LP28014SE

Standalone 1A Single Cell Linear Charger

Features

- Easy-to-use standalone single cell charger
- High input voltage linear charger
  - Support up to 6.5V input voltage with 40V absolute maximum input rating
  - Maximum BAT withstand voltage up to 15V
  - Programmable up to 1A fast charge current
  - Trickle charge 10% of fast charge current
  - Programmable termination current
- High integration
  - Integrated reverse blocking MOSFET
  - Integrated charge current sensing
  - Internal loop compensation
  - Charge operation indication driver
- Support full charge cycle of trickle charge, constant current charge and constant voltage charge, charge termination and recharge
- <0.1μA battery leakage current
- Protections
  - Input under-voltage lockout (UVLO)
  - Over-voltage protection (OVP)
  - Battery reverse connection protection
  - Thermal regulation fold back
- RoHS Compliant and 100% Lead (Pb)-Free

Applications

- Wireless Speaker
- Cordless Power Tools
- Gaming Devices
- Portable Media Players
- Handheld Battery-Powered Devices
- Charging Docks and Cradles
- Toys
- E-Cigarettes

General Description

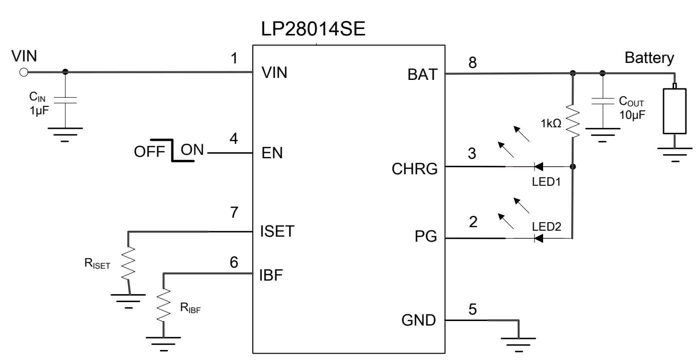
The LP28014SE device is a highly advanced linear charger for single cell Li-Ion and Li-Polymer battery. The device is ideally suited for portable applications since the DFN-8 package and low number of external components required.

The device employs a full charge algorithm with trickle current/constant current/constant voltage mode, charge termination and recharge. The device supports charge current up to 1A programmed by one external resistor. The device can withstand an input voltage up to 40V which can protect from the accidental insertion of high voltage adaptor. The device can withstand a BAT voltage up to 15V which is suited for power battery application. Without input supply, the battery reverse current is less than 0.1μA.

The device provides various safety features for battery charging, including input-over-voltage protection, battery reverse connection protection and device junction temperature-limit protection by limiting the charge current, which is implemented by an internal thermal fold back regulation loop.

The LP28014SE is available in a DFN-8 (2mmx2mm) package.

Typical Application Circuit



Order Information

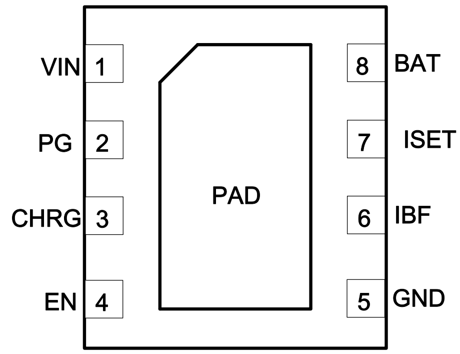
LP28014SE □□ □ □□□

- □□□: Battery Voltage
  - Default:4.20V
  - 435:4.35V
  - 44:4.40V
- □: F: Pb-Free
- □□: Package Type
  - QV: DFN-8

Device Information

Part Number	Top Marking	Battery Voltage	Moisture Sensitivity Level	Package	Shipping
LP28014SEQVF	LPS LP28014 SEYWX	4.20V	MSL3	DFN-8	4K/REEL
LP28014SEQVF-435	LPS LP28014 SEAYWX	4.35V	MSL3	DFN-8	4K/REEL
LP28014SEQVF-44	LPS LP28014 SEBYWX	4.40V	MSL3	DFN-8	4K/REEL
Marking indication: Y: Production year. W: Production week. X: Series number.					

Pin Diagram



DFN-8 (Top View)

Pin Description

Pin	Name	Description
1	VIN	Positive Supply Voltage Input. Place a 1μF ceramic capacitor from VIN to GND and place the capacitor as close as possible to IC.
2	PG	Open-Drain Status Output. Low indicates the input voltage is above the input UVLO voltage and the OUT (battery)+150mV voltage, and lower than OVP threshold.
3	CHRG	Open-Drain Charge Status Output. When the device is in charging state, the CHRG pin is pulled low by an internal NMOS. When the charge cycle is completed, the internal NMOS turned-off, the pin could be pulled high by an external pull-up resistor.
4	EN	Charge Enable Input. Low active.
5	GND	GND. Connect to the system ground.
6	IBF	Termination Current Program Pin. Connect this pin with an external resistor (R_{IBF}) to GND to program the charge termination current.
7	ISET	Fast Charge Current Program Pin. Connect this pin with an external resistor (R_{ISET}) to GND to program the fast charge current.
8	BAT	Battery Pin. Connect to the battery, A 1~10μF capacitor is needed typically.
9	PAD	Ground reference for the device that is also the thermal pad used to conduct heat from the device.

Absolute Maximum Ratings (1)

- VIN to GND ---------- -0.3V to 40V
- BAT to GND ---------- -5V to 15V
- Other Pin to GND ---------- -0.3V to 6.5V
- Output Current ---------- 1200mA
- Maximum Power Dissipation (P_D, T_A=25℃) ---------- 1.5W
- Maximum Junction Temperature (T_J) ---------- 150℃
- Storage Temperature ---------- -55℃ to 150℃
- Maximum Soldering Temperature (at leads, 10 sec) ---------- 260℃

Note: (1) Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions 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.

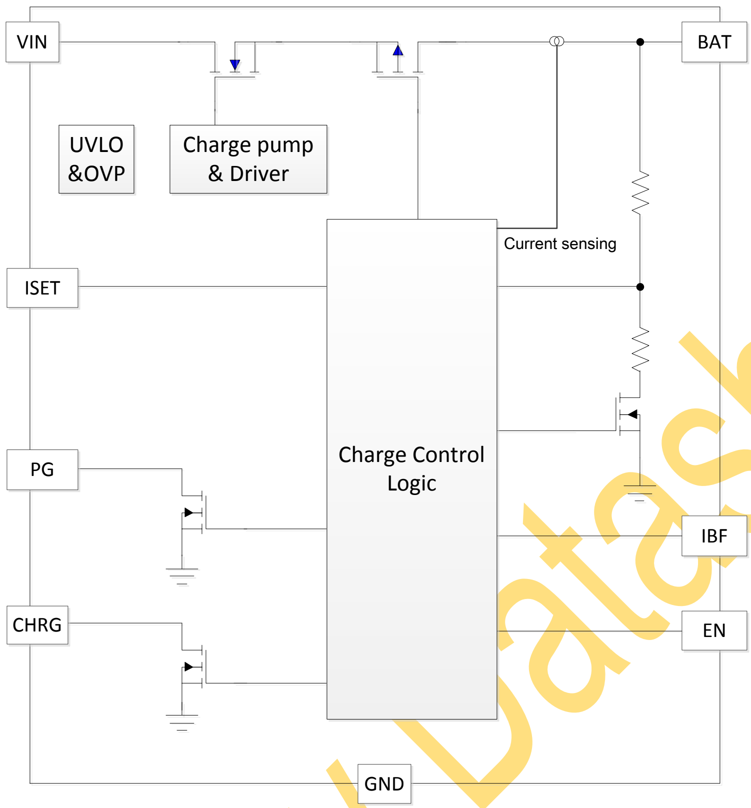
ESD Susceptibility

- HBM(Human Body Model) ---------- 2KV
- MM(Machine Model) ---------- 200V

Recommended Operating Conditions

- Input Voltage ---------- 4.5V to 6V
- Maximum Charge Current ---------- 1000mA
- Operating Junction Temperature Range (T_J) ---------- -40℃ to 150℃
- Operating Ambient Temperature Range (T_A) ---------- -40℃ to 85℃

Functional Block Diagram



Electrical Characteristics

(The specifications are at T_A=25℃, V_{IN} = 5V, unless otherwise noted.)

Symbol	Parameter	Condition	Min	Typ	Max	Units
INPUT VOLTAGE AND CURRENT						
V_{IN}	Input Voltage Range		4.5		6	V
I_{CC}	Input Supply Current	Standby mode (charge terminated)		200	400	uA
V_{UVLO}	Under Voltage Lockout of V_{IN}	V_{IN} Rising	3.3	3.5	3.7	V
V_{UVLO_HYS}	V_{UVLO} Hysteresis	V_{IN} Falling		170		mV
V_{OVP}	Over-Voltage Protection Threshold Voltage	V_{IN} Rising	6	6.5	7	V
V_{OVP_HYS}	OVP Hysteresis	V_{IN} Falling		300		mV
QUIESCENT CURRENT						
$I_{BAT\_Leakage}$	Battery Leakage Current	LP28014SEQVF V_{IN} floating, V_{BAT}=4.2V			-0.1	μA
$I_{BAT\_Standby}$	Battery Standby Current	Charge Terminated LP28014SEQVF V_{IN}=5V, V_{BAT}=4.2V			-2	μA
BATTTERY CHARGER						
V_{FLOAT}	Regulated Output Voltage	LP28014SEQVF	-1%	4.2	1%	V
		LP28014SEQVF-435	-1%	4.35	1%	V
		LP28014SEQVF-44	-1%	4.4	1%	V
I_{BAT}	Constant Charge Current	R_{ISET}=1.8kΩ, Constant Current Mode	900	1000	1100	mA
		R_{ISET}=3.6kΩ, Constant Current Mode	450	500	550	mA
I_{TERM}	Termination Current	R_{ISET}=1.8kΩ, R_{IBF}=18kΩ		100		mA
		R_{ISET}=1.8kΩ, R_{IBF}=36kΩ		50		mA
I_{TRIKL}	Trickle Charge Current	V_{BAT}<V_{TRIKL}, R_{ISET}=1.8kΩ		100		mA
V_{TRIKL}	Trickle Charge Threshold Voltage	LP28014SEQVF V_{BAT} Rising		2.6		V

		LP28014SEQVF-435 V_{BAT} Rising		2.6		V
		LP28014SEQVF-44 V_{BAT} Rising		2.6		V
V_{TRHYS}	Trickle Charge Hysteresis Voltage	LP28014SEQVF V_{BAT} Falling		170		mV
		LP28014SEQVF-435 V_{BAT} Falling		170		mV
		LP28014SEQVF-44 V_{BAT} Falling		170		mV
ΔV_{RECHRG}	Battery Recharge Voltage Difference Threshold (V_{FLOAT} -V_{RECHRG})	LP28014SEQVF V_{BAT} Falling		150		mV
		LP28014SEQVF-435 V_{BAT} Falling		150		mV
		LP28014SEQVF-44 V_{BAT} Falling		150		mV
T_{J_LIMIT}	Junction Temperature Limit	Thermal protection state		145		℃
R_{DS}	VIN-BAT MOSFET on-resistance			600		mΩ
ISET/CHARG/PG PINs						
V_{ISET}	ISET Pin Voltage			1		V
V_{STAT}	STAT Pin Output Low Voltage	I_{STAT}=5mA			0.5	V
I_{STAT}	CHRG/PG Pin Sink Current				5	mA
EN PIN						
V_{EN_ON}	EN Logic-Low Voltage Threshold	EN Falling			0.4	V
V_{EN_OFF}	EN Logic-High Voltage Threshold	EN Rising	1.4			V

Typical Characteristics

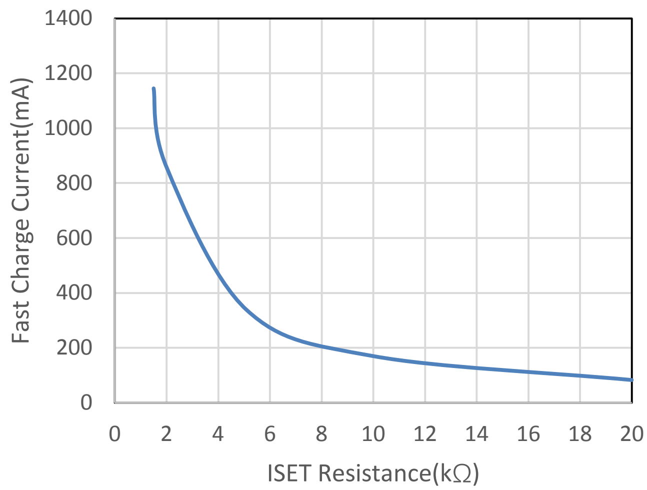


Figure 1. Fast Charge Current vs ISET Resistance
V_{IN}=5V, V_{BAT}=3.7V, 25C°

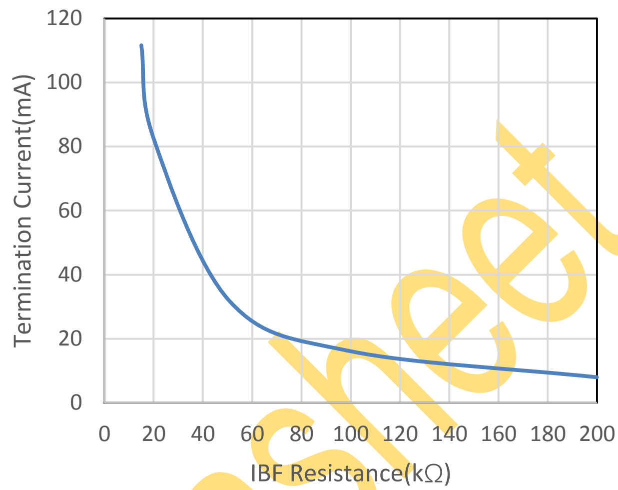


Figure 2. Termination vs IBF Resistance
R_{ISET}=1/10R_{IBF}, 25C°

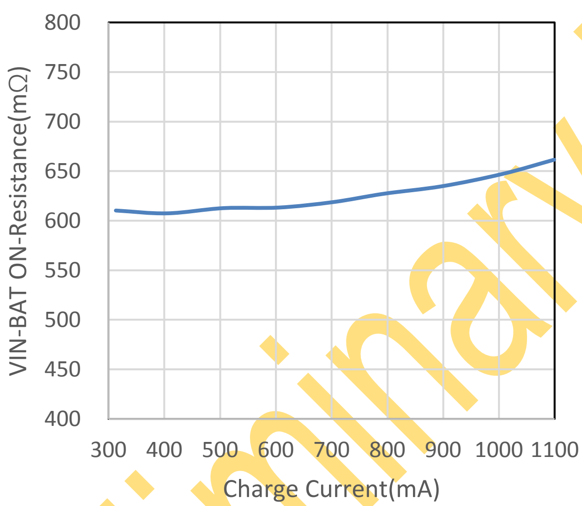


Figure 3. VIN-BAT ON-Resistance vs Charge Current
V_{BAT}=3.7V , 25C°

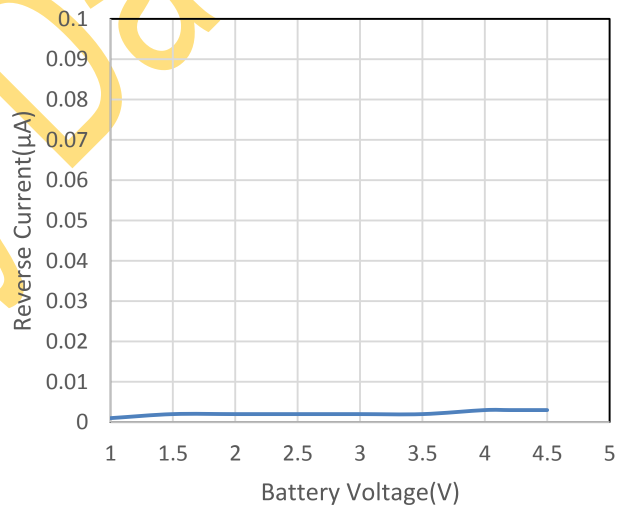


Figure 4. Battery Reverse Current vs V_{BAT}
V_{IN}=Floating, 25C°

Detailed Description

Overview

The LP28014SE device is a highly advanced linear charger with up to 1A maximum charge current for single cell Li-Ion and Li-Polymer battery. The device charges the battery in three modes: trickle current mode, constant current mode and constant voltage mode.

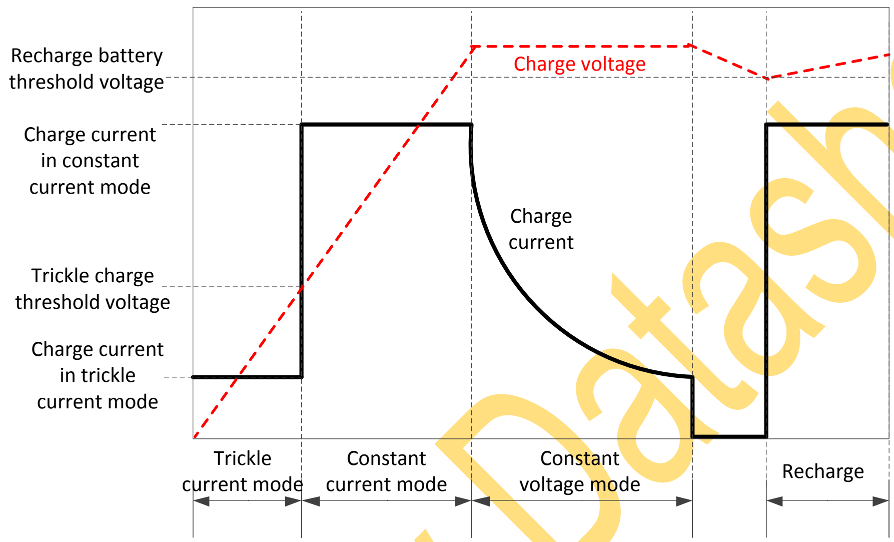


Figure 5. Typical Charge Profile

When the battery voltage is lower than trickle charge threshold voltage 2.6V (typical), the device is in trickle current mode, the charge current will be set as approximately 10% of the ISET programmed fast current to bring the battery voltage up to a safe level for full current charging. When the battery voltage rises to be higher than trickle charge threshold voltage, the device enters the constant current mode, where the charge current is 100% of the ISET programmed current. When the battery voltage approaches the float voltage, the device goes to constant voltage mode, the charge current starts to decrease. When the charge current is lower than the IBF programed termination current threshold, the device will terminate the charging.

The device will automatically recharge the battery while the battery voltage drops 150mV (typical, ΔV_{RECHRG}) from the float voltage.

ISET Programming Charge Current

The constant charge current (I_{BAT}) is set by a resistor (R_{ISET}) connecting from the ISET pin to GND. The relationship of the constant current and the programming resistance is established by the following formula:

$$I_{BAT} = \frac{V_{ISET} \times 1800}{R_{ISET}}$$

IBF Programming Termination Current

The battery charge termination current (I_{TERM}) is programmed by the resistor connecting from the IBF pin to GND and the resistor connecting from the ISET pin to GND, the formula showed as below:

$$I_{TERM} = \frac{R_{ISET} \times I_{BAT}}{R_{IBF}}$$

Automatic Recharge

Once the charge cycle is terminated, the LP28014SE device continuously monitors the voltage on the BAT pin by a comparator with a 1.95ms filter. A new charge cycle restarts when the battery voltage drops by a voltage difference ΔV_{RECHRG} 150mV (typical) from the float voltage, which means the battery level drops to approximately 80% to 90% capacity. This ensures that the battery always keeps at or near a fully charged condition.

Undervoltage Lockout (UVLO)

An internal UVLO circuit monitors the input voltage and keeps the device in Shutdown mode until the input supply rises above the UVLO threshold. The UVLO circuitry has a built-in hysteresis of 170 mV. Again, the input supply must rise to a level 150 mV above the battery voltage before the LP28014SE become operational. The UVLO circuit is always active. Whenever the input supply is below the UVLO threshold or within +150 mV of the voltage at the VBAT pin, the LP28014SE are placed in Shutdown mode. During any UVLO condition, the battery reverse discharge current is less than 0.1 μA.

Enable Function

The LP28014SE features an enable/disable function. An input "Low" signal or floating connection on EN pin will enable the device. To ensure the device be active, the EN low voltage level must be lower than 0.4V. The device will enter the shutdown mode when the voltage on the EN pin is higher than 1.4V. If the enable function is not needed in a specific application, the EN pin could be shorted to GND or floating to keep the device continuously active.

Charge Status Indicator (CHAG & PG)

When the input voltage is above the UVLO and above the battery voltage+150mV ($V_{IN}>V_{BAT}+150mV$), and also lower than OVP ($V_{IN}<V_{OVP}$), the PG internal NMOS turns on and provides a low impedance path to ground.

Function	PG
$V_{IN}<V_{UVLO}$	Hi-Z
$V_{UVLO}<V_{IN}<V_{OVP}$	Low
$V_{OVP}<V_{IN}$	Hi-Z

CHRG pull-down state indicates that the LP28014SE is in a charge cycle. When the charger is not in charging status, the CHRG pin will become high impedance.

Function	CHRG
Charging	Low
Other Status	Hi-Z

Junction Temperature-Limit Protection

An internal thermal regulation foldback loop reduces charge current if the junction temperature attempts to rise above a preset value of approximately 145℃. This function protects the device from excessive temperature and allows the user to get the limits of the power handling capability of a given circuit board without risk of damaging the device. The charge current can be set according to typical ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions.

The reason which causes the LP28014SE device to reduce charge current through thermal foldback loop is the power dissipation of the device. Nearly all of the power dissipation is generated by the internal MOSFETs, the power dissipation can be calculated approximately:

$$P_D = (V_{IN} - V_{BAT}) \times I_{BAT}$$

Where P_D is the power dissipation, V_{IN} is the input supply voltage, V_{BAT} is the battery voltage and I_{BAT} is the charge current.

Application Information

Thermal Consideration

Due to the low efficiency of linear charging, the most important factors are thermal design and cost, which are a direct function of the input voltage, output charge current and thermal impedance between the battery charger and the ambient cooling air. The worst-case situation is when the device has transitioned from the trickle current mode to the constant current mode. In this situation, the battery charger has to dissipate the maximum power.

In this case, with a 5V input voltage source, 1A constant current, the max power dissipation could be:

$$P_{Dmax} = (5V - 2.6V) \times 1A = 2.4W$$

This power dissipation with the battery charger in the DFN-8 package may cause thermal regulation to decrease the charge current. Then a trade-off must be made between the charge current, cost and thermal requirements of the charger.

External Capacitors

In order to maintain good stability in the whole charge cycle, a minimum capacitance of 1~10 μF is recommended to bypass the VBAT pin to GND. In addition, the battery and interconnections appear inductive at high frequencies. These elements are in the control feedback loop during constant voltage mode. Therefore, the bypass capacitance may be necessary to compensate for the inductive nature of the battery pack.

Again, a minimum capacitance of 1~10 μF is recommended to bypass the VIN pin to GND.

ISET and IBF Resistors

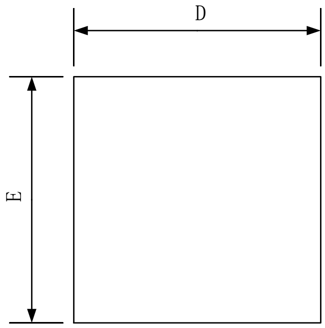
In order to acquire the constant and termination current accuracy, better than 1% precision resistance is recommended.

Layout Consideration

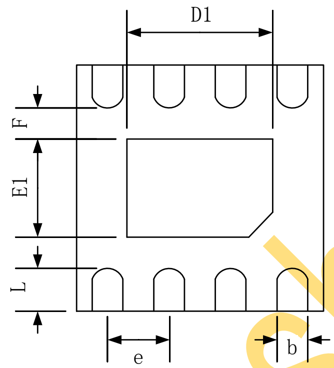
For optimum voltage regulation, place the battery pack as close as possible to the device's BAT and GND pins. This is recommended to minimize voltage drops along the high current-carrying PCB traces. If the PCB layout is used as a heat sink, adding many vias in the heat sink pad can help conduct more heat to the PCB backplane, thus reducing the maximum junction temperature. It is also recommended to place the capacitor C_{IN} and C_{OUT} as close as possible to the corresponding pins and GND pin.

Packaging Information

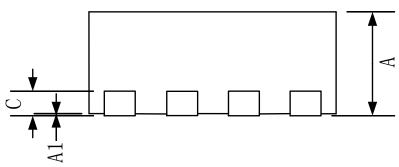
DFN-8



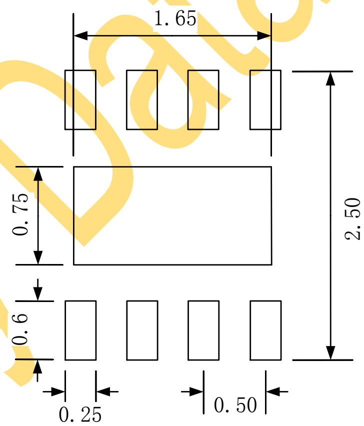
TOP VIEW



BOTTOM VIEW



SIDE VIEW



Recommended Land Pattern

SYMBOL	Dimensions In Millimeters		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.18	0.25	0.30
c	0.20 REF		
D	1.90	2.00	2.10
D1	1.10	1.30	1.65
E	1.90	2.00	2.10
E1	0.60	0.75	0.85
e	0.50 BSC		
L	0.25	0.35	0.40
F	0.25	0.30	0.35