1A Charge And Dual Channel Ultra-Fast CMOS LDO Regulator

General Description

The LP78092 is a PMIC , which has 1ch Charger and 2ch LDO with TQFN16 package.

Its charger is a complete constant-current constant voltage linear charger for single cell lithium-ion batteries. 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 LP78092 automatically enters a low current state, dropping the battery drain current to less than 8μA.

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.

The LP78092 contains a dual channel, low noise, and low dropout regulator sourcing up to 600mA at each channel. The range of output voltage is from 0.81V to Vin by operating from 2.5V to 6.5V input.

LP78092 offers 2% accuracy, extremely low dropout voltage (280mV @ 400mA), and extremely low ground current, only 75μA per LDO. The shutdown current is near zero current which is suitable for battery-power devices. Other features include current limiting, over temperature, output short circuit protection.

Order Information

LP78092 □ □ □

- F: Pb-Free
- Package Type
  - QV:TQFN-16

Features

- **Charger:**
  - Programmable Charge Current Up to 1000mA
  - 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
  - 8μA Leakage Current in Shutdown
  - Drainage Charge Current Thermal Regulation Status Outputs for LED or System Interface
- **LDO:**
  - Wide Operating Voltage Ranges : 2.5V to 6.0V
  - Low-Noise for RF Applications
  - High PSRR: -68dB at 1kHz
  - No Noise Bypass Capacitor Required
  - Dual LDO Outputs (280mV/400mA)
  - Ultra-low Quiescent Current 75uA
  - Built-in Short-Circuit Protection
- Consumption Available in TQFN-16 Package
- RoHS Compliant and 100% Lead (Pb)-Free

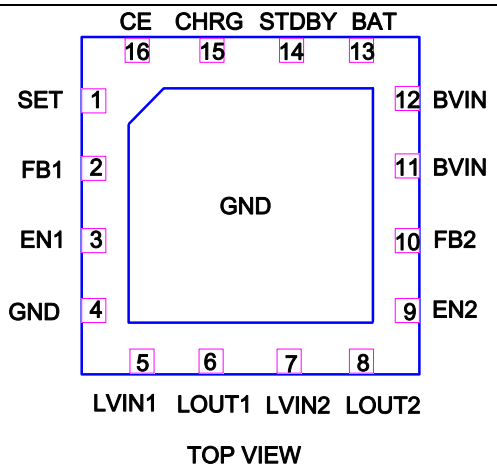
Marking Information

Device	Marking	Package	Shipping
LP78092QVF		QV:TQFN16	3K/REEL

Applications

- MID/Pad
- Power Bank
- Smart Phone
- Bluetooth Applications

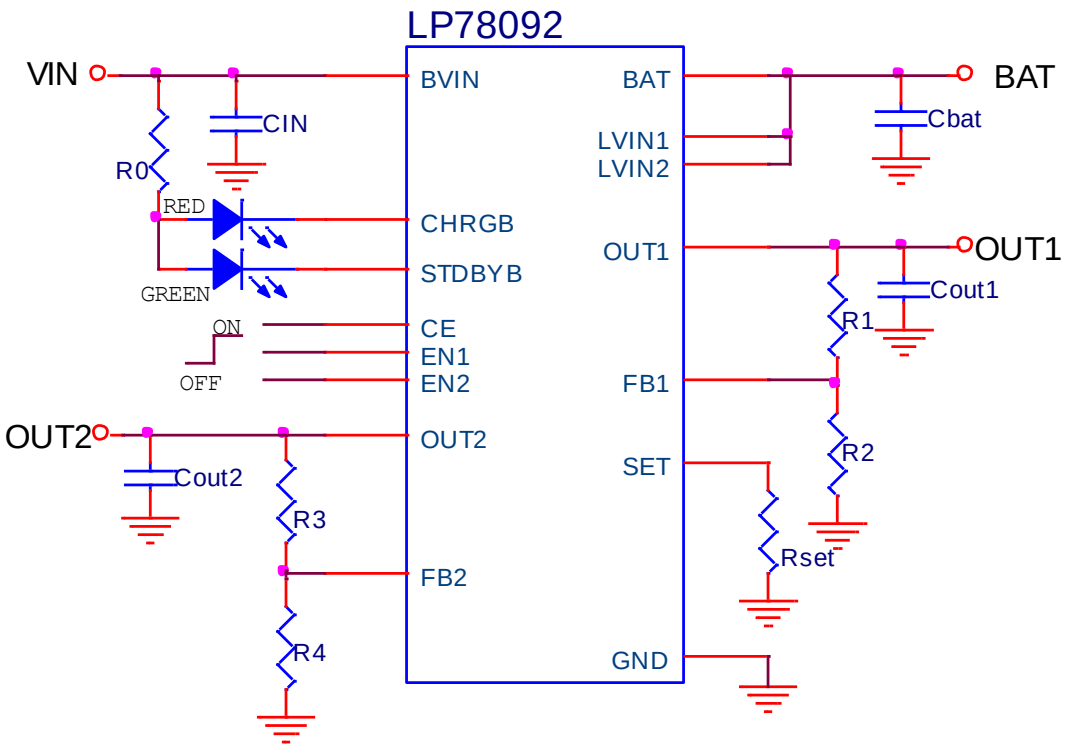
Functional Pin Description

Package Type	Pin Configurations
TQFN-16	

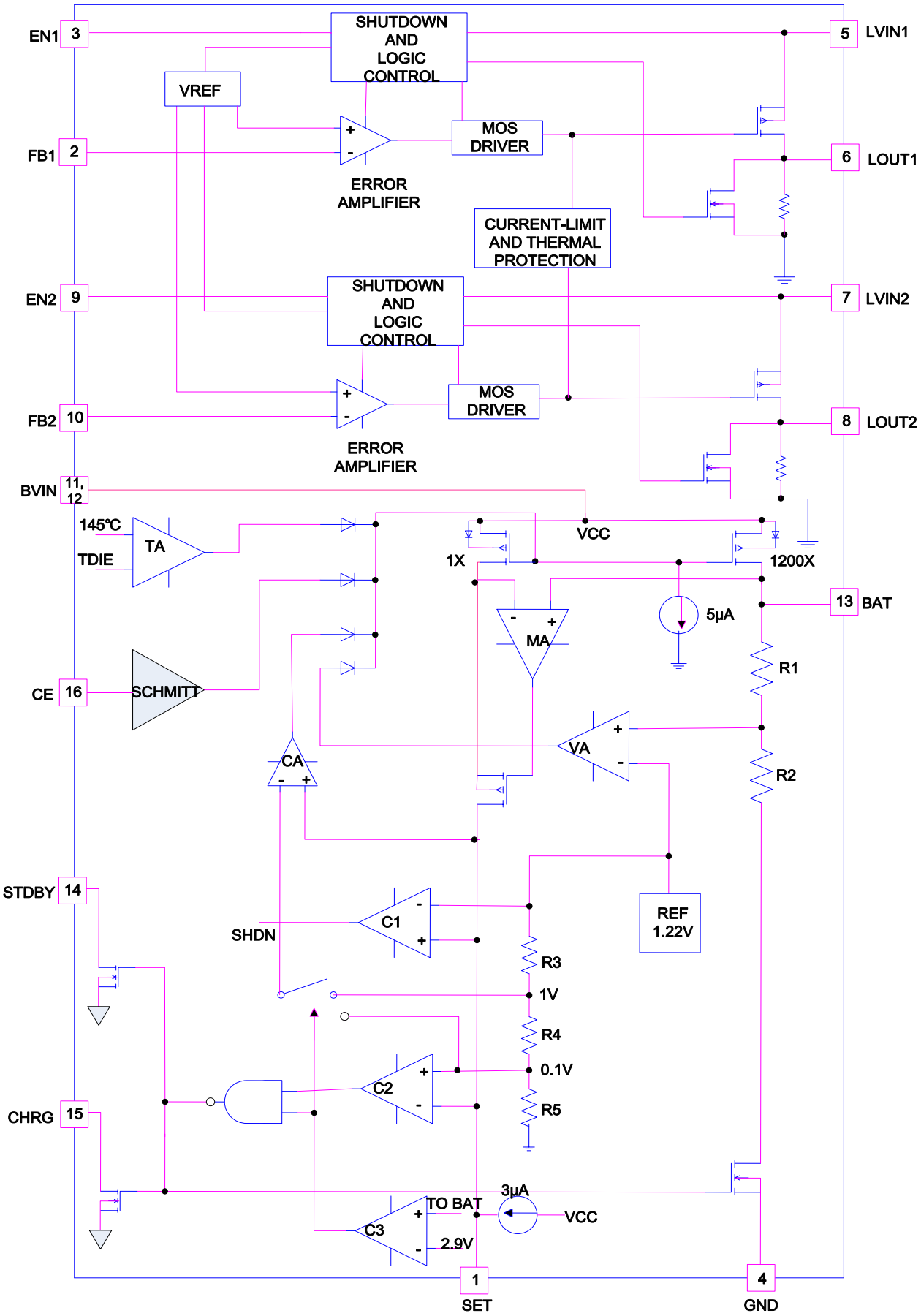
Pin Description

PIN No.	PIN	DESCRIPTION
1	SET	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.LP78092: Iset=1000/R_{PROG}.
2	FB1	Feedback pin for channel 1 LDO. The reference voltage is 0.8V.
3	EN1	Enable pin for channel 1 LDO. Active high.
4	GND	Ground pin.
5	LVIN1	Power supply for channel 1 LDO.
6	LOUT1	Output pin of Channel 1 LDO.
7	LVIN2	Power supply for channel 2 LDO.
8	LOUT2	Output pin of Channel 2 LDO.
9	EN2	Enable pin for channel 2 LDO. Active high.
10	FB2	Feedback pin for channel 2 LDO. The reference voltage is 0.8V.
11,12	BVIN	BVIN is the input power source for charger. Connect to a wall adapter.
13	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.
14	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.
15	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.
16	CE	Enable charger pin. Active high.

Application Circuit



Function Block Diagram



Absolute Maximum Ratings

- Input Voltage to GND (LVIN1/2，BVIN) ---------- -0.3V to 6.5V
- VOUT1/2 ---------- -0.3V to 6V
- BAT, SET, STAT, EN, CE ---------- -0.3V to VIN+0.3V
- BAT Short-Circuit Duration ---------- Continuous
- BAT Pin Current ---------- 1200mA
- Maximum Junction Temperature ---------- 125°C
- Operating Junction Temperature Range (T_J) ---------- -40℃ to 85°C
- Maximum Soldering Temperature (at leads, 10 sec) ---------- 260°C

Thermal Information

- Maximum Power Dissipation (P_D,T_A<40°C) ---------- 1.5W
- Thermal Resistance (J_A) ---------- 68℃/W

Electrical Characteristics

(The specifications which apply over the full operating temperature range, otherwise specifications are at T_A=25°C. LVIN1/2=BVIN= 5V, unless otherwise noted.)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX	UNITS
Charge						
VIN	Adapter/USB Voltage Range		3.9	5	6.5	V
I_{CC}	Input Supply Current	Charge Mode, R_{SET} = 10k		300	2000	uA
		Standby Mode (Charge Terminated)		200	500	
		Shutdown Mode (R_{SET} Not Connected, VCC < V_{BAT}, or VCC < V_{UV})		25	50	
V_{FLOAT}	Regulated Output (Float) Voltage	0°C ≤ TA ≤ 85°C, I_{BAT} = 40mA	4.158	4.2	4.242	V
I_{BAT}	BAT Pin Current	R_{SET} = 1k, Current Mode	900	1000	1100	mA
		R_{SET} = 2k, Current Mode	450	500	550	
		Standby Mode, V_{BAT} = 4.2V		-2.5	-6	uA
		Shutdown Mode (R_{SET} Not Connected)	0	±1	±2	
		Sleep Mode, VCC = 0V		±1	±2	
I_{TRIKL}	Trickle Charge Current	V_{BAT} < V_{TRIKL}, R_{SET} = 2k		50		mA
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{SET} = 10k, V_{BAT} Rising	2.8	2.9	3.0	V
V_{TRHYS}	Trickle Charge Hysteresis Voltage	R_{SET} = 10k		120		mV
V_{UV}	VCC Under voltage Lockout Threshold	From VCC Low to High		3.9		V
V_{UVHYS}	VCC Under voltage Lockout Hysteresis		150	200	300	mV
V_{ASD}	VCC – V_{BAT} Lockout Threshold Voltage	VCC from Low to High	70	100	140	mV
		VCC from High to Low	5	30	50	mV
I_{TERM}	C/10 Termination Current Threshold	R_{SET} = 10k	0.085	0.10	0.115	mA/mA
		R_{SET} = 2k	0.085	0.10	0.115	mA/mA
V_{SET}	SET Pin Voltage	R_{SET} = 10k, Current Mode		2		V
V_{STAT}	STAT Pin Output Low Voltage	I_{STAT} = 5mA		0.35	0.6	V
ΔV_{RESTAT}	Recharge Battery Threshold Voltage	V_{FLOAT} - V_{RESTAT}	100	150	200	mV
T_{LIM}	Junction Temperature in Constant Temperature Mode				145	°C
R_{ON}	Power FET “ON” Resistance (Between VCC and BAT)				300	mΩ
V_{CEL}	Logic-Low Voltage				0.4	V
V_{CEH}	Logic-High Voltage		1.4			
LDO						
VIN1	Supply voltage		2.5		6.5	V
I_{LOAD}	Output Loading Current	V_{EN}=VIN,VIN>2.5V		600		mA
I_{LIM}	Current Limit	R_{LOAD} = 1Ω	750			mA
V_{FB}	Adjustable voltage reference	I_{OUT}=1mA	0.784	0.8	0.816	V
I_Q	Quiescent Current	V_{EN} ≥ 1.4V, I_{OUT} = 0mA		75	130	μA
V_{DROP}	Dropout Voltage	I_{OUT} = 200mA, V_{OUT} >2.8V		140	160	mV
		I_{OUT} = 400mA, V_{OUT} >2.8V		280	320	
ΔV_{LINE}	Line Regulation	VIN = (V_{OUT} + 1V) to 5.5V, I_{OUT} = 1mA			0.3	%
ΔV_{LOAD}	Load Regulation	1mA < I_{OUT} < 400mA			0.6	%
I_{STBY}	Standby Current	V_{EN} = GND, Shutdown		0.01	1	μA
I_{EN}	EN Input Bias Current	V_{EN} = 1V or 5V	0.8		5.3	uA
V_{ENL}	Logic-Low Voltage				0.4	V
V_{ENH}	Logic-High Voltage		1.4			
V_N	Output Noise Voltage	10Hz to 100kHz,		100		uVRMS
T_{SD}	Thermal Shutdown Temperature			150		°C

Charge Characteristics

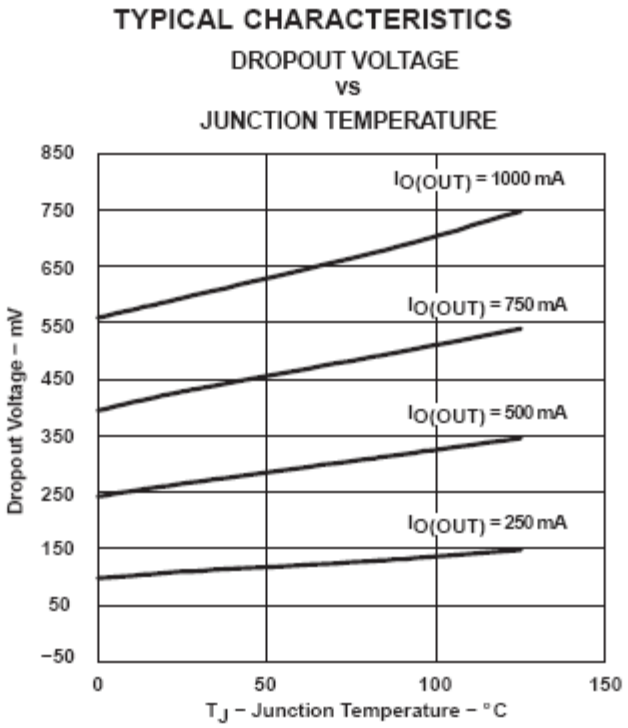


Figure 1

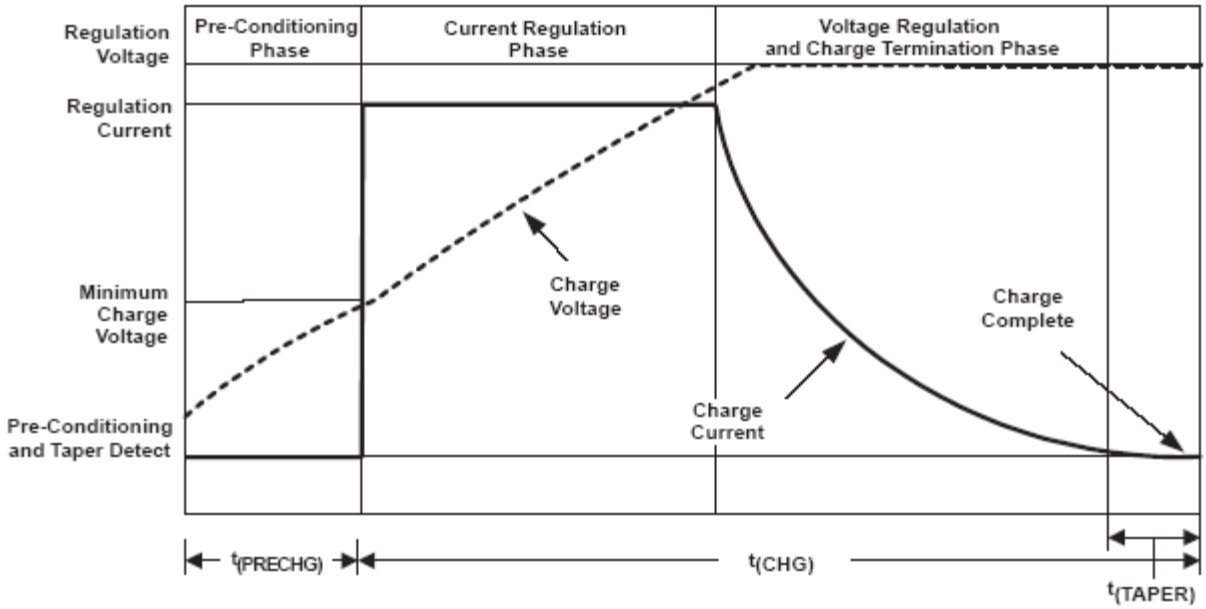


Figure 2. Typical Charging Profile

Application Information

The LP78092 is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 1000mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. The LP78092 includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus, the basic charger circuit requires only two external components. Furthermore, the LP78092 is capable of operating from a USB power source. For LDO part, like any low-dropout regulator, the external capacitors used with the LP78092 must be carefully selected for regulator stability and performance. Using a capacitor whose value is > 2μF on the LP78092 input and the amount of capacitance can be increased without limit. The input capacitor must be located a distance of not more than 0.5 inch from the input pin of the IC and returned to a clean analog ground. There is a special attention which is the input capacitance should not be less than output capacitance. Any good quality ceramic or tantalum can be used for this capacitor. The capacitor with larger value and lower ESR (equivalent series resistance) provides better PSRR and line-transient response. The output capacitor must meet both requirements for minimum amount of capacitance and ESR in all LDOs application. The LP78092 is designed specifically to work with low ESR ceramic output capacitor in space-saving and performance consideration. Using a ceramic capacitor whose value is at least 1μF with ESR is > 25mΩ on the LP78092 output ensures stability. The LP78092 still works well with output capacitor of other types due to the wide stable ESR range. Output capacitor of larger capacitance can reduce noise and improve load transient response, stability, and PSRR. The output capacitor should be located not more than 0.5 inch from the VOUT pin of the LP78092 and returned to a clean analog ground.

Normal Charge Cycle

A charge cycle begins when the voltage at the V_{IN} pin rises above the UVLO threshold level and a 1% SET ram resistor is connected from the SET 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 LP78092 supplies approximately 1/10 the SET 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 SET rammed charge current is supplied to the battery. When the BAT pin approaches the final float voltage (4.2V), the LP78092 enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the SET rammed value, the charge cycle ends.

RSET ramming Charge Current

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

LP78092:

RSET=1000V/ICHG , ICHG= 1000V/RSET

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

IBAT= VSET x 500/RSET

Note: Vset is 2Volts.

Charge Termination

A charge cycle is terminated when the charge current falls to 1/10th the SET rammed value after the final float voltage is reached. This condition is detected by using an internal, filtered comparator to monitor the SET pin. When the SET pin voltage falls below 100mV for longer than t_{TERM} (typically 1ms), charging is terminated. The charge current is latched off and the LP78092 enters standby mode, where the input supply current drops to 200μA. (Note: C/10 termination is disabled in trickle charging and thermal limiting modes).

When charging, transient loads on the BAT pin can cause the SET pin to fall below 200mV for short periods of time before the DC charge current has dropped to 1/10th the SET 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 SET rammed value, the LP78092 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 LP78092 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 SET pin. Figure 2 shows the state diagram of a typical charge cycle.

Charge Status Indicator (STAT)

The charge status output has two different states: strong pull-down (~10mA) and high impedance. The strong pull-down state indicates that the LP78092 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 LP78092 is in under voltage lockout mode: either V_{IN} is less than 100mV above the BAT pin voltage or insufficient voltage is applied to the V_{IN} pin.

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

Function	CHRG(pin15)	STDBY(pin14)
Charging	Low	High
charge completed	High	Low

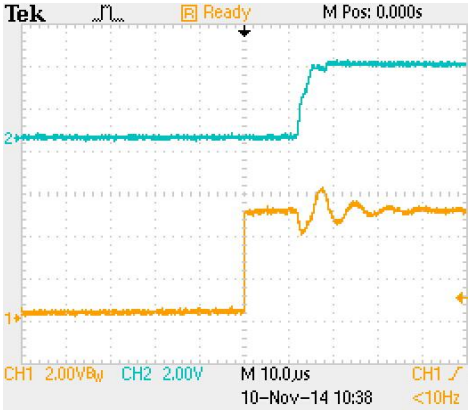
Thermal Limiting

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 LP78092 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 LP78092. 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. TQFN-16 power considerations are discussed further in the Applications Information section.

Automatic Recharge

Once the charge cycle is terminated, the LP78092 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.

Start-up Function



The LP78092 features an LDO regulator enable/disable function. To assure the LDO regulator will switch on, the EN turn on control level must be greater than 1.4 volts but not above Vin+0.3V. The LDO regulator will go into the shutdown mode when the voltage on the EN pin falls below 0.4 volts. For protecting the system, the LP78092 have a quick-discharge function. If the enable function is not needed in a specific application, it may be tied to VIN to keep the LDO regulator in a continuously on state.

Feedback Capacitor and Voltage

For adjustable version, connecting a 22pF between output pin and FB pin significantly reduces output voltage ripple, it is critical that the capacitor connection should be direct and PCB traces should be as short as possible.

The output voltage of dual LDO could be set by the formula below:

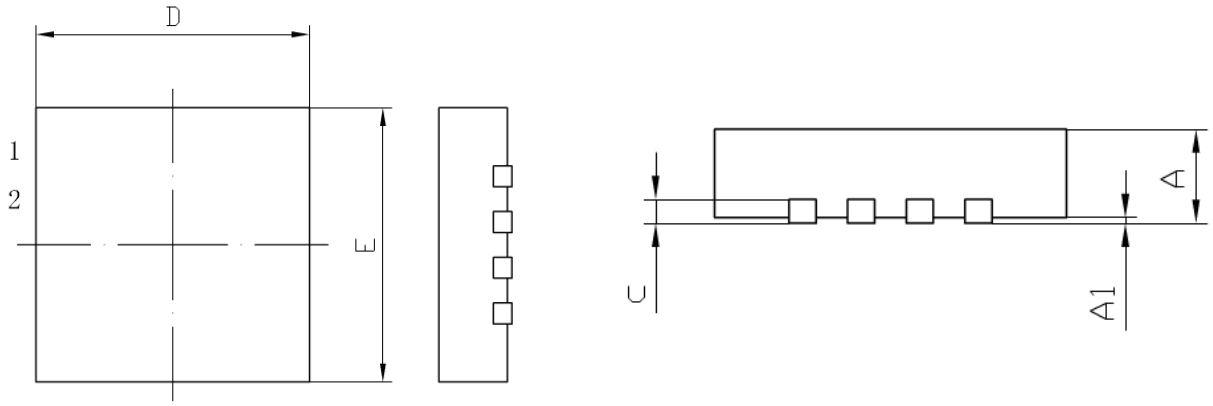
$Vout=V_{FB} \times (1+R1/R2)$,

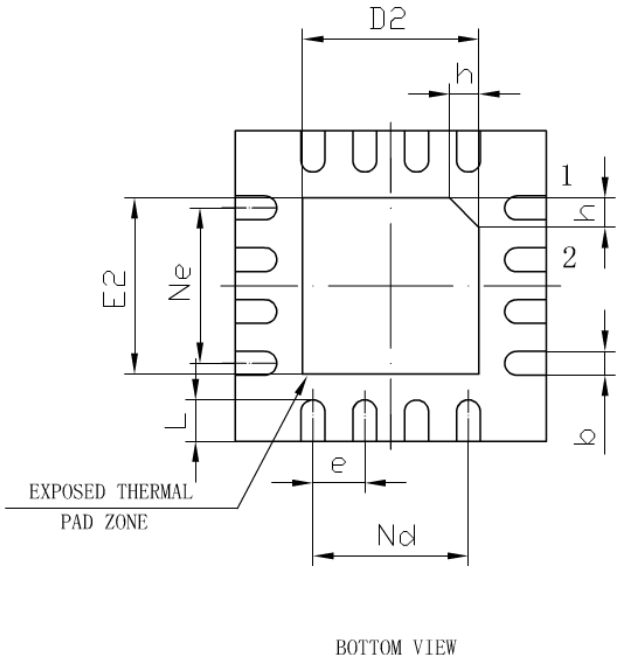
which V_{FB} = 0.8V

Considering the practical application, we may add a small capacitor with R1 in parallel which could be 33pF or 47pF.

Packaging Information

TQFN-16





BOTTOM VIEW

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	1.55	1.65	1.75
e	0.50BSC		
Ne	1.50BSC		
Nd	1.50BSC		
E	2.90	3.00	3.10
E2	1.55	1.65	1.75
L	0.35	0.40	0.45
h	0.20	0.25	0.30