

### General Description

The SY2A67932 integrates a linear charger for 1-cell or 2-cell Li-ion and Li-polymer batteries with a wide input operation voltage range of 4.5V~36V. It supports 4.05V, 4.1V, and 4.2V cell voltage batteries. The linear charger has high accuracy trickle charge current, constant charge current, constant charge voltage regulation loops, charge termination, and auto-recharge functions. The constant charging current is programmable up to 400mA using an external resistor. The device also integrates a thermal regulation loop, battery overvoltage protection, and battery temperature monitoring functions. Additionally, an open-drain output can provide charge status indication when connected to a LED.

The SY2A67932 also integrates a linear regulator that supplies power to the system with a wide input operation voltage range of 4.5V~36V. The output voltage of the linear regulator is programmed by an external resistor divider. The linear regulator can supply up to 500mA of load current. It has a high accuracy output voltage loop, overload protection, and short circuit protection.

The SY2A67932 has thermal shutdown protections for both the linear charger and the linear regulator to prevent the device from overheating. The device is available in a compact QFN 4mm×4mm-16 pin package.

### Features

- Wide Input Voltage Range: 4.5V~36V
- 400mA Linear Charger
  - Supports 1-cell or 2-cell Li-ion and Li-polymer Batteries
  - Supports 4.05V, 4.1V and 4.2V Cell Voltage Batteries
  - $\pm 0.5\%$  Battery Charge Voltage Regulation Accuracy
  - Programmable Constant Charge Current and Termination Current
  - 100mA~400mA Constant Charge Current with  $\pm 10\%$  Accuracy
  - 20mA~100mA Termination Current with  $\pm 20\%$  Accuracy
  - Thermal Regulation
- Integrated 500mA Linear Regulator with Overload and Short-Circuit Protection
- Thermal Shutdown Function
- RoHS Compliant and Halogen Free
- Compact Package: QFN4×4-16
- AEC-Q100 Grade1 Qualified

### Applications

- Automotive Applications
- Portable Battery-Powered Equipment

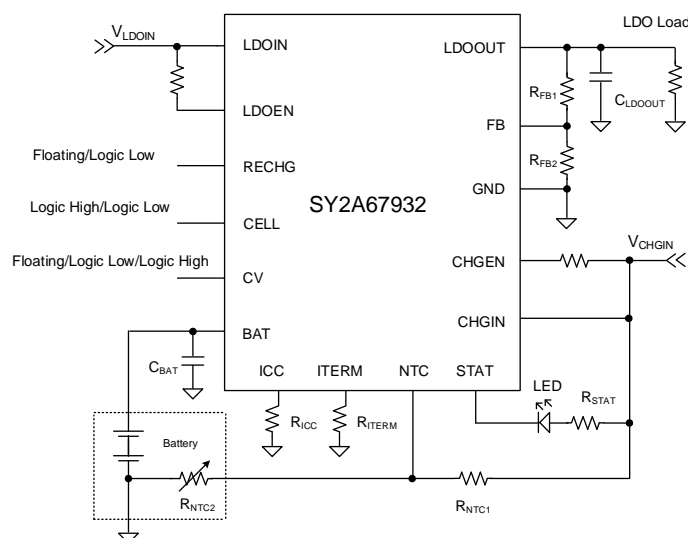


Figure 1. Typical Application Circuit



SILERGY

**SY2A67932**

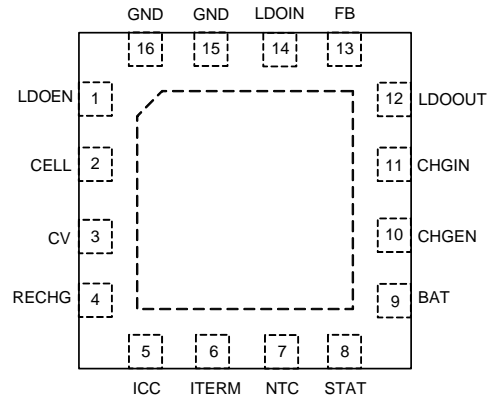
## Ordering Information

Ordering Part Number	Package type	Top Mark
SY2A67932QIA	QFN4x4-16 RoHS Compliant and Halogen Free	<b>BXJxyz</b>

Device code: BXJ

*x=year code, y=week code, z= lot number code*

## Pinout (Top View)



**(QFN4x4-16)**

Pin No	Pin Name	Pin Description
1	LDOEN	Linear regulator enable pin. Pull the LDOEN pin high to enable the regulator. Pull low to shutdown.
2	CELL	Cell selection pin. Pull the CELL pin low for 1-cell, pull it high for 2-cell battery. Do not leave floating.
3	CV	Battery cell voltage selection pin. Pull the CV pin low for 4.05V/cell, leave this pin floating for 4.1V/cell, and pull high for 4.2V/cell.
4	RECHG	Auto-recharge function enable pin. Pull the RECHG pin low to enable the auto-recharge function and leave this pin floating to disable auto-recharge function.
5	ICC	Constant charge current program pin. Connect a resistor $R_{ICC}$ from the ICC pin to GND to program the constant charge current as $I_{CC} = (1V / R_{ICC}) \times 1000$ .
6	ITERM	Termination and trickle current program pin. Connect a resistor $R_{ITERM}$ from ITERM pin to GND to program the termination and trickle current based on the equation: $I_{TERM} = I_{TC} = (1V / R_{ITERM}) \times 1000$ .
7	NTC	Battery temperature sense pin. Connect a resistor divider between the CHGIN and GND pins with the thermistor in series, and the center tap connected to the NTC pin, to program the allowable temperature range. When the NTC voltage is out of the normal temperature range, the charging process is suspended.
8	STAT	Charge status indication pin. Open drain output pin connected to the CHGIN pin through a LED and its current limiting resistor to indicate the charge status. When the charging process is completed, the STAT pin becomes high-impedance, and the LED turns off.
9	BAT	Battery connection point to the positive terminal of the battery pack. This pin is also used to sense the battery voltage.
10	CHGEN	Linear charger enable pin. Pull the CHGEN pin high to enable the linear charger.
11	CHGIN	Linear charger input pin. Bypass this pin to GND with a 2.2 $\mu$ F ceramic capacitor. When $V_{CHGIN}$ falls below $V_{BAT} + \Delta V_{SLEEP}$ , the charger enters sleep mode.
12	LDOOUT	Linear regulator output pin.
13	FB	Linear regulator output voltage feedback input pin. Connect a resistor divider from the LDOOUT pin to the FB pin to GND to program the output voltage. The reference voltage at the FB pin is 1V.
14	LDOIN	Linear regulator input pin and internal power source input pin. Bypass the LDOIN pin to GND with a 2.2 $\mu$ F ceramic capacitor.
15-16	GND	Ground connection pin.
-	Thermal Pad	Exposed pad. Connect to a large area copper pour or ground plane for heat dissipation.



Block Diagram

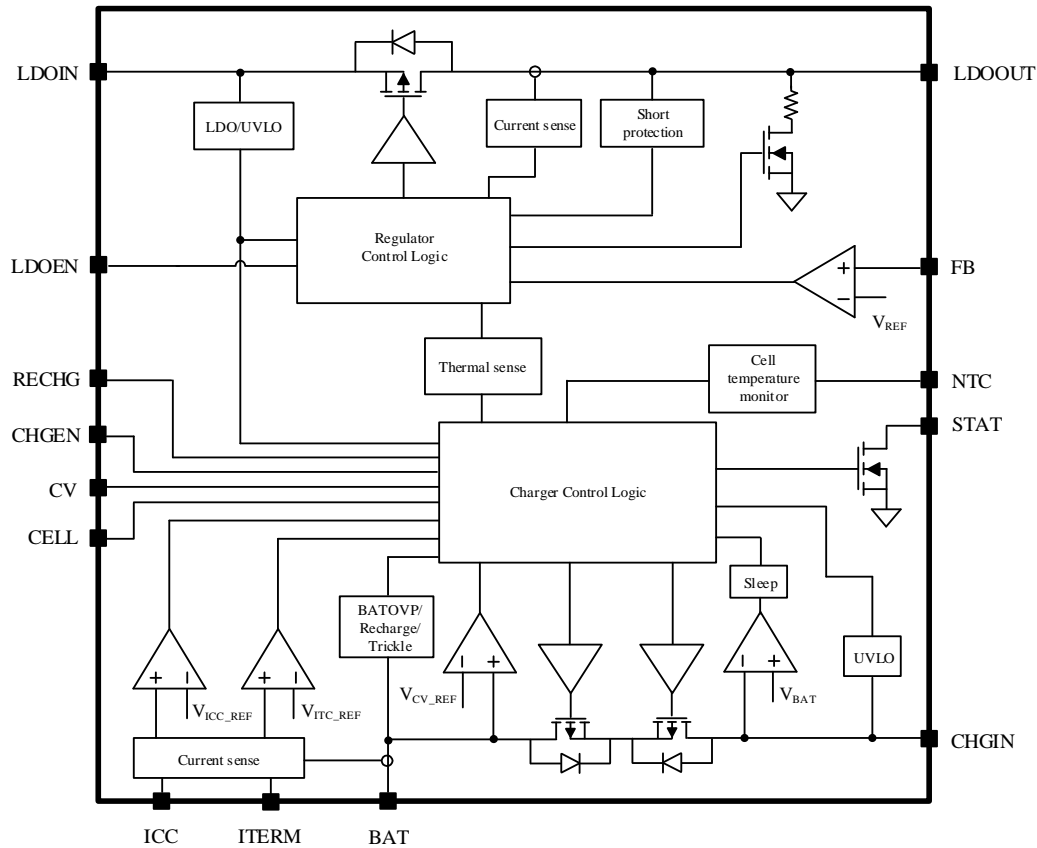


Figure 2. Block Diagram

Absolute Maximum Ratings (1)	Min	Max	Unit
LDOIN, LDOEN, CHGIN, CHGEN, STAT, NTC, CELL, CV, RECHG	-0.3	40	V
LDOOUT	-0.3	V <sub>LDOIN</sub>	
BAT	-5	15	°C
FB, ICC, ITERM	-0.3	6	
Junction Temperature, Operating	-40	150	°C
Lead Temperature (Soldering, 10 sec.)		300	
Storage Temperature	-65	150	

Thermal Information (2)	Typ	Unit
θ <sub>JA</sub> Junction-to-ambient Thermal Resistance	36	°C/W
θ <sub>JC</sub> Junction-to-case Thermal Resistance	29	
P <sub>D</sub> Power Dissipation T <sub>A</sub> =25°C	3.5	W

Recommended Operating Conditions (3)	Min	Max	Unit
LDOIN, LDOEN, CHGIN, CHGEN, STAT, NTC, CELL, CV, RECHG	0	36	V
LDOOUT	2	24	
BAT	0	12	°C
ICC ITERM	0	5	
Output Current Limit Setting Ambient Temperature	-40	125	



**Electrical Characteristics**  $V_{LDOIN} = V_{LDOEN} = 12V, V_{LDOOUT} = 10V, V_{CHGIN} = V_{CHGEN} = 10V, V_{BAT} = 7V, T_A = -40^{\circ}C$  to  $+125^{\circ}C, T_A < T_J < 150^{\circ}C, T_A = 25^{\circ}C$  for typical values, unless otherwise specified

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
<b>Linear Regulator</b>						
Input voltage range	$V_{LDOIN}$		4.5		36	V
Output voltage range	$V_{LDOOUT}$		1		15	V
FB regulation voltage	$V_{REF}$	$T_A = -40^{\circ}C \sim 125^{\circ}C, I_{LDOOUT} = 5mA$	0.98	1	1.02	V
		$T_A = 25^{\circ}C, I_{LDOOUT} = 5mA$	0.99	1	1.01	V
Line regulation	$\Delta V_{LNR}$	$I_{LDOOUT} = 10mA, V_{LDOOUT} = 3.3V, 12 \leq V_{LDOIN} \leq 36V$		1	10	mV
Load regulation	$\Delta V_{LDR}$	$V_{LDOIN} = 5V, 10mA \leq I_{LDOOUT} \leq 0.5A, V_{LDOOUT} = 3.3V, T_A = 25^{\circ}C$		1	15	mV
Dropout voltage	$\Delta V_{DROP}$	$I_{LDOOUT} = 10mA$			20	mV
		$I_{LDOOUT} = 500mA, T_A = 25^{\circ}C$			700	mV
Shutdown current	$I_{SD}$	$V_{LDOEN} < 0.4V, V_{LDOIN} = 16V, T_A = -40^{\circ}C \sim 85^{\circ}C$			2	$\mu A$
Output current	$I_O$	$V_{LDOIN} = V_{LDOOUT} + 0.6V$	0		500	mA
Output current limit	$I_{LIMIT}$	$T_A = 25^{\circ}C$		700		mA
LDOIN UVLO threshold	$V_{LDOIN\_UVLO}$	$V_{LDOIN}$ rising	3	3.5	4	V
LDOIN UVLO threshold hysteresis	$\Delta V_{LDOIN\_UVLO}$	$V_{LDOIN}$ falling		200		mV
LDOEN input logic-high threshold	$V_{LDOEN\_H}$		1.5			V
LDOEN input logic-low threshold	$V_{LDOEN\_L}$				0.4	V
LDOOUT shutdown discharge resistance	$R_{DIS}$			600		$\Omega$
LDOOUT short circuit protection threshold	$V_{FB\_SHORT}$	$V_{FB}$ falling	40%	50%	60%	$V_{REF}$
LDOOUT short circuit protection Hysteresis	$\Delta V_{FB\_SHORT}$	$V_{FB}$ rising		5%		$V_{REF}$
LDOOUT hiccup mode interval time	$t_{SC\_OFF}$			300		ms
<b>Linear Charger</b>						
Input voltage range	$V_{CHGIN}$		4.5		36	V
CHGIN UVLO threshold	$V_{CHGIN\_UVLO}$	$V_{CHGIN}$ rising	3	3.5	4	V
CHGIN UVLO threshold hysteresis	$\Delta V_{CHGIN\_UVLO}$	$V_{CHGIN}$ falling		200		mV
Sleep mode threshold	$\Delta V_{SLEEP}$	Measured from CHGIN to BAT, $V_{CHGIN}$ falling	380	450	520	mV
Sleep mode threshold hysteresis	$\Delta V_{SLEEP\_HYS}$	$V_{CHGIN}$ rising		50		mV
Charger start deglitch time	$t_{START}$	$V_{CHGIN} > V_{BAT} + \Delta V_{SLEEP}, V_{CHGIN} > V_{CHGIN\_UVLO}, V_{LDOIN} > V_{LDOIN\_UVLO}, V_{CHGEN} > 1.5V$	30	50	70	ms
Charge voltage regulation	$V_{BAT\_REG}$ $T_A = 25^{\circ}C$	$V_{CELL} < 0.4V, V_{CV} < 0.4V, I_{BAT} = 10mA$	4.030	4.05	4.070	V
		$V_{CELL} < 0.4V, CV$ pin is	4.079	4.10	4.120	V

		floating, $I_{BAT}=10mA$				
		$V_{CELL}<0.4V$ , $V_{CV}>1.5V$ , $I_{BAT}=10mA$	4.179	4.20	4.221	V
		$V_{CELL}>1.5V$ , $V_{CV}<0.4V$ , $I_{BAT}=10mA$	8.060	8.10	8.141	V
		$V_{CELL}>1.5V$ , CV pin is floating, $I_{BAT}=10mA$	8.159	8.20	8.241	V
		$V_{CELL}>1.5V$ , $V_{CV}>1.5V$ , $I_{BAT}=10mA$	8.358	8.40	8.442	V
<b>Electrical Characteristics (cont.)</b> $V_{LDOEN} = V_{LDOEN} = 12V$ , $V_{LDOOUT} = 10V$ , $V_{CHGIN} = V_{CHGEN} = 10V$ , $V_{BAT} = 7V$ , $T_A = -40^\circ C$ to $+125^\circ C$ , $T_A < T_J < 150^\circ C$ , $T_A = 25^\circ C$ for typical values, unless otherwise specified						
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Charge voltage regulation	$V_{BAT\_REG}$ $T_A = -40$ $\sim 125^\circ C$	$V_{CELL}<0.4V$ , $V_{CV}<0.4V$ , $I_{BAT}=10mA$	4.001	4.05	4.099	V
		$V_{CELL}<0.4V$ , CV pin is floating, $I_{BAT}=10mA$	4.051	4.10	4.149	V
		$V_{CELL}<0.4V$ , $V_{CV}>1.5V$ , $I_{BAT}=10mA$	4.149	4.20	4.250	V
		$V_{CELL}>1.5V$ , $V_{CV}<0.4V$ , $I_{BAT}=10mA$	8.003	8.10	8.197	V
		$V_{CELL}>1.5V$ , CV pin is floating, $I_{BAT}=10mA$	8.102	8.20	8.298	V
		$V_{CELL}>1.5V$ , $V_{CV}>1.5V$ , $I_{BAT}=10mA$	8.299	8.40	8.501	V
Battery voltage OVP threshold	$V_{BAT\_OVP}$	$V_{BAT}$ rising	101.5%	103%	104.5%	$V_{BAT\_REG}$
Battery voltage OVP threshold hysteresis	$\Delta V_{BAT\_OVP}$	$V_{BAT}$ falling		0.5%		$V_{BAT\_REG}$
Constant current charge to trickle current charge threshold	$V_{TRK}$	$V_{CELL}<0.4V$ , $V_{BAT}$ falling, $T_A = 25^\circ C$	2.9	3	3.1	V
		$V_{CELL}>1.5V$ , $V_{BAT}$ falling, $T_A = 25^\circ C$	5.8	6	6.2	V
Recharge threshold	$\Delta V_{RCH}$	$V_{CELL}<0.4V$ , $T_A = 25^\circ C$	70	100	130	mV
		$V_{CELL}>1.5V$ , $T_A = 25^\circ C$	140	200	260	mV
Termination deglitch time	$t_{TERM}$			30		ms
Recharge deglitch time	$t_{RCHG}$			30		ms
Constant charge current accuracy	$I_{CC\_ACC}$	$I_{CC} = 200mA$ , $T_A = -40 \sim 85^\circ C$	-10%		10%	
Trickle charge current accuracy	$I_{TC\_ACC}$	$I_{TC} = 50mA$ , $T_A = -40 \sim 85^\circ C$	-20%		20%	
Charge termination current accuracy	$I_{TERM\_ACC}$	$I_{TERM} = 50mA$ , $T_A = -40 \sim 85^\circ C$	-20%		20%	
CHGIN sleep current	$I_{SLEEP}$	$V_{BAT} > V_{TRK}$ , $V_{BAT} - V_{CHGIN} = 0.8V$ , $V_{NTC} = 50\% V_{CHGIN}$ , $T_A = -40 \sim 85^\circ C$			2	$\mu A$
Charger shutdown current	$I_{CHGSD}$	$V_{CHGEN} < 0.4V$ , $V_{NTC} = 50\% V_{CHGIN}$ , $T_A = -40 \sim 85^\circ C$			2	$\mu A$
Battery discharge current	$I_{BAT}$	$V_{CHGEN} < 0.4V$ , $V_{NTC} = 50\% V_{CHGIN}$ , $T_A = -40 \sim 85^\circ C$			1	$\mu A$



CELL/CV/CHGEN /RECHG input logic-high threshold	V <sub>H</sub>		1.5			V
CELL/CV/CHGEN /RECHG input logic-low threshold	V <sub>L</sub>				0.4	V
UTP threshold	V <sub>NTC_UTP</sub>	V <sub>NTC</sub> rising	59%	60%	61%	V <sub>CHGIN</sub>
UTP threshold hysteresis	ΔV <sub>NTC_UTP</sub>	V <sub>NTC</sub> falling		3%		
OTP threshold	V <sub>NTC_OTP</sub>	V <sub>NTC</sub> falling	29%	30%	31%	
OTP threshold hysteresis	ΔV <sub>NTC_OTP</sub>	V <sub>NTC</sub> rising		2%		
<b>Quiescent Current</b>						
Quiescent current when the regulator is on, and the charger is disabled	I <sub>Q_CHGDIS</sub> -V <sub>LDOOUT</sub> /R <sub>Fb</sub>	V <sub>LDOIN</sub> =12V, V <sub>LDOOUT</sub> =10V, V <sub>LDOEN</sub> >1.5V, V <sub>CHGIN</sub> =10V, V <sub>CHGEN</sub> <0.4V (Exclude FB resistor divider current) , T <sub>A</sub> = -40~85°C		9	13	μA
Quiescent current when the regulator is on, and the charger is disconnected	I <sub>Q_LDOONLY</sub> -V <sub>LDOOUT</sub> /R <sub>Fb</sub>	V <sub>LDOIN</sub> =12V, V <sub>LDOOUT</sub> =10V, V <sub>LDOEN</sub> >1.5V, CHGIN is floating, V <sub>CHGEN</sub> <0.4V (Exclude FB resistor divider current) ,T <sub>A</sub> = -40~85°C		7	11	μA
<b>Electrical Characteristics (cont.)</b> V <sub>LDOIN</sub> = V <sub>LDOEN</sub> =12V, V <sub>LDOOUT</sub> =10V, V <sub>CHGIN</sub> =V <sub>CHGEN</sub> =10V, V <sub>BAT</sub> =7V, T <sub>A</sub> = -40°C to +125°C, T <sub>A</sub> <T <sub>J</sub> <150°C, T <sub>A</sub> =25°C for typical values, unless otherwise specified						
<b>Parameter</b>	<b>Symbol</b>	<b>Test Conditions</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Unit</b>
<b>Thermal Protection</b>						
Thermal shutdown threshold	T <sub>SD</sub>	Temperature rising edge		165		°C
Thermal shutdown threshold hysteresis	T <sub>SD_HYS</sub>	Temperature falling edge		30		°C
Thermal regulation threshold	T <sub>REG</sub>			120		°C

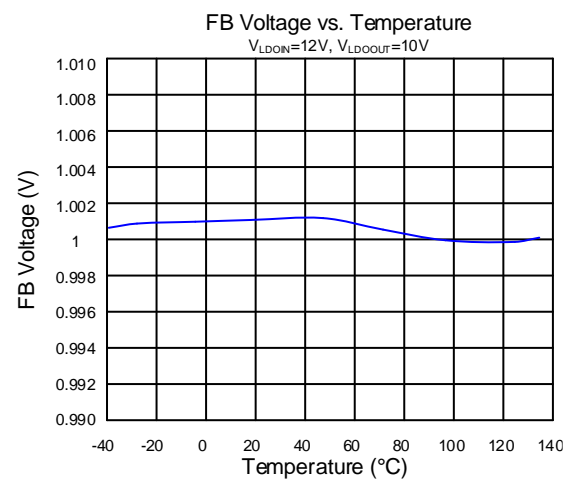
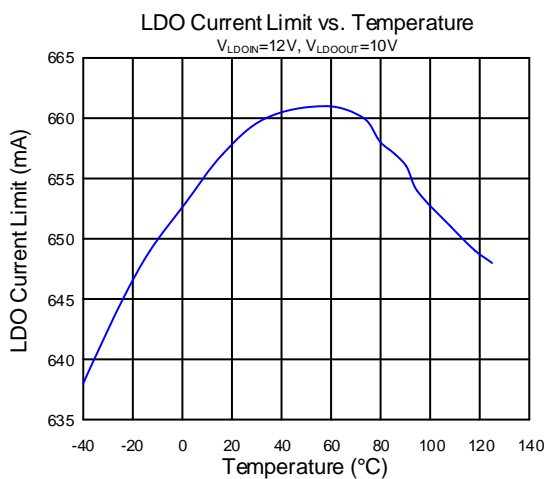
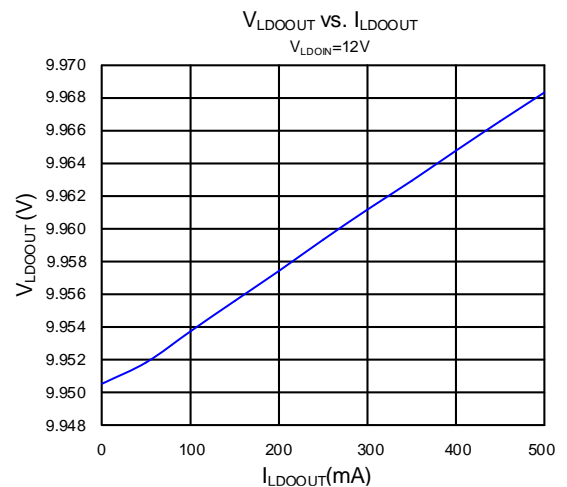
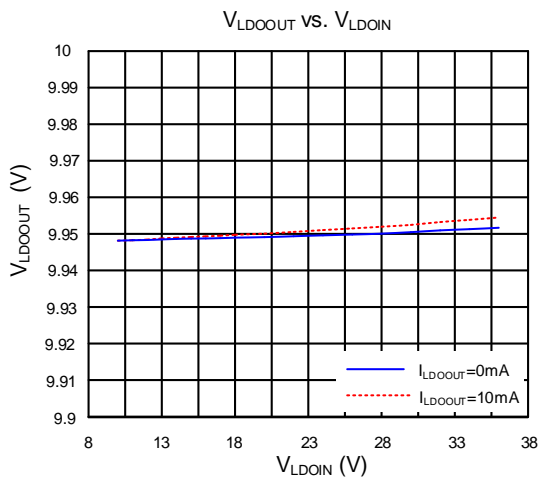
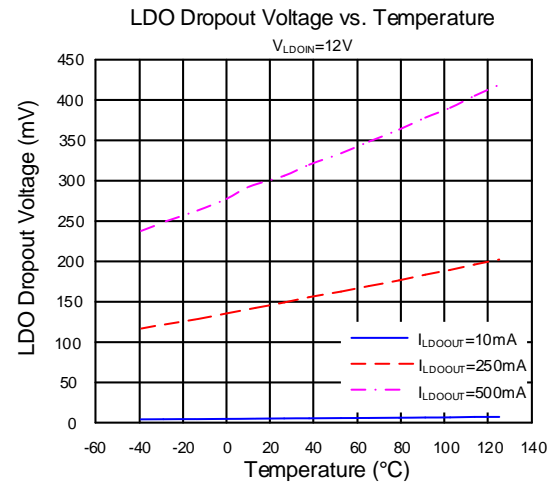
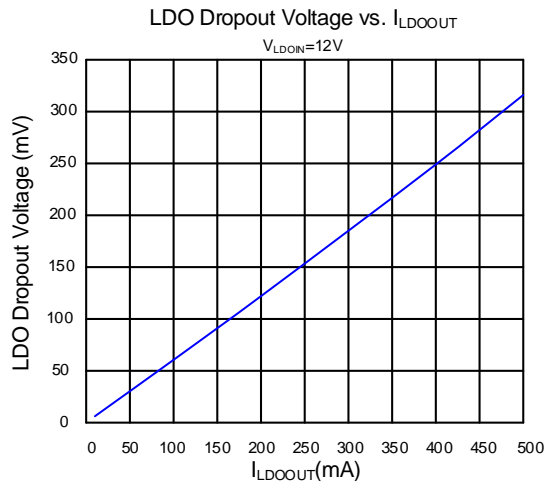
**Note 1:** Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

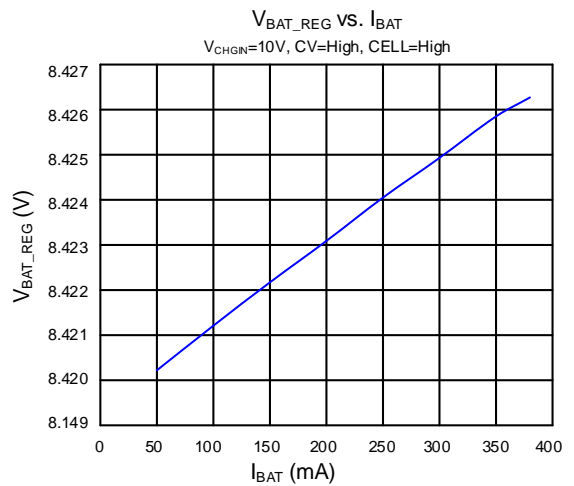
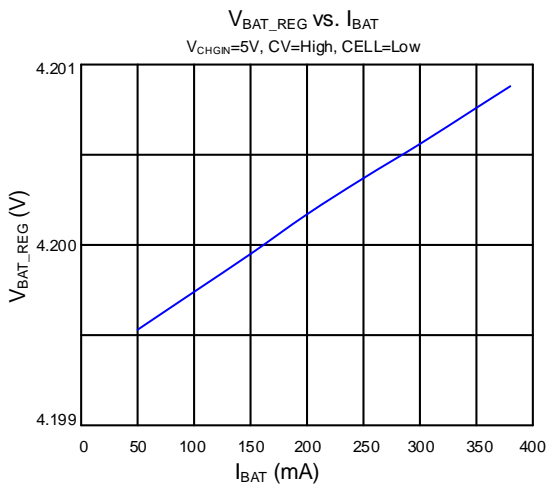
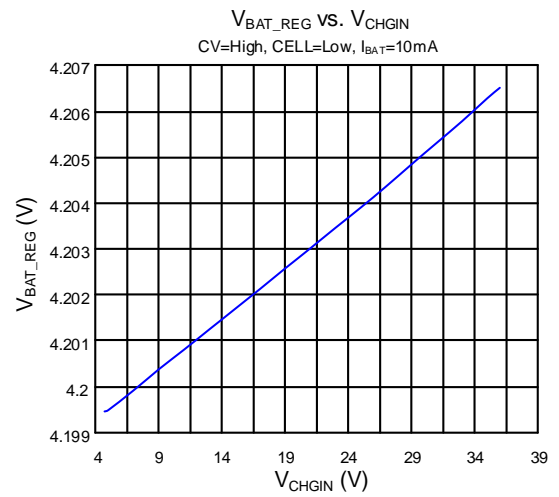
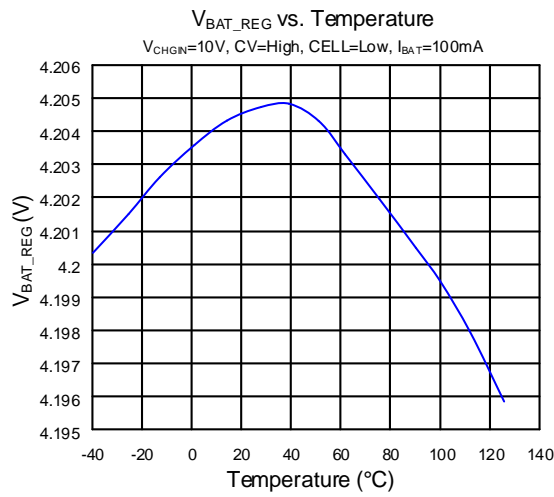
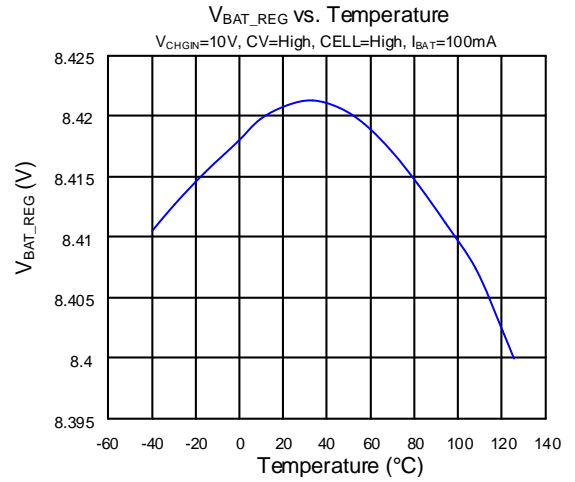
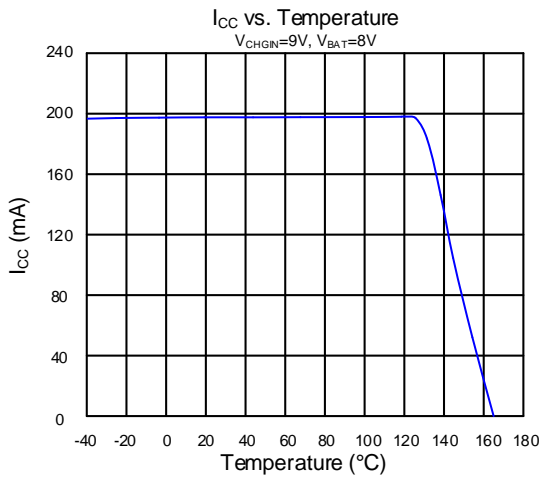
**Note 2:** Package thermal resistance is measured in the natural convection at T<sub>A</sub> = 25°C on a highly effective four-layer thermal conductivity test board of JEDEC 51-2,5,7 thermal measurement standard.

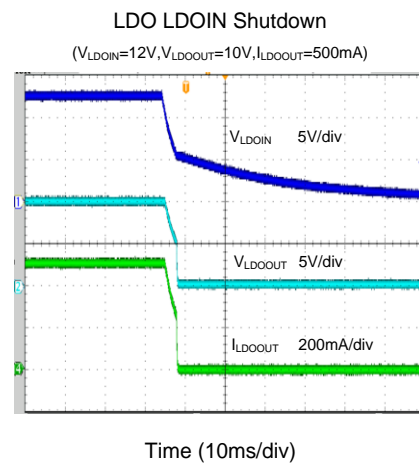
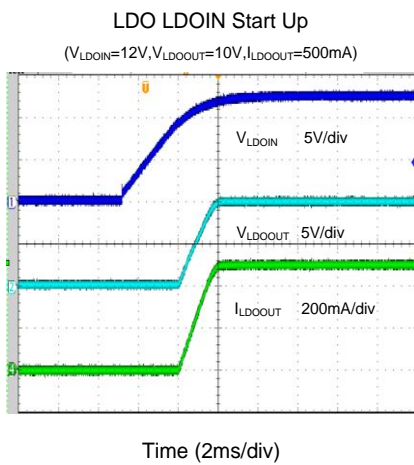
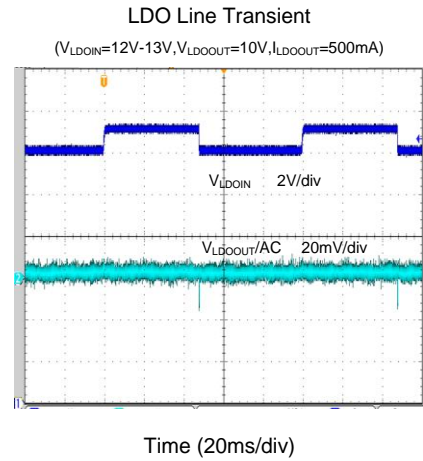
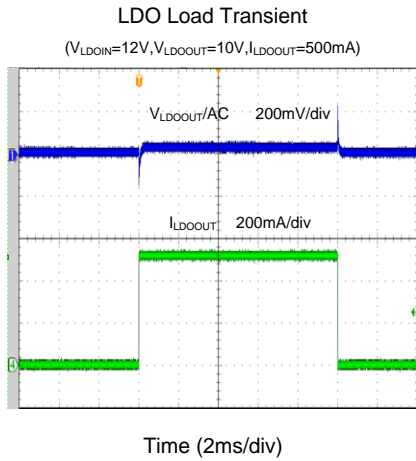
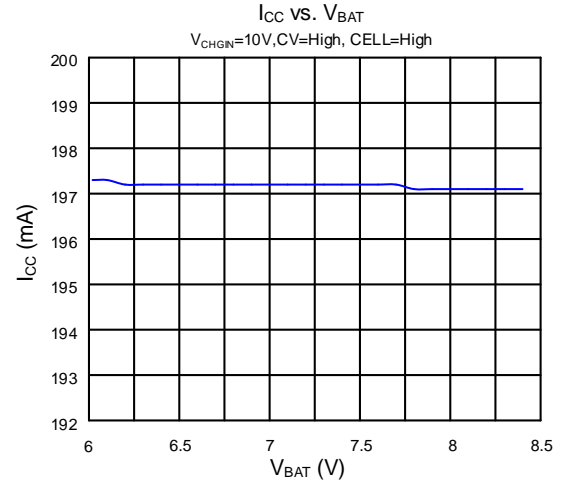
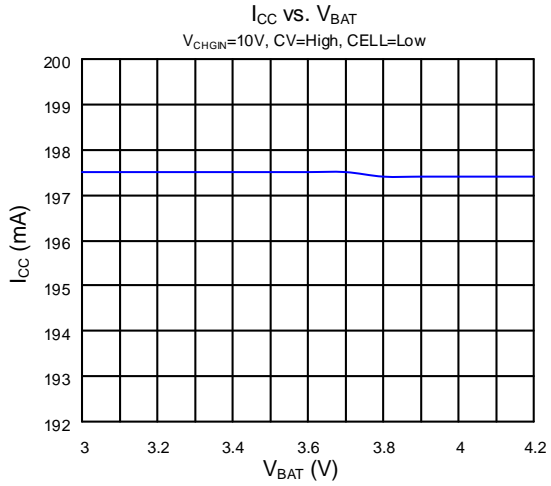
**Note 3:** The device is not guaranteed to function outside its operating conditions.

## Typical Performance Characteristics

( $T_A=25^\circ\text{C}$ ,  $V_{\text{LDOIN}}=12\text{V}$ ,  $V_{\text{LDOOUT}}=10\text{V}$ ,  $V_{\text{CHGIN}}=10\text{V}$ ,  $V_{\text{BAT}}=7\text{V}$ ,  $C_{\text{LDOIN}}=2.2\mu\text{F}$ ,  $C_{\text{LDOOUT}}=4.7\mu\text{F}$ ,  $C_{\text{CHGIN}}=2.2\mu\text{F}$ ,  $C_{\text{BAT}}=20\mu\text{F}$ , unless otherwise noted)

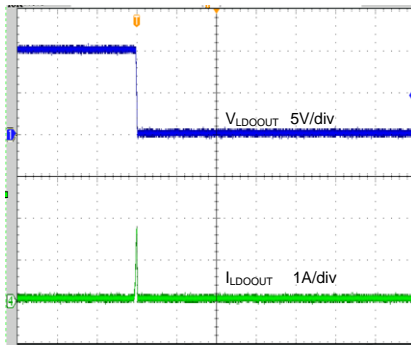






### LDO Short Circuit Entry

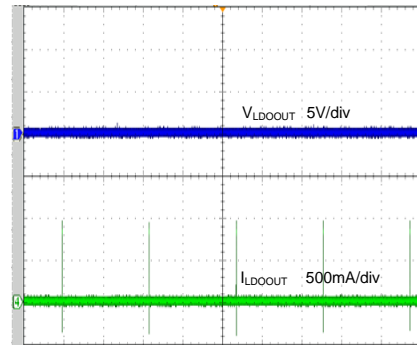
( $V_{LDOIN}=12V, V_{LDOOUT}=10V, I_{LDOOUT}=0mA$  to short-circuit)



Time (2ms/div)

### LDO Short Circuit Steady State

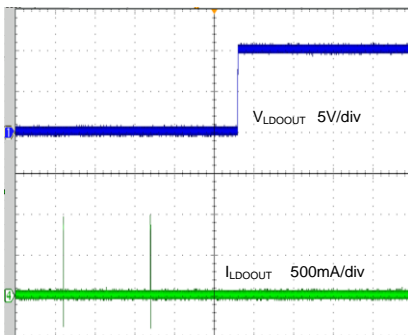
( $V_{LDOIN}=12V$ )



Time (100ms/div)

### LDO Short Circuit Recovery

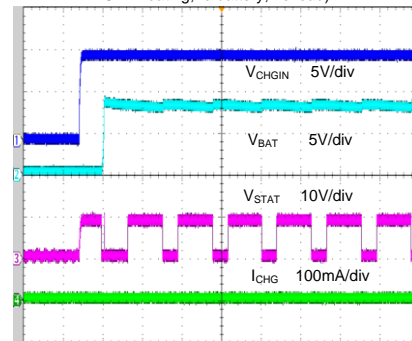
( $V_{LDOIN}=12V, V_{LDOOUT}=10V$ , short-circuit to  $I_{LDOOUT}=0mA$ )



Time (100ms/div)

### Charger CHGIN Start Up

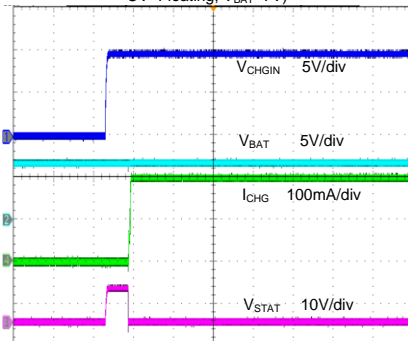
( $V_{CHGIN}=10V, I_{CC}=200mA, I_{TC}=I_{TERM}=50mA, CELL=High, CV=Floating, no battery, no load$ )



Time (100ms/div)

### Charger Hot Plug (CC mode)

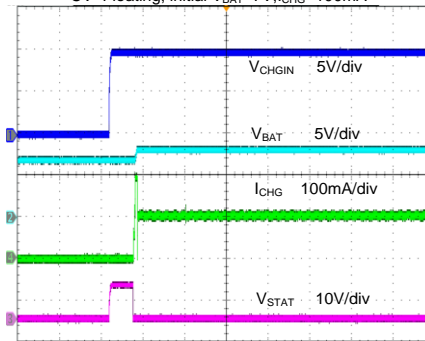
( $V_{CHGIN}=10V, I_{CC}=200mA, I_{TC}=I_{TERM}=50mA, CELL=High, CV=Floating, V_{BAT}=7V$ )



Time (100ms/div)

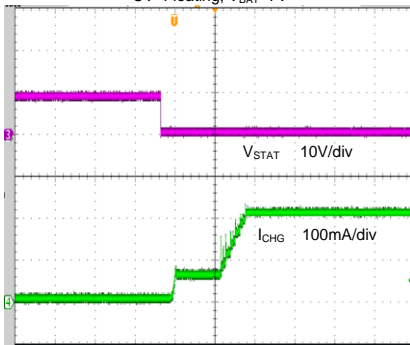
### Charger Hot Plug (CV mode)

( $V_{CHGIN}=10V, I_{CC}=200mA, I_{TC}=I_{TERM}=50mA, CELL=High, CV=Floating, initial V_{BAT}=7V, I_{CHG}=100mA$ )



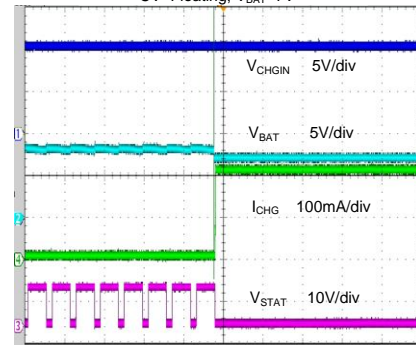
Time (100ms/div)

**Charge Current Soft Start (CC mode)**  
 $V_{CHGIN}=10V, I_{CC}=200mA, I_{TC}=I_{TERM}=50mA, CELL=High,$   
 $CV=Floating, V_{BAT}=7V$



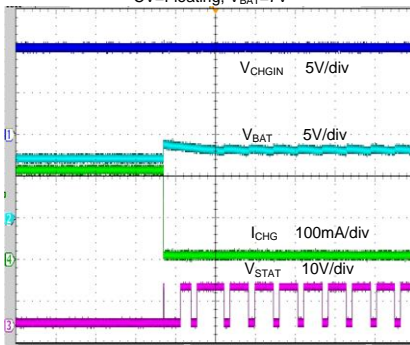
Time (2ms/div)

**Battery Insert (CC mode)**  
 $V_{CHGIN}=10V, I_{CC}=200mA, I_{TC}=I_{TERM}=50mA, CELL=High,$   
 $CV=Floating, V_{BAT}=7V$



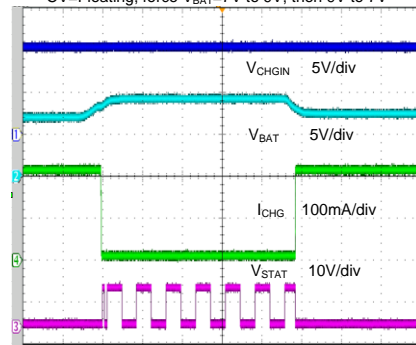
Time (200ms/div)

**Battery Removal (CC mode)**  
 $V_{CHGIN}=10V, I_{CC}=200mA, I_{TC}=I_{TERM}=50mA, CELL=High,$   
 $CV=Floating, V_{BAT}=7V$



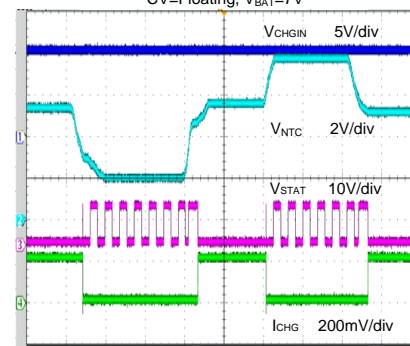
Time (200ms/div)

**Battery OVP and Recovery**  
 $V_{CHGIN}=10V, I_{CC}=200mA, I_{TC}=I_{TERM}=50mA, CELL=High,$   
 $CV=Floating, \text{force } V_{BAT}=7V \text{ to } 9V, \text{ then } 9V \text{ to } 7V$



Time (1s/div)

**NTC UTP/OTP and Recovery**  
 $V_{CHGIN}=10V, I_{CC}=200mA, I_{TC}=I_{TERM}=50mA, CELL=High,$   
 $CV=Floating, V_{BAT}=7V$



Time (2s/div)

## Application Information

The SY2A67932 integrates a 500mA linear regulator and a 400mA linear charger for 1-cell or 2-cell Li-ion and Li-polymer batteries.

The linear charger can automatically start and complete a full charging cycle without intervention. The charging cycle includes trickle current charge, constant current charge, constant voltage charge, charge termination, and auto-recharge. It also has a thermal regulation loop, battery overvoltage protection, and battery temperature monitor function. All these features ensure the safety of the battery pack during the charging process.

The linear regulator can supply the system with a wide input operation voltage range of 4.5V~36V. It has an output voltage loop to adjust the output voltage, an output current limit to prevent the linear regulator from overloading, and output short-circuit protection.

### Linear Regulator Operation

#### Linear Regulator Power-On-Reset (POR):

When the input voltage of the linear regulator rises above the UVLO threshold and the EN pin is pulled high, the linear regulator turns on the output with soft-start.

The regulator is disabled when the EN pin is pulled low. An internal 600Ω resistor is connected to the LDOOUT pin to quickly discharge the output voltage in this case.

#### Linear Regulator Output Voltage Setting:

The linear regulator output voltage is programmed by using the external resistor divider (see Figure 3).

The linear regulator voltage can be calculated by using the following equation:

$$V_{LDOOUT} = V_{REF} \times \frac{R_1 + R_2}{R_2}$$

Where:  $V_{REF}$  is the regulation voltage at FB, with a value of 1V.

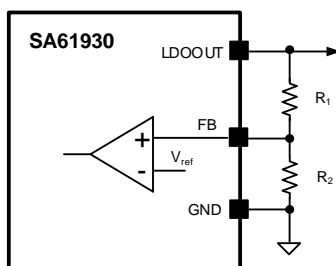


Figure 3. Regulator Output Voltage Setting Network

### Linear Regulator Protection Features:

#### LDOOUT Overload Protection:

The linear regulator can supply up to 500mA continuous current to the load. When the output current exceeds the output current limit, the output current is limited to protect it against overload.

#### LDOOUT Short-Circuit Protection:

When  $V_{FB}$  falls below the  $V_{FB\_SHORT}$  threshold, the regulator turns off the output and enters hiccup mode. In this mode, the linear regulator restarts with a soft-start process after a 300ms interval.

#### Thermal Shutdown Protection:

The SY2A67932 monitors the junction temperature of the linear regulator and charger to prevent the device from overheating. The SY2A67932 shuts down when the junction temperature exceeds 165 °C and returns to normal operation when the junction temperature falls below 135 °C.

### Linear Charger Operation

#### Linear Charger Power-On-Reset (POR):

LDOIN powers the internal circuits, requiring an external source connected to the LDOIN pin to guarantee the charger's functionality.

The charging process of the linear charger initiates when the input voltage exceeds  $V_{BAT} + \Delta V_{SLEEP\_HYS}$ , and the CHGEN pin is simultaneously pulled high. This process begins with a soft start after a 50ms deglitch time period.

If the input voltage of the linear charger falls below  $V_{BAT} + \Delta V_{SLEEP}$  or the CHGEN pin is pulled low, the charger will enter sleep mode.

#### Battery Charging Profile:

The linear charger can automatically start and complete a full charging cycle. The complete charging cycle includes trickle current charge, constant current charge, constant voltage charge, charge termination, and auto-recharge (see Figure 4).

- Trickle current charge ( $t_0-t_1$ ):** The charger charges the battery with current  $I_{TC}$  until  $V_{BAT} > V_{TRK}$ . This feature ensures safe charging.
- Constant current charge ( $t_1-t_2$ ):** After  $V_{BAT} > V_{TRK}$ , the charger enters a constant current charge until  $V_{BAT} = V_{BAT\_REG}$ . In this constant current charge mode, the charge current is limited to  $I_{CC}$ .
- Constant voltage charge ( $t_2-t_3$ ):** The charger enters a constant voltage charge when  $V_{BAT}$  reaches  $V_{BAT\_REG}$ . In constant voltage charge,  $V_{BAT}$  is

regulated to  $V_{BAT\_REG}$ , and the charge current decreases progressively until the charge current is less than  $I_{TERM}$ .

4. **Charge termination ( $t_3-t_4$ ):** The charger terminates the charging cycle when the charge current is lower than  $I_{TERM}$ , and  $V_{BAT} > V_{BAT\_REG} - \Delta V_{RCH}$ .
5. **Recharge ( $t_4$ -):** Due to the system consumption and battery leakage current, the battery voltage drops gradually after charge termination. If the auto-recharge function is enabled (pull RECHG pin low), the charger starts a new charging cycle to recharge the battery when  $V_{BAT}$  is lower than  $V_{BAT\_REG} - \Delta V_{RCH}$ .

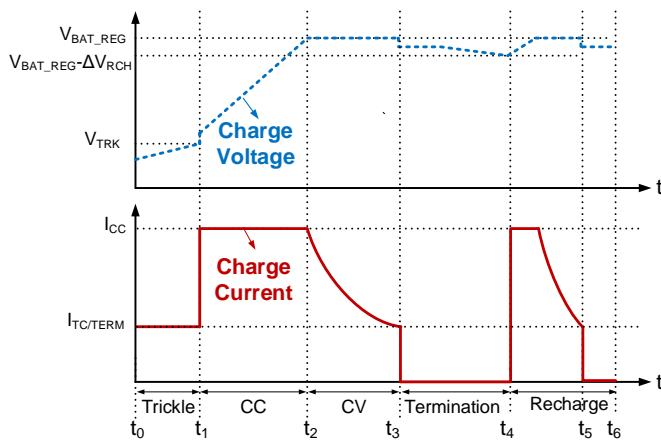


Figure 4. Battery Charging Profile

### Charger Constant Charge Current Setting:

The constant charge current can be programmed by an external resistor (see Figure 5) and can be calculated by using the following equation:

$$I_{CC} = \frac{1}{R_3} \times 1000$$

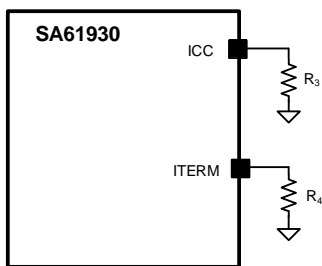


Figure 5.  $I_{CC}$  and  $I_{TERM}$  Setting Network

### Charger Trickle Charge Current and Termination Current Setting:

The trickle charge current is equal to the termination current, and they are programmed by an external resistor (see Figure 5).

The trickle charge current and termination current can be calculated by using the following equation:

$$I_{TERM} = I_{TC} = \frac{1}{R_4} \times 1000$$

### Battery Cell and Charge Voltage Configuration:

The charger can support 1-cell or 2-cell batteries, selectable via the CELL pin. Pull the CELL pin low for 1-cell and high for 2-cell batteries. Do not leave this pin floating.

The CV pin can be used to set the battery charge voltage. Pull the CV pin low for 4.05V/cell, leave the CV pin floating for 4.1V/cell, and pull the CV pin high for 4.2V/cell. Table 1 summarizes all the setting combinations:

Table 1. Battery Cell Number and Charge Voltage Setting

CELL pin state	CV pin state	$V_{BAT\_REG}(V)$
Low	Low	4.05
	Floating	4.1
	High	4.2
High	Low	8.1
	Floating	8.2
	High	8.4

### Charging Status Indication Function:

The STAT pin is an open drain output pin. A pull-up resistor connected between the CHGIN and STAT pin is needed for charging status indication. Connecting an LED in series with the pull-up resistor is recommended to show the charging status directly.

- **Charging-in-Process:** STAT pin is driven low. The LED stays on during trickle current charging, constant current charging, and constant voltage charging.
- **Charging Suspended:** High-Impedance. The LED turns off when the CHGEN/CHGIN/LDOIN pins are low, thermal shutdown is triggered, or the charging is completed.
- **Fault Mode:** Output toggles high/low with 1.3Hz frequency, and the LED flashes. The fault modes include NTC (UTP/OTP) and BATOVP.
- LED on indicates charging-in-process.
- LED off indicates charging suspended.
- LED flashing indicates fault mode.

### Linear Charger Protection: BAT Over-Voltage Protection

When the battery voltage is higher than the  $V_{BAT\_OVP}$  threshold, the charger stops charging, and the STAT pin blinks at a frequency of 1.3Hz. The charger returns to

normal operation when the battery voltage returns to the normal range.

### NTC Protection

The SY2A67932 monitors the battery pack's temperature by measuring the voltage of the CHGIN and NTC pins. The charger triggers the UTP when the ratio K ( $K = \frac{V_{NTC}}{V_{CHGIN}}$ ) is higher than  $K_{UT}$  ( $K_{UT} = \frac{V_{NTC\_UTP}}{V_{CHGIN}}$ ). The OTP is triggered when the ratio K is lower than  $K_{OT}$  ( $K_{OT} = \frac{V_{NTC\_OTP}}{V_{CHGIN}}$ ). When UTP or OTP is triggered, the charger stops charging, and the STAT pin blinks at 1.3Hz. The temperature sensing network is shown in Figure 6.

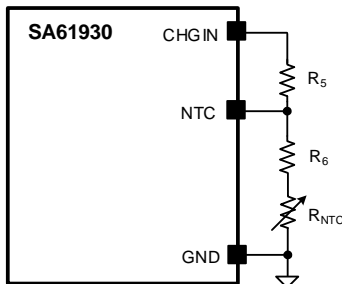


Figure 6. NTC Setting Network

### Thermal Regulation

To avoid overheating and limit the maximum device temperature, the SY2A67932 continuously monitors the internal junction temperature. When the junction temperature exceeds 120°C, the charger automatically reduces the charge current to prevent the junction temperature from further increasing.

## Design Procedure

### Linear Regulator Output Voltage Resistor Divider Selection:

Choose  $R_1$  and  $R_2$  to program the proper output voltage. To minimize the power consumption under light loads, choosing large resistance values for both  $R_1$  and  $R_2$  is recommended. If the  $V_{LDOOUT}$  is 10V, then  $R_1 = 180k\Omega$ . Using the following equation,  $R_2$  is calculated to be 20kΩ:

$$R_2 = \frac{1V}{V_{LDOOUT} - 1V} \times R_1$$

### Regulator and Charger Enable Control:

The LDOEN pin is the logic enable pin which controls the on/off state of the linear regulator. When the LDOEN pin is pulled below 0.4V, the regulator shuts down. When LDOEN is pulled above 1.5V, the regulator starts up after about a 2ms deglitch time.

Similarly, when the CHGEN pin is pulled below 0.4V, the charger is disabled. When the CHGEN pin is pulled above 1.5V, the charger starts up after about a 50ms deglitch time.

Adding a 10k resistor between the CHGEN/LDOEN pins and the power source is recommended.

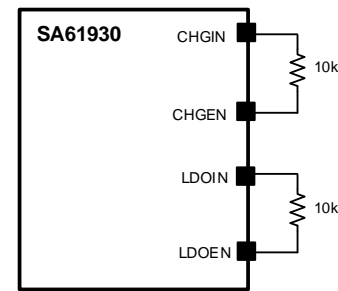


Figure 7. LDOEN and CHGEN Pin Network

### Input Capacitor Selection:

A 2.2μF ceramic capacitor should be placed as close as possible between the LDOIN and the GND pins for optimal performance. A 2.2μF ceramic capacitor should also be placed between the CHGIN pin and the ground. Using larger capacitance values stabilizes the input voltage and enhances the line transient response.

### Output Capacitor Selection:

For the linear regulator, placing a 4.7μF ceramic capacitor close to its output is recommended for stability. A feed-forward capacitor, typically with a capacitance of 2.2nF, should be connected in parallel with  $R_1$  to enhance load transient response. It's important to note that this feed-forward capacitor is not essential for stable operation, but it does help in improving transient performance.

The linear charger remains stable even without an output capacitor when a battery is connected. However, when the battery is not present, it is still necessary to include a capacitor to control the output voltage effectively.

### NTC Resistor Selection:

Choose  $R_5$  and  $R_6$  to program the UTP and OTP threshold values (see Figure 6).

The calculation steps are as follows:

1. Assume the resistance of the battery NTC thermistor is  $R_{UT}$  at the UTP threshold and  $R_{OT}$  at the OTP threshold.
2. Calculate  $R_5$  and  $R_6$  using the following equations:

$$R_6 = \frac{K_{OT}(1 - K_{UT}) \cdot R_{UT} - K_{UT}(1 - K_{OT}) \cdot R_{OT}}{K_{UT} - K_{OT}}$$

$$R_5 = \left( \frac{1}{K_{OT}} - 1 \right) (R_6 + R_{OT})$$

If the typical values ( $K_{UT} = 60\%$  and  $K_{OT} = 30\%$ ) are chosen, the equations can be simplified to:

$$R_6 = 0.4R_{UT} - 1.4R_{OT}$$

$$R_5 = 2.3(R_6 + R_{OT})$$



### Application Schematic

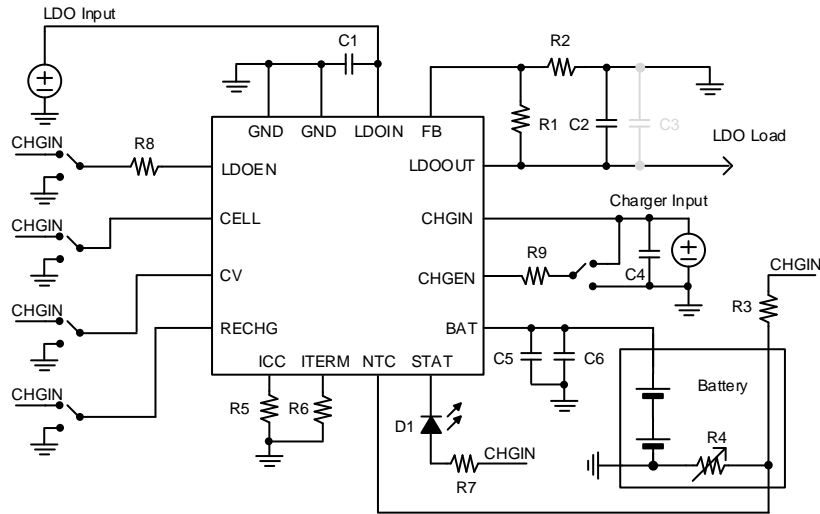


Figure 8. Schematic Resistors Diagram

### BOM List

Designator	Description	Part Number	Manufacturer
C <sub>1</sub> , C <sub>4</sub>	2.2μF/50V/X7R, 1206	C3216X7R1H225K160AB	TDK
C <sub>2</sub>	4.7μF/50V/X7R, 1206	C3216X7R1H475K160AC	TDK
C <sub>5</sub> , C <sub>6</sub>	10μF/50V/X7R, 1206	C3216X7R1H106K160AC	TDK
R <sub>1</sub>	180kΩ, 1%, 0603		
R <sub>2</sub>	20kΩ, 1%, 0603		
R <sub>3</sub> , R <sub>4</sub>	100kΩ, 1%, 0603		
R <sub>5</sub>	5.1kΩ, 1%, 0603		
R <sub>6</sub>	20kΩ, 1%, 0603		
R <sub>7</sub> , R <sub>8</sub> , R <sub>9</sub>	10kΩ, 1%, 0603		
D <sub>1</sub>	LED Chip, 0603		

Note: The voltage divider resistors R<sub>3</sub>, R<sub>4</sub> on the EVB are used to set the NTC pin voltage at 50% V<sub>CHGIN</sub>, so the device can enter charge mode.

## PCB Layout Guide:

It is recommended to follow the EVB layout to achieve optimal regulation, ripple rejection, transient response, and thermal performance. If changes are necessary, refer to the figure and guidelines below:

1. Place input and output bypass ceramic capacitors close to LDOIN, CHGIN, LDOOUT, and BAT, respectively.

2. Ensure all feedback connections are short and direct. Place the feedback resistor divider as close to the chip as possible.

3. Connect LDOIN, CHGIN, LDOOUT, BAT, and GND to large copper areas. Maximize the GND copper area on the top and bottom layers to improve heat dissipation, thermal performance, and long-term reliability.

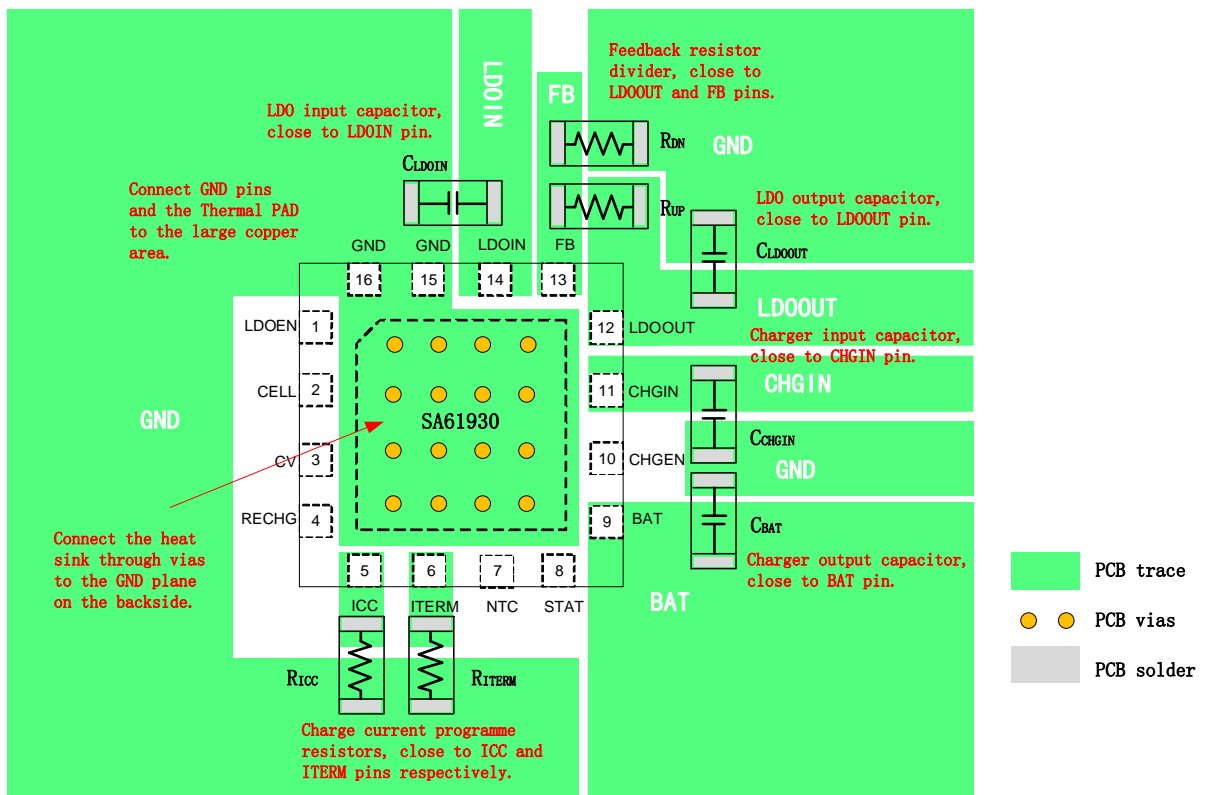
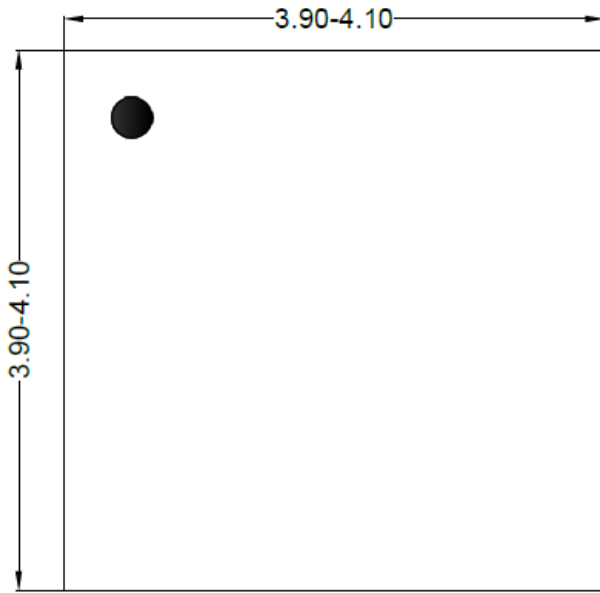
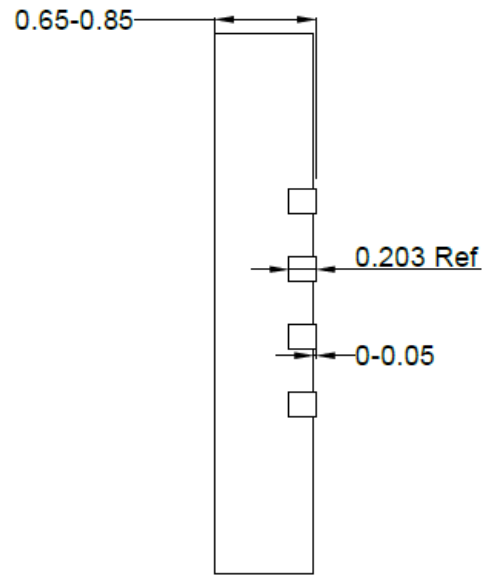


Figure 9. PCB Layout Suggestion

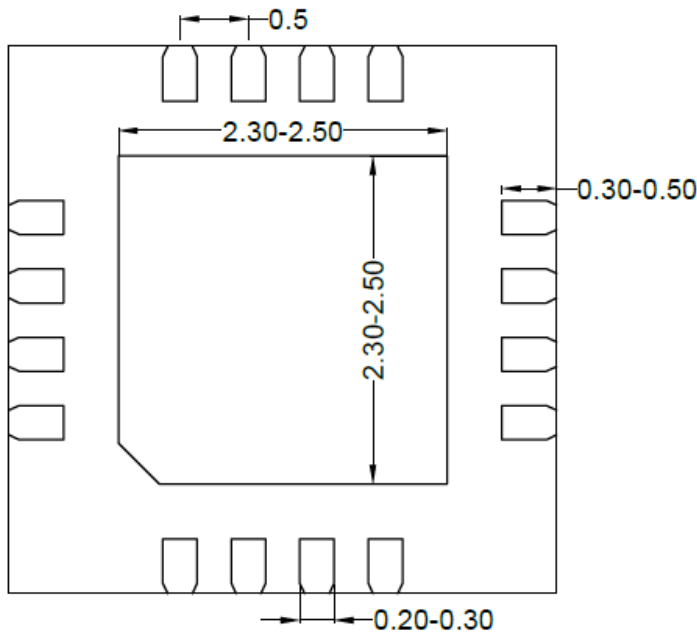
**QFN4x4-16 Package Outline Drawing**



**Top View**



**Side View**



**Bottom View**

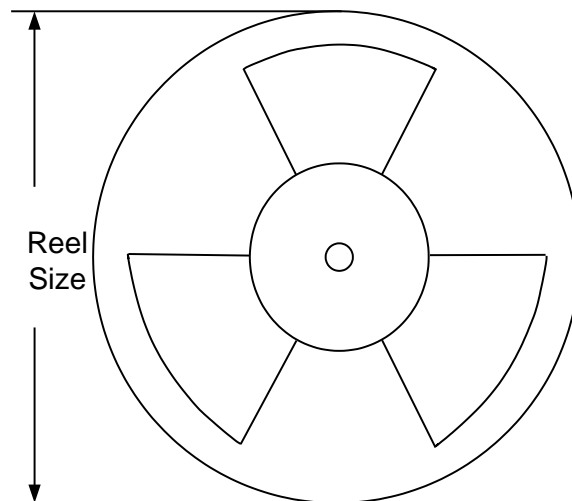
*Note: All dimensions are in millimeters and exclude mold flash & metal burr.*

**Taping & Reel Specification**

**QFN4x4 Taping Orientation**

Feeding direction →

**Carrier Tape & Reel Specification for Packages**



Package type	Tape width (mm)	Pocket pitch (mm)	Reel size (Inch)	Trailer length (mm)	Leader length (mm)	Qty per reel
QFN4x4	12	8	13"	400	400	5000

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