Smart Charger With Power Path

General Description

The LP78090 is a monolithic linear battery charger whit smart power path switch for single-cell Li-ion batteries in a wide range of tablet and other portable devices. It integrates a linear regulated voltage for power the system and charging the battery at the same time. This device supports both USB and high power DC adapter input. Its charger is a complete constant-current constant voltage linear charger with adjustable charge current up to 1000mA. No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be ISET rammed externally with a single resistor. The charger automatically terminates the charge cycle when the charge current drops to 1/10th the ISET rammed value after the final float voltage is reached. When the input supply (wall adapter or USB supply) is removed, the LP78090 automatically enters a low current state, dropping the battery drain current to less than 15μA.
When connecting a high power DC adapter, the smart power path management allows LP78090 power the system with VIN voltage or BAT voltage by switching the voltage level on SC pin and charge the battery simultaneously. This allows immediate system operation even under moving away or deeply discharged battery. When the input current limit is reached, the voltage applied on the SYS pin would pull down to the battery voltage making the charge current decrease. If the current out of SYS pin is more than charge current plus 1200mA, LP78090 with turn power adapter and battery support the system load together. The LP78090 provides an internal path from battery to system in the event the input is removed.
Other features include charge current monitor, under voltage lockout, automatic recharge and a status pin to indicate charge termination and the presence of an input voltage.

Order Information

LP78090 □ □ □

- F: Pb-Free
- Package Type
  - QV:TDFN-10

Features

- Programmable Charge Current Up to 1000mA
- Smart Power Path Management
- No MOSFET, Sense Resistor or Blocking Diode Required
- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- 15μA Leakage Current in Shutdown
- Charging Operation and Charge Complete Indicator
- Thermal Limiting Regulation on Chip
- Internal Soft Start Function
- Built-in Short-Circuit Protection
- Consumption Available in TDFN-10 Package
- RoHS Compliant and 100% Lead (Pb)-Free

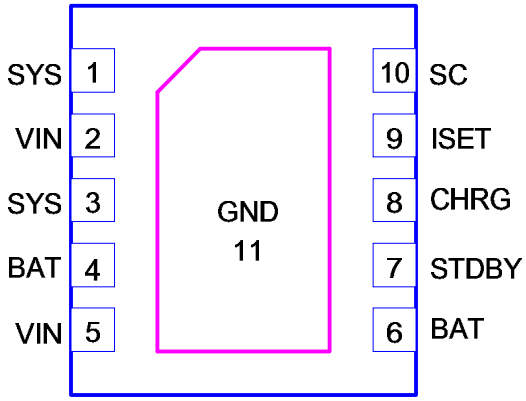
Marking Information

Device	Marking	Package	Shipping
LP78090QVF		QV:TDFN10	3K/REEL

Applications

- MID/Pad
- Automobile Data Recorder or Event Data Recorder
- Power Bank
- Smart Phone
- Bluetooth Applications

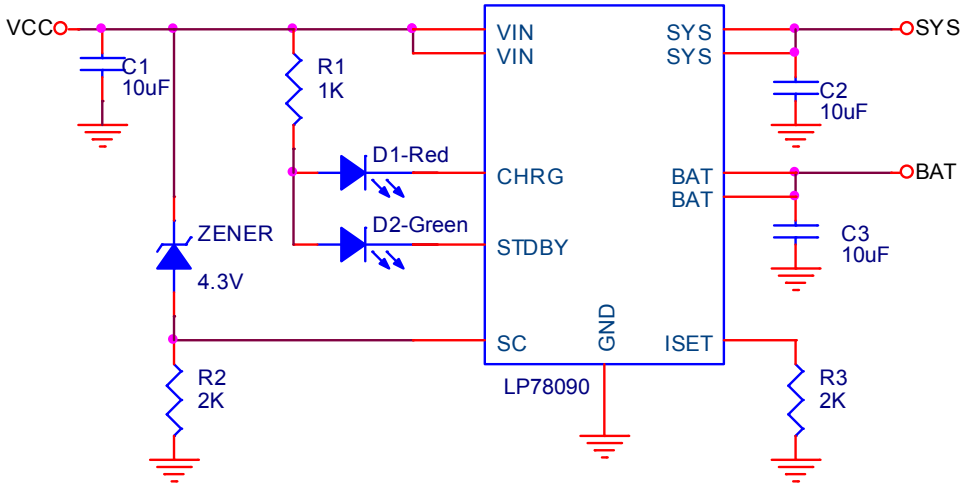
Functional Pin Description

Package Type	Pin Configurations
TDFN-10	

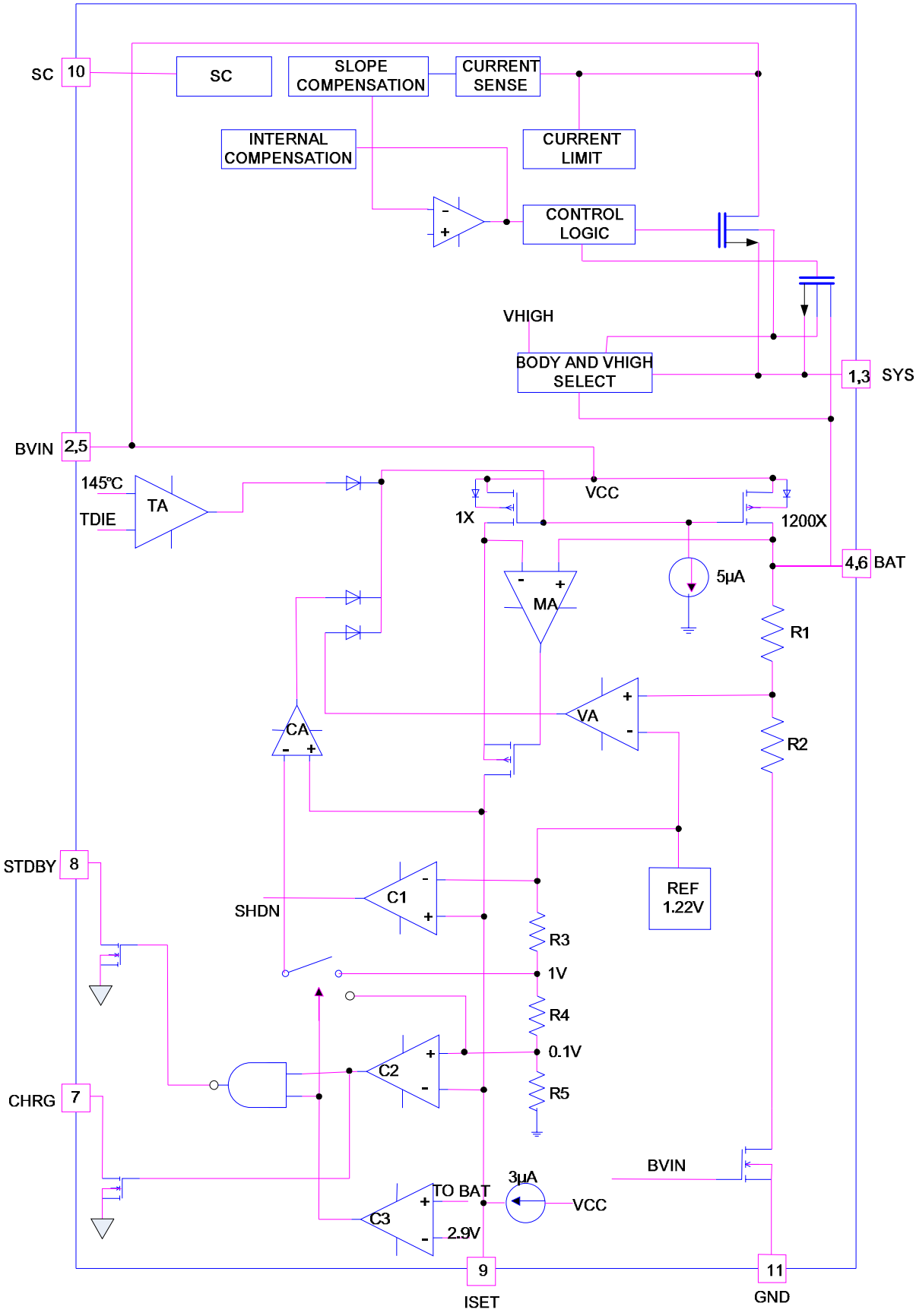
Pin Description

PIN No.	PIN	DESCRIPTION
1,3	SYS	Output of power supply for system.
2,5	VIN	Power supply input for system and charge.
4,6	BAT	BAT is the connection to the battery. Typically a 10μF Tantalum capacitor is needed for stability when there is no battery attached. When a battery is attached, only a 0.1μF ceramic capacitor is required.
7	CHRG	Open-Drain Charge Status Output. When the battery is charging, the STAT pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed, the pin is pulled High.
8	STDBY	Open-Drain Complete Status Output. When the battery is charging, the STAT pin is pulled high by an internal N-channel MOSFET. When the charge cycle is completed, the pin is pulled Low.
9	ISET	Charge Current Program, Charge Current Monitor and Shutdown Pin. The charge current is programmed by connecting a 1% resistor(R_{PROG})to ground. When charging in constant-current mode, this pin servos to 2V. In all modes, the voltage on this pin can be used to measure the charge current using the following formula.LP78090: Iset=1200/R_{PROG}.
10	SC	Smart controller.
11	GND	Ground pin.

Application Circuit



Function Block Diagram



Absolute Maximum Ratings

- Input Voltage to GND (VIN) ---------- -0.3V to 6.5V
- V_{SYS} ---------- -0.3V to 6V
- BAT, ISET, STAT ---------- -0.3V to VIN+0.3V
- BAT Short-Circuit Duration ---------- Continuous
- BAT Pin Current ---------- 1200mA
- Maximum Junction Temperature ---------- 125°C
- Operating Junction Temperature Range (TJ) ---------- -40℃ to 85°C
- Maximum Soldering Temperature (at leads, 10 sec) ---------- 260°C

Thermal Information

- Maximum Power Dissipation (PD,TA<40°C) ---------- 1.5W
- Thermal Resistance (JA) ---------- 68℃/W

Electrical Characteristics

(The specifications which apply over the full operating temperature range, otherwise specifications are at TA = 25°C. VIN1/2=BVIN = 5V, unless otherwise noted.)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX	UNITS
Charge						
VIN	Adapter/USB Voltage Range		3.9	5	5.5	V
I_Q	Input Supply Current	Charge Mode, R_{ISET} = 10k		330	2000	uA
		Standby Mode (Charge Terminated)		230	500	
		Shutdown Mode (R_{ISET} Not Connected, VIN < V_{BAT}, or VIN < V_{UV} and SC=0V)		40	60	
V_{FLOAT}	Regulated Output (Float) Voltage	0°C ≤ T_A ≤ 85°C, I_{BAT} = 40mA	4.158	4.2	4.242	V
I_{BAT}	Current Input to Battery	R_{ISET} = 1.2k, Current Mode	800	1000	1200	mA
		R_{ISET} = 2k, Current Mode	500	600	700	
		Standby Mode, V_{BAT} = 4.2V Shutdown Mode		-2.5	-6	uA
		(R_{ISET} Not Connected)	0	±1	±2	
		Sleep Mode, VIN = 0V		±1	±2	
ISYS	Current Limit form BAT or VIN to SYS		1100	1250	1400	mA
I_{TRIKL}	Trickle Charge Current	V_{BAT} < V_{TRIKL}, R_{ISET} = 1.2k	80	100	120	mA
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{ISET} = 10k, V_{BAT} Rising	2.8	2.9	3.0	V
V_{TRHYS}	Trickle Charge Hysteresis Voltage	R_{ISET} = 10k		120		mV
V_{UV}	VIN Under voltage Lockout Threshold for Charge	VIN From Low to High		3.9		V
V_{UVHYS}	VIN Under voltage Lockout Hysteresis for Charge		150	200	300	mV
V_{MSD}	Manual Shutdown Charge Threshold Voltage	ISET Pin Falling		2.2		V
V_{ASD}	VIN – VBAT Lockout Threshold Voltage	VIN from Low to High	70	100	140	mV
		VIN from High to Low	5	30	50	mV
I_{TERM}	C/10 Charge Termination Current Threshold	R_{ISET} = 10k, I_{TERM} / I_{Charge}	0.085	0.10	0.115	mA/mA
		R_{ISET} = 2k, I_{TERM} / I_{Charge}	0.085	0.10	0.115	mA/mA
V_{SET}	ISET Pin Voltage	R_{ISET} = 10k, Current Mode		2		V
V_{STAT}	CHRG、STDBY Pin Output Low Voltage	I_{STAT} = 5mA		0.35	0.6	V
V_{RESTAT}	Recharge Battery Voltage			4.05		V
ΔV_{RESTAT}	Recharge Battery Threshold Voltage	V_{FLOAT} - V_{RESTAT}	100	150	200	mV
R_{ON}	Power FET "ON" Resistance (Between VIN and BAT)				300	mΩ
$R_{DS(ON)}$	Path Switch NMOS $R_{DS(ON)}$			130		mΩ
V_{SCL}	Logic-Low Voltage				0.4	V
V_{SCH}	Logic-High Voltage		1			V
ISC		VIN=V_{SC}=5V	-1		1	uA
V_{SYS}	Voltage on SYS pin	4.3V < VIN	VIN			V
		VIN=FLOAT	VBAT			
		VIN < 4.3V	VBAT			
T_{LT}	Thermal Limit Temperature			120		℃
T_{SD}	Thermal Shutdown			150		℃

Charge Characteristics

TYPICAL CHARACTERISTICS

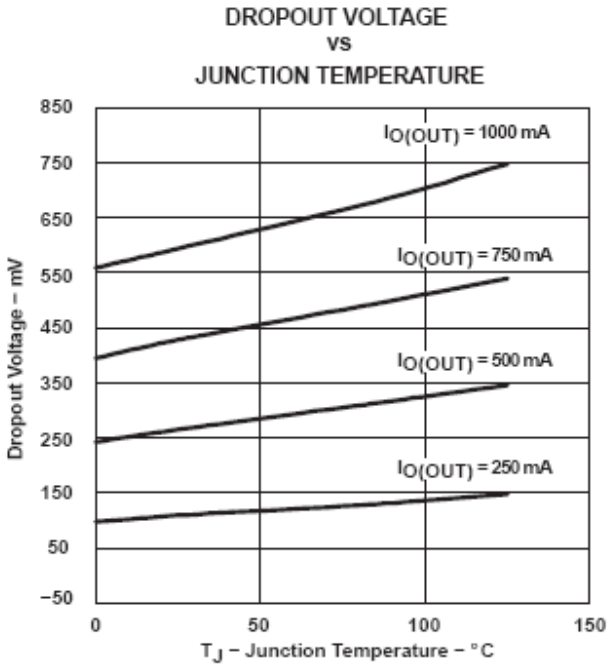


Figure 1

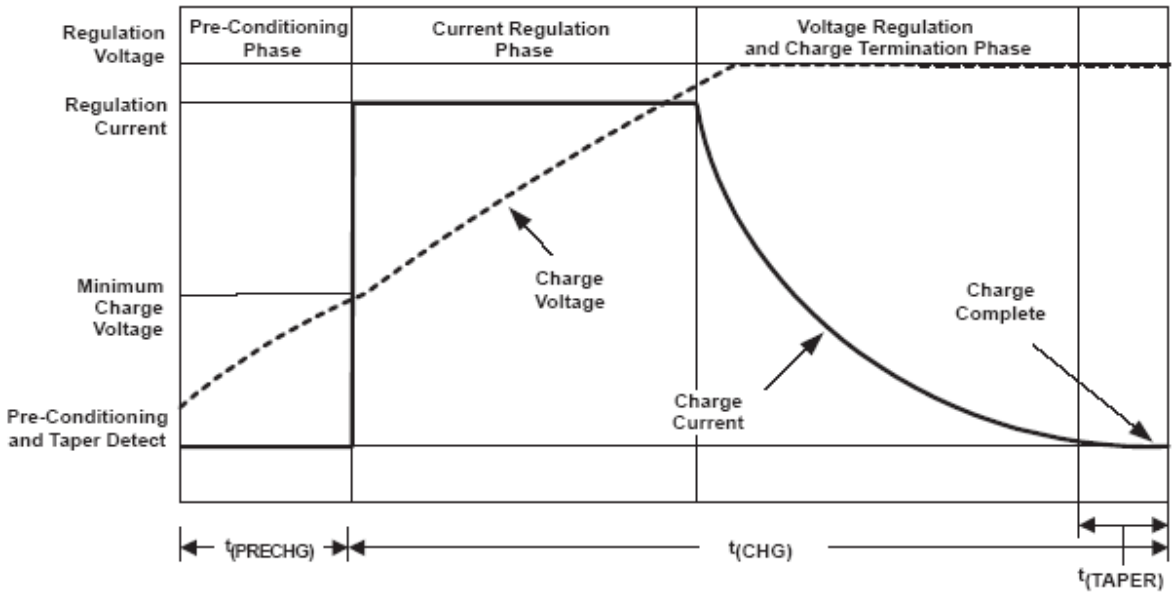


Figure 2. Typical Charging Profile

Application Information

The LP78090 is a linear switching charger IC with smart power path management integrated for powering the system and charging a single cell lithium-ion battery simultaneously. It can deliver up to 1000mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. The LP78090 includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus, the basic application circuit requires only four external components. Furthermore, the LP78090 is capable of operating from a USB power source , 500mA for USB 2.0 and 850mA for USB3.0 with resistor change on ISET pin.

It has precious average input current limit and average current limit form battery to system, to make maximum use of the allowable input power. And LP78090 would give priority to ensuring the system load approximately up to 2.4A, which contains 1.2A form VIN and 1.2A form battery. LP78090 will reduce charging current or even power from battery to satisfy the system load when its demand is over the input current limit. In low system load situation, the remaining current is supply for charger programmed by an external resistor connected from ISET pin to GND. The device would reduce the charge current when the die temperature exceeds 120℃.

Two 130mΩ MOSFET integrated work as an ideal diode to connecting the battery and VIN to the system load, and one of this two MOSFET will turn on allowing the battery to power up the system when the input is removed with circuit in page 3.

SYS Pin Voltage Switch

The voltage on the SYS pin is set by the SC voltage, VIN voltage and battery voltage. VIN<4.3V condition, voltage power for system always keeps with battery voltage. 4.3V < VIN condition, voltage power for system always keeps with VIN voltage

Current Limit

The current limit regulate in two directions: from VIN to system and from battery to system, each one is limited to 1.2A. When the system load needs the current above 1.2A, LP78090 would divert part of charge current to system. And the device would power system from VIN and battery when the system current is more than charge current plus 1.2A.

Normal Charge Cycle

A charge cycle begins when the voltage at the VIN pin rises above the UVLO threshold level and a 1% ISET ram resistor is connected from the ISET pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.9V, the charger enters trickle charge mode. In this mode, the LP78090 supplies approximately 1/10 the ISET rammed charge current to bring the battery voltage up to a safe level for full current charging.

When the BAT pin voltage rises above 2.9V, the charger enters constant-current mode, where the ISET rammed charge current is supplied to the battery. When the BAT pin approaches the final float voltage (4.2V), the LP78090 enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the ISET rammed value, the charge cycle ends.

ISET ramming Charge Current

The charge current is ISET rammed using a single resistor from the ISET pin to ground. The battery charge current is 500 times the current out of the ISET pin. The ISET ram resistor and the charge current are calculated using the following equations:

LP78090:

RSET=1200V/ICHG , ICHG= 1200V/RSET

The charge current out of the BAT pin can be determined at any time by monitoring the ISET pin voltage using the following equation:

IBAT= VSET x 600/RSET

Note: Vset is 2Volts.

Charge Termination

When charging, transient loads on the BAT pin can cause the ISET pin to fall below 200mV for short periods of time before the DC charge current has dropped to 1/10th the ISET rammed value. The 1ms filter time (t_{TERM}) on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination. Once the average charge current drops below 1/10th the ISET rammed value, the LP78090 terminates the charge cycle and ceases to provide any current through the BAT pin. In this state, all loads on the BAT pin must be supplied by the battery.

The LP78090 constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.05V recharge threshold (V_{RESTAT}), another charge cycle begins and current is once again supplied to the battery. To manually restart a charge cycle when in standby mode, the input voltage must be removed and reapplied, or the charger must be shut down and restarted using the ISET pin. Figure 2 shows the state diagram of a typical charge cycle.

Charge Status Indicator

The charge status output has two different states: strong pull-down (~10mA) and high impedance. The strong pull-down state indicates that the LP78090 is in a charge cycle. Once the charge cycle has terminated, the pin state is determined by under voltage lockout conditions. High impedance indicates that the LP78090 is in under voltage lockout mode: either VIN is less than 100mV above the BAT pin voltage or insufficient voltage is applied to the VIN pin.

A microprocessor can be used to distinguish between these two states—this method is discussed in the Applications Information section.

Function	CHRG(pin8)	STDBY(pin7)
Charging	Low	High
charge completed	High	Low

Thermal Limiting

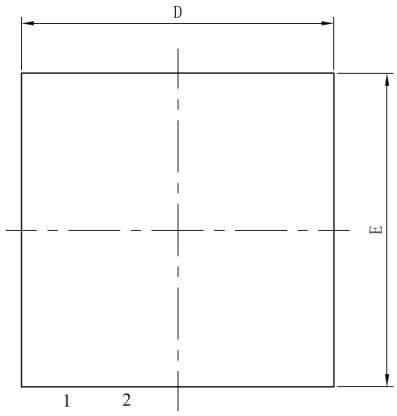
An internal thermal feedback loop reduces the ISET rammed charge current if the die temperature attempts to rise above a preset value of approximately 120°C. This feature protects the LP78090 from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the LP78090. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions. TDFN power considerations are discussed further in the Applications Information section.

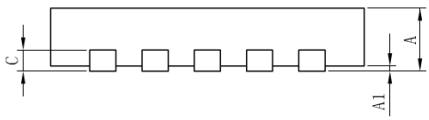
Automatic Recharge

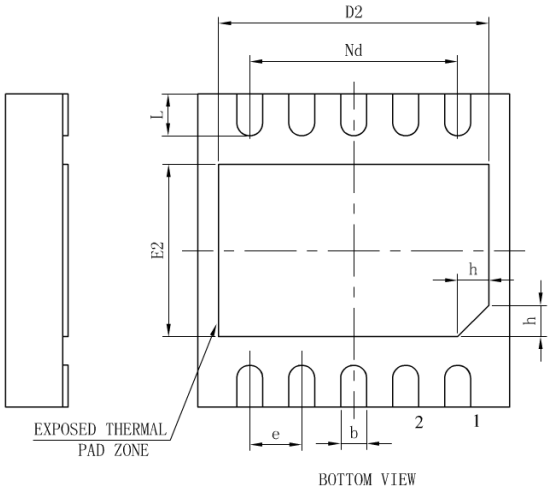
Once the charge cycle is terminated, the LP78090 continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time ($t_{RECHARGE}$). A charge cycle restarts when the battery voltage falls below 4.05V (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. STAT output enters a strong pull-down state during recharge cycles.

Packaging Information

TDFN-10







SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0. 70	0.75	0. 80
A1	—	0.02	0. 05
b	0. 18	0.25	0. 30
c	0. 18	0.20	0. 25
D	2. 90	3. 00	3. 10
D2	2. 40	2. 50	2. 60
e	0. 50BSC		
Nd	2. 00BSC		
E	2. 90	3. 00	3. 10
E2	1. 45	1. 55	1. 65
L	0. 30	0.40	0. 50
h	0. 20	0. 25	0. 30