LP4078

1A Single Cell Linear Charger

Features

- 1% Charge Voltage Accuracy
- 1A Maximum Charge Current
- <0.1μA Battery Reverse Current
- JEITA Temperature Standard Followed
- No External MOSFETs, Sense Resistor and Reverse-Blocking Diode Required
- Trickle Current/Constant Current/Constant Voltage Mode Supported
- Charge Termination and Automatic Recharge
- Maximum Input Voltage up to 40V with 22V Input-Over-Voltage Protection
- Maximum BAT Withstand Voltage up to 15V
- Thermal Feedback Regulation
- Battery Reverse Connection Protection
- ESD Protection
- RoHS Compliant and 100% Lead (Pb)-Free
- Package: 3x3mm DFN-10

Applications

- Portable Media Players
- Cellular and Smart Mobile Phone
- Handheld Battery-Powered Devices
- Charging Docks and Cradles

Order Information

LP4078 □□ □ □□□

Battery Voltage
Default:4.20V
435:4.35V
440:4.40V

F: Pb-Free

Package Type
QV: DFN-10

General Description

The LP4078 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-10 package and low number of external components required.

The LP4078 device employ a completed charge algorithm with trickle current/constant current/constant voltage mode and charge termination. The device supports charge current up to 1A which can be program 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 20V which is suited for power battery application. Without input supply, the battery reverse current is less than 0.1μA.

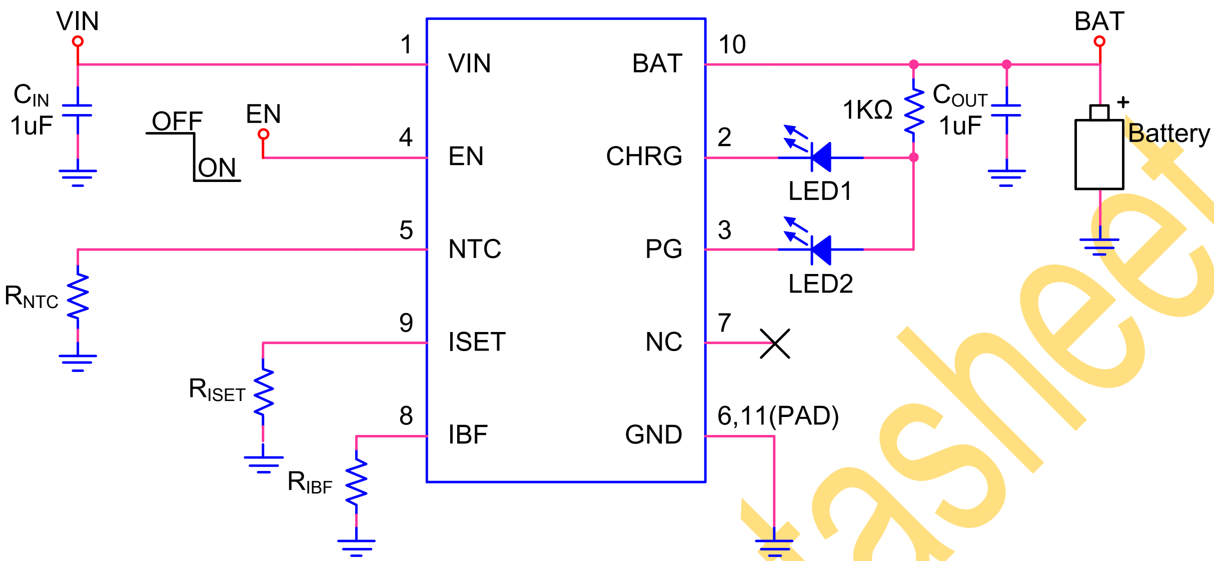
The LP4078 device support JEITA temperature standard by an NTC monitoring battery temperature circuit. The device provides various safety features for battery charging, including input-over-voltage protection, battery reverse connection protection and device junction temperature-limit protection by limiting the charge current, which is implemented by an internal thermal feedback regulation loop.

The LP4078 is available in a DFN-10 (3x3mm) package.

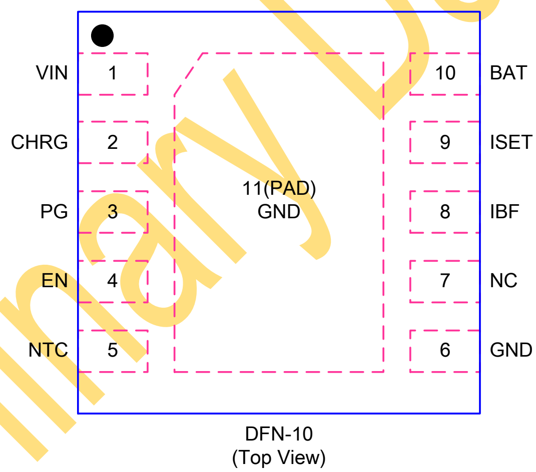
Marking Information

Device	Marking	Package	Shipping
LP4078QVF	LPS LP4078 YWX	DFN-10	5K/REEL
Marking indication: Y: Year code. W: Week code. X: Batch numbers.			

Typical Application Circuit



Pin Diagram



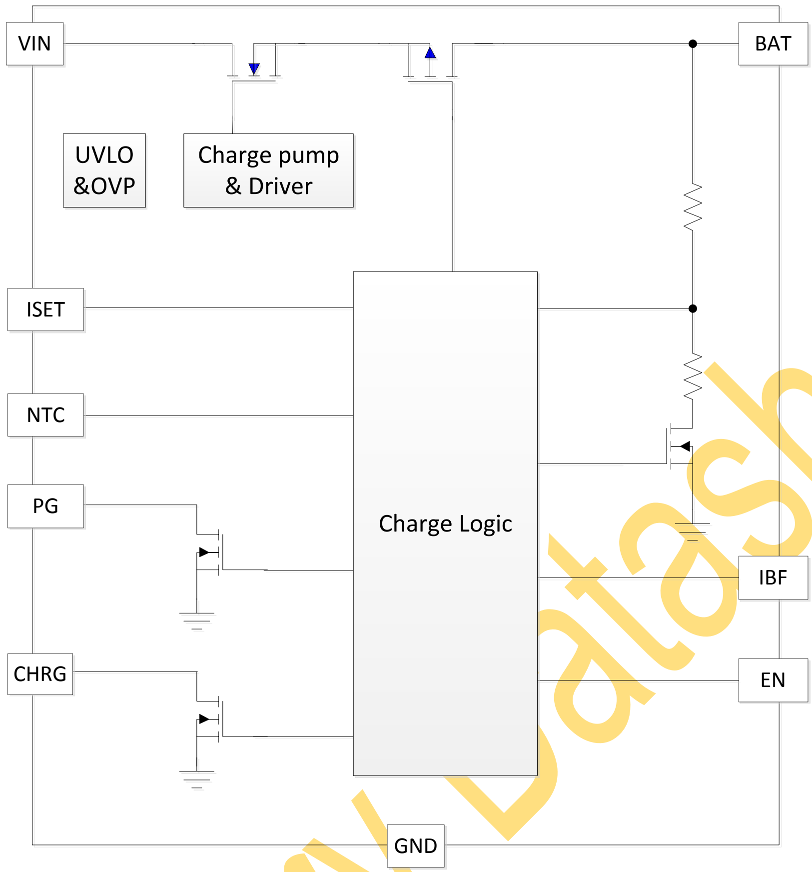
DFN-10 (Top View)

Pin Description

Pin No.	Name	Description
1	VIN	Input Supply Source. Connect to a wall adaptor typically.
2	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.
3	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.
4	EN	Charge Enable Input (Low Active).

5	NTC	Negative Thermal Coefficient (NTC) Thermistor Pin.
6	GND	Ground.
7	NC	No Connection.
8	IBF	Charge Termination Current Threshold Program Pin. Connect this pin with an external resistor (R_{IBF}) to GND to program the charge termination current threshold.
9	ISET	Charge Constant Current Program Pin. Connect this pin with an external resistor (R_{ISET}) to GND to program the constant current.
10	BAT	Battery Pin. Connect to the battery, A 1~10μF capacitor is needed typically.
11(PAD)	GND	Ground.

Functional Block Diagram



Absolute Maximum Ratings (Note 1)

- VIN to GND -- -0.3V to 40V
- BAT to GND -- -0.3V 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℃

Electrical Characteristics

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

Symbol	Parameter	Condition	Min	Typ	Max	Units
I_{CC}	Input Supply Current	Standby Mode (Charge Terminated)			1	mA
V_{UVLO}	Under Voltage Lockout of VIN	V_{IN} Rising		3.5		V
V_{UVLO_HYS}	V_{UVLO} Hysteresis	V_{IN} Falling		170		mV
V_{OVP}	Over-Voltage Protection Threshold Voltage	V_{IN} Rising		22		V
V_{OVP_HYS}	OVP Hysteresis Voltage	V_{IN} Falling		300		mV
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
V_{FLOAT}	Regulated Output (Float) Voltage	LP4078QVF	-1%	4.2	1%	V
		LP4078QVF-435		4.35		
		LP4078QVF-440		4.4		
I_{BAT}	Constant Charge Current	R_{ISET}=1.7kΩ, Constant Current Mode	900	1000	1100	mA
		R_{ISET}=3.4kΩ, Constant Current Mode	450	500	550	mA
		After Terminated, V_{IN} =5V, V_{BAT} =4.2V			-2	μA
I_{LEAK}	Leakage Current	V_{IN} =Floating, V_{BAT} =4.2V			-0.1	μA
I_{TRIKL}	Trickle Charge Current	V_{BAT}<V_{TRIKL}, R_{ISET}=1.8kΩ		100		mA

V_{TRIKL}	Trickle Charge Threshold Voltage	V_{BAT} Rising		2.6		V
V_{TRHYS}	Trickle Charge Hysteresis Voltage			170		mV
I_{TERM}	Termination Current	R_{ISET}=1.7kΩ, R_{BF}=17kΩ		100		mA
ΔV_{RECHRG}	Battery Recharge Voltage Difference Threshold	V_{FLOAT} -V_{RECHRG}		150		mV
V_{ISET}	ISET Pin Voltage	R_{ISET}=17kΩ		1		V
I_{STAT}	CHRG/PG Pin Sink Current				5	mA
V_{STAT}	CHRG/PG Pin Output Low Voltage	I_{STAT}=5mA			0.1	V
T_{J_LIMIT}	Junction Temperature-Limit	Thermal Protection State		145		℃
V_{NTC_0}	Low Temperature Pending Voltage Threshold			1.15		V
V_{NTC_10}	Half Charge Current Mode Voltage Threshold (Low Temperature)			0.75		V
V_{NTC_60}	High Temperature Disable Voltage Threshold			0.17		V
V_{NTC_HYS}	NTC Hysteresis			30		mV
I_{NTC}	NTC Bias Current	R_{NTC}=10K		48		μA
R_{DS}	VIN to BAT ON-Resistance	R_{ISET}=1.8kΩ V_{BAT}=3.5V		600		mΩ

Typical Characteristics

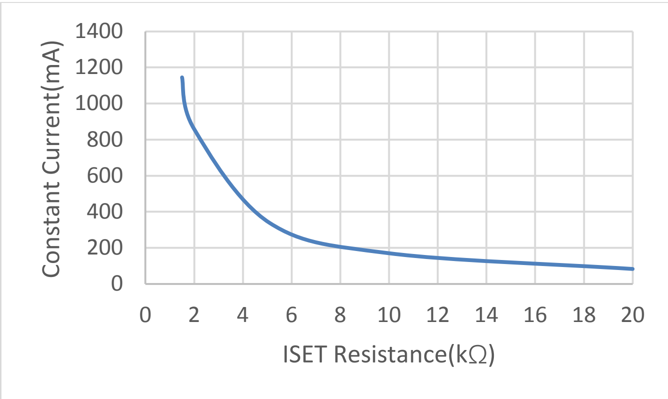


Figure 1. Constant current vs ISET Resistance
V_{IN}=5V, V_{BAT}=3.7V, 25C°

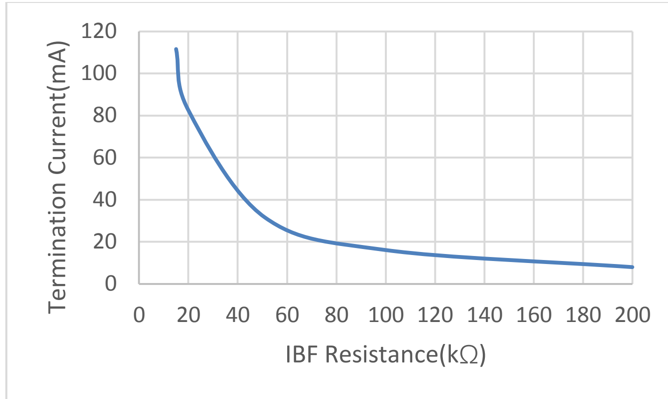


Figure 2. Termination vs IBF Resistance
R_{ISET}=1/10R_{IBF}, 25C°

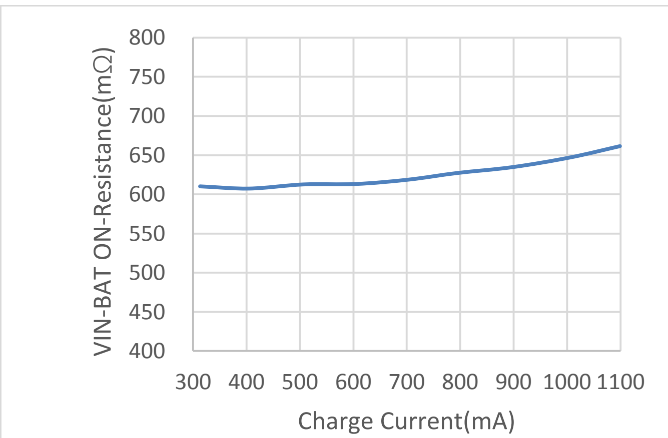


Figure 3. VIN-BAT ON-Resistance vs Charge Current
V_{BAT}=3.7V , 25C°

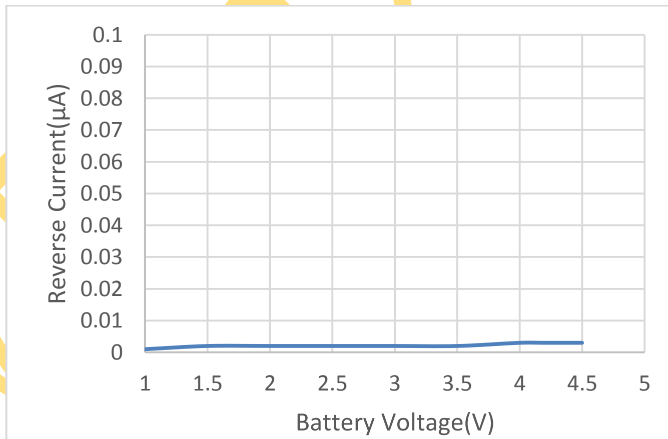


Figure 4. Battery Reverse Current vs V_{BAT}
V_{IN}=Floating, 25C°

Detailed Description

Overview

The LP4078 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.

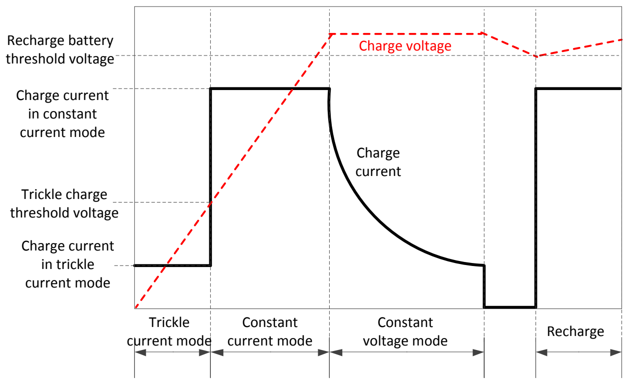


Figure 5. Typical Charge Profile

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 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:

$$I_{BAT} = \frac{V_{ISET} \times 1700}{R_{ISET}}$$

IBF Programming Termination Current Threshold

The battery charge termination current threshold (I_{BF}) 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:

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

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 LP4078 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 LP4078 are placed in Shutdown mode. During any UVLO condition, the battery reverse discharge current is less than 0.1 μA.

Enable Function

The LP4078 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.

Automatic Recharge

Once the charge cycle is terminated, the LP4078 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.

NTC Function

The LP4078 device continuously monitors the battery temperature by measuring the voltage of the NTC pin. The NTC function of the LP4078 is designed to follow the new JEITA temperature standard for Li-Ion battery charging. The device includes three temperature thresholds, 60℃, 10℃, and 0℃. The temperature thresholds are implemented by the voltage thresholds inside the device. The constant charge current is 100% of programmed current while the NTC temperature is between 10℃ and 60℃. If the NTC temperature is between 0℃ and 10℃, the constant charge current level will be set as half of the programmed current. If the NTC temperature is above 60℃ or below 0℃, the charge is disabled.

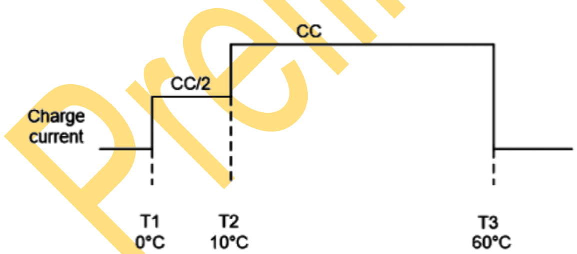


Figure 6. Constant charge current vs NTC temperature

The NTC function is implemented by using an internal 48μA current source to bias the thermistor connected from the NTC pin to GND (the evaluation circuit is designed with a 10k NTC β=3370 [SEMITEC 103AT-2 or Mitsubishi TH05-3H103F]).

If NTC feature is not needed, a fixed 10kΩ resistor can be placed between the NTC pin and GND to ensure normal operation of the device. Since the I_{NTC} is fixed along with the NTC temperature thresholds, it is not recommended to use thermistor values other than the 10k NTC (at 25℃).

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 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 has two different states: pull-down (~5mA maximum sink current) to GND and high impedance. The pull-down state indicates that the LP4078 is in a charge cycle. When the charge current decreases to the battery termination charge current threshold (I_{BF}), the CHRG pin will become high impedance.

Function	CHRG
Charging	Low
Charge Termination	Hi-Z

Junction Temperature-Limit Protection

An internal thermal feedback loop reduces charge current if the junction temperature attempts to rise above a preset value of approximately 145℃. This function protects the LP4078 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 LP4078 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.

Power Dissipation

The reason which causes the LP4078 device to reduce charge current through thermal feedback 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. The approximate ambient temperature which the thermal feedback begins to protect the device can be calculate as:

$$T_A = 125℃ - P_D \times \theta_{JA}$$

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 DFN10 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

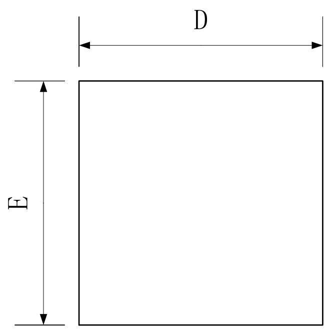
In order to acquire the constant and termination current accuracy, better than 1% precision resistance is recommended.

Layout Consideration

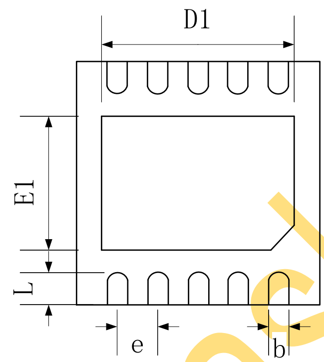
For optimum voltage regulation, place the battery pack as close as possible to the device's BAT and GND pins. This is recommended to minimize voltage drops along the high current-carrying PCB traces. If the PCB layout is used as a heat sink, adding many vias in the heat sink pad can help conduct more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

Packaging Information

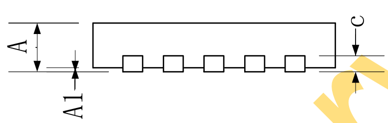
DFN-10



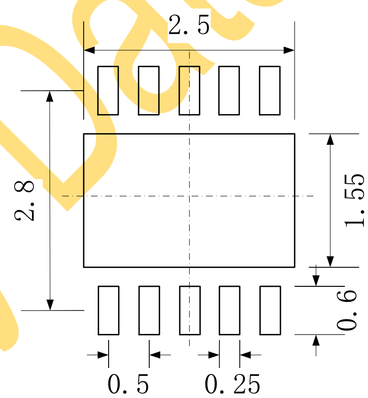
TOP VIEW



BOTTOM VIEW



SIDE VIEW



Recommended Land Pattern

SYMBOL	MILLIMETER		
	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	2.90	3.00	3.10
D1	2.40	2.50	2.60
E	2.90	3.00	3.10
E1	1.45	1.55	1.65
e	0.50 BSC		
L	0.30	0.40	0.50