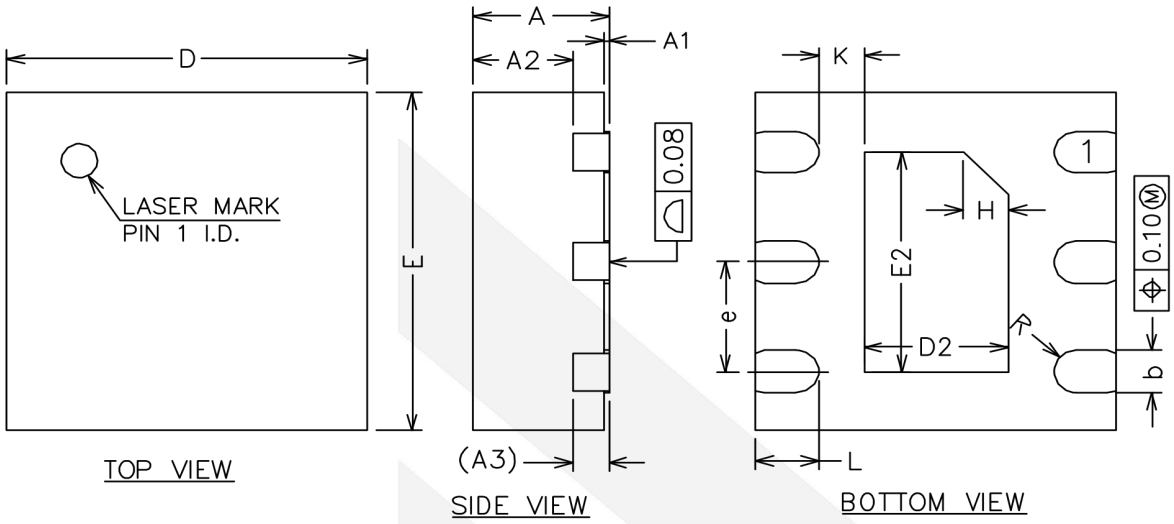
Burst Mode Operation under Light Load Condition

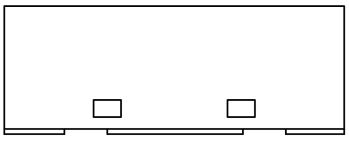
The boost converter of DIO6095 enters into Burst Mode operation under light load condition. Refer to Boost Controller Operation for details.

Down Mode Regulation and Pass-Through Mode Operation

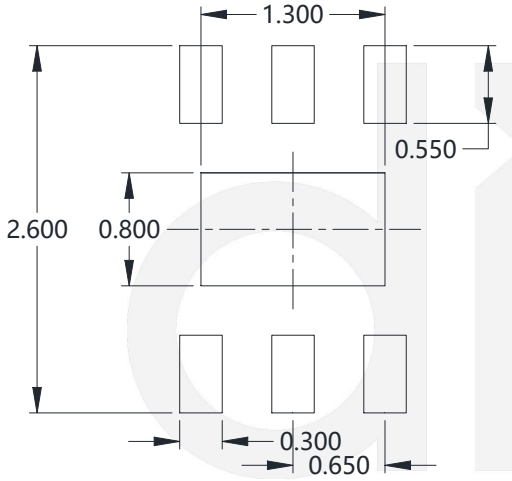
The boost converter of DIO6095 automatically enters into Down Mode or pass-through mode operation when input voltage is higher than the output voltage. Refer to Down Mode Regulation and Pass-Through Operation for details.

Physical Dimensions: DFN2*2-6



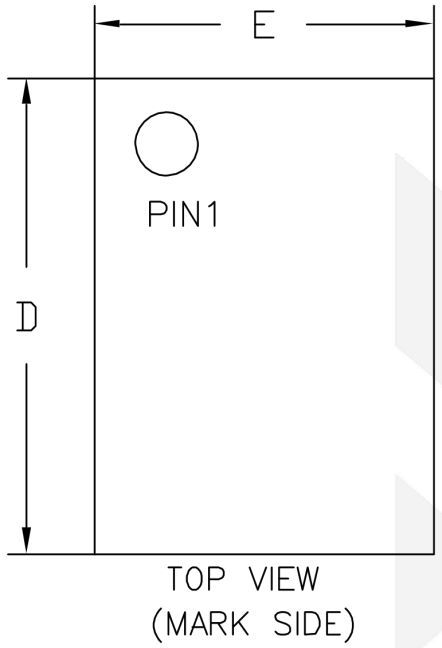


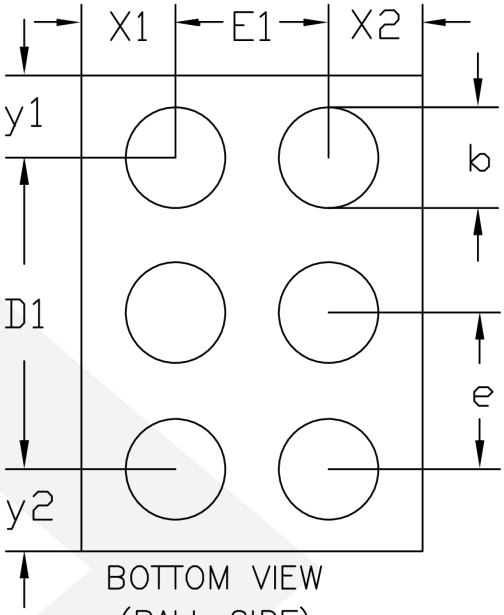
COMMON DIMENSIONS (UNITS OF MEASURE=MILLIMETER)			
Symbol	**MIN**	**NOM**	**MAX**
A	0.70	0.75	0.80
A1	0	0.02	0.05
A2	0.50	0.55	0.60
A3		0.20REF	
b	0.20	0.25	0.30
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D2	0.70	0.80	0.90
E2	1.20	1.30	1.40
e	0.55	0.65	0.75
H		0.25REF	
K	0.20	-	-
L	0.30	0.35	0.40
R	0.11	-	-

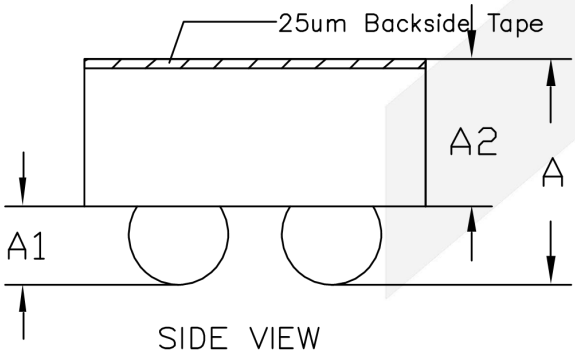


RECOMMENDED LAND PATTERN(Uint:mm)

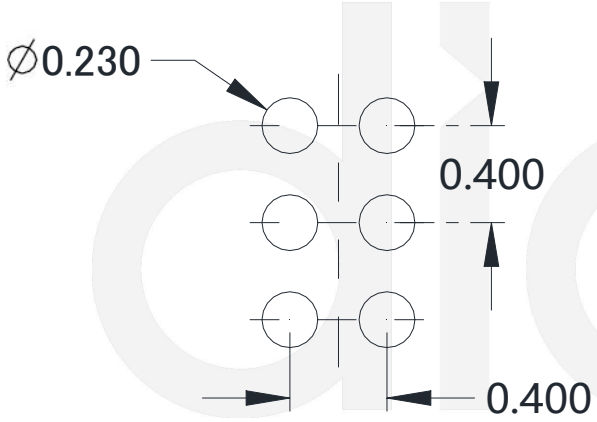
Physical Dimensions: WLCSP-6







COMMON DIMENSIONS (UNITS OF MEASURE=MILLIMETER)			
Symbol	**MIN**	**NOM**	**MAX**
A	0.535	0.580	0.625
A1	0.182	0.202	0.222
A2	0.353	0.378	0.403
D	1.196	1.226	1.256
D1		0.800 BSC	
E	0.854	0.884	0.914
E1		0.400 BSC	
b	0.240	0.260	0.280
e		0.400 BSC	
x1		0.242 REF	
x2		0.242 REF	
y1		0.213 REF	
y2		0.213 REF	



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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.

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