# SY6912A

## 2A Multi-Cell High Efficiency Switching Charger

## General Description

SY6912A is a 4.0-23V input, 2A multi-cell synchronous Buck Li-Ion battery charger, suitable for portable application. Select pin is convenient for multi-cell charging. 800 kHz synchronous buck regulator integrates of 25V rating FETs with ultra low on- resistance to achieve high efficiency and simple circuit design.

## Ordering Information

SY6912 □(□□)□
- Temperature Code
- Package Code
- Optional Spec Code

| Ordering Number | Package type | Note |
|---|---|---|
| SY6912AFCC | SO8E | |

## Features

- Wide Input Voltage Range: 4.0V to 23V
- High Efficiency Int. Synchronous Buck Regulator with Fixed 800kHz Switching Frequency
- Selectable for Multi-cell Charging
- Trickle Current / Constant Current / Constant Voltage Charging Mode
- Programmable (2A Max) Constant Charging Current
- Programmable Charging Timer
- Input Voltage UVLO and Battery OVP
- Over Temperature Protection
- Output Short Circuit Protection
- Automatic Shutdown Prevents Reverse Energy Flow
- Charging Status Indication
- Normal Synchronous Buck Operation when Battery Removed
- Compact package SO8E

## Applications

- Cellular Telephones,
- PDA, MP3 Players, MP4 Players
- Digital Cameras
- Bluetooth Applications
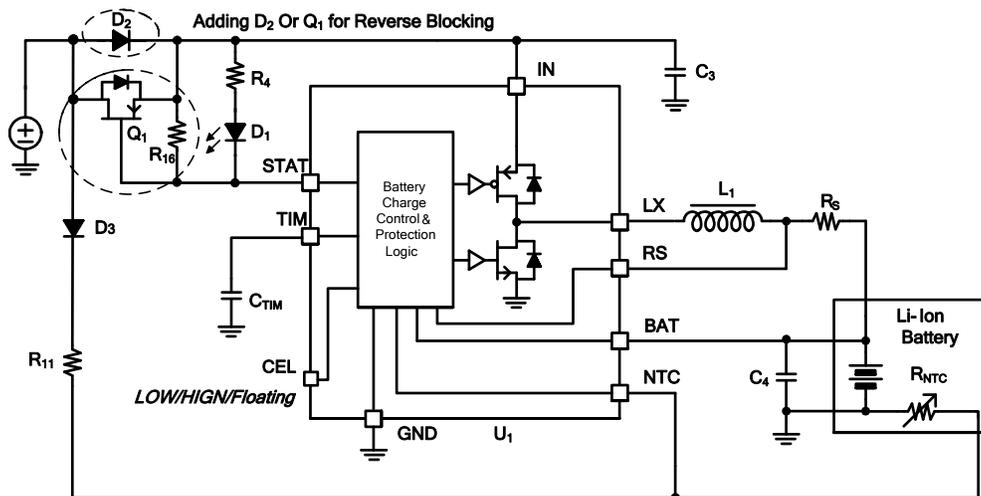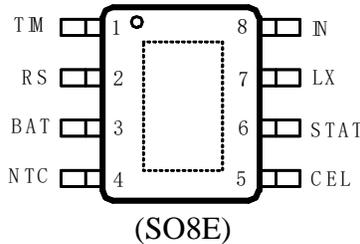- PSP Game Players, NDS Game Players
- Notebook

## Typical Applications



**Figure 1. SY6912A Schematic Diagram**

## Pinout (top view)



(SO8E)

**Top Mark: AIQ*xyz* (device code: AIQ, *x=year code, y=week code, z= lot number code)**

| Name | Number | Description |
|------|--------|-------------|
| RS | 2 | Charging current program pin. Connect a current sense resistor from RS pin to BAT pin. Average charging current is detected for both TC mode and CC mode. |
| BAT | 3 | Battery positive pin. |
| NTC | 4 | Thermal protection pin. UTP threshold is about $75\%V_{IN}$ and OTP threshold is about $30\%V_{IN}$. Pull up to VIN can disable charging logic and make the IC operate as normal buck regulator. Pull down to ground can shutdown the IC. |
| CEL | 5 | Pull down for single-cell, pull high for 2 cells, open for 3 cells. |
| STAT | 6 | Charging status indication pin. It is open drain output pin and can be used to turn on a LED to indicate the charging in process. When the charging is done, LED is off. |
| LX | 7 | Switch node pin. This pin connects the drains of the integrated main and synchronous power MOSFET switches. Connect to external inductor. |
| IN | 8 | Positive power supply input pin. $V_{IN}$ ranges from 4V to 23V for normal operation. It has UVLO function and must be 120mV greater than the battery voltage to enable normal operation. |
| TIM | 1 | Charging time limit pin. Connect this pin with a capacitor to ground. Internal current source charges the capacitor for TC mode and CC mode's charging time limit. TC charging time limit is about 1/9 of CC charging time. |
| GND | Exposed pad | Ground pin. |

## Absolute Maximum Ratings (Note 1)

CEL, NTC, STAT ------------------------------------------------------------------------------------------------------- -0.5-32V
IN, BAT, LX -------------------------------------------------------------------------------------------------------------- -0.5-25V
TIM ------------------------------------------------------------------------------------------------------------------------- -0.5- 3.6V
RS ----------------------------------------------------------------------------------------------------------------- BAT-0.3~BAT+0.3V
LX Pin current continuous ------------------------------------------------------------------------------------------- 2.5A
Power Dissipation, $P_D$ @ $T_A = 25°C$, SO8E------------------------------------------------------------------------- 3.3W
Package Thermal Resistance (Note 2)
       $\theta_{JA}$ ------------------------------------------------------------------------------------------------------ 30°C/W
       $\theta_{JC}$------------------------------------------------------------------------------------------------------- 20°C/W
Junction Temperature Range ------------------------------------------------------------------------------------- -40°C to 150°C
Lead Temperature (Soldering, 10 sec.) ------------------------------------------------------------------------------- 260°C
Storage Temperature Range ----------------------------------------------------------------------------------- -65°C to 125°C
ESD Susceptibility (Note 2)
HBM (Human Body Mode) ------------------------------------------------------------------------------------------------ 2kV
MM (Machine Mode) --------------------------------------------------------------------------------------------------- 200V

## Recommended Operating Conditions(Note 3)

CEL, NTC, STAT --------------------------------------------------------------------------------------------------------- -0.3-30V
IN, BAT, LX --------------------------------------------------------------------------------------------------------------- -0.3-23V

TIM ---------------------------------------------------------------------------------------------------------------------- -0.3- 3.6V

RS ----------------------------------------------------------------------------------------------------------------- BAT-0.1~BAT+0.1V

LX Pin current continuous ------------------------------------------------------------------------------------------------------- 2A

Junction Temperature Range ----------- --------------------------------------------------------------------- -20°C to 125°C

Ambient Temperature Range ------------------------------------------------------------------------------------- -40°C to 85°C

# Electrical Characteristics

$T_A$=25°C, $V_{IN}$=15V, GND=0V, $C_{IN}$=10uF, $L_B$=2.2uH, $R_S$=25mΩ, $C_{TIM}$=330nF, unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Bias Supply ($V_{IN}$)** | | | | | | |
| $V_{IN}$ | Supply voltage | | 4.0 | | 23 | V |
| $V_{UVLO}$ | $V_{IN}$ under voltage lockout threshold | $V_{IN}$ rising and measured from $V_{IN}$ to GND | | | 3.9 | V |
| $\Delta V_{UVLO}$ | $V_{IN}$ under voltage lockout hysteresis | Measured from $V_{IN}$ to GND | | 190 | | mV |
| $V_{OVP}$ | Input overvoltage protection | $V_{IN}$ rising and measured from $V_{IN}$ to GND | | | 24 | V |
| $\Delta V_{OVP}$ | Input overvoltage protection hysteresis | Measured from $V_{IN}$ to GND | | 750 | | mV |
| **Quiescent Current** | | | | | | |
| $I_{BAT}$ | Battery discharge current | NTC pull down to GND | | | 25 | uA |
| $I_{IN}$ | Input quiescent current | Disable Charging | | | 2.0 | mA |
| **Oscillator and PWM** | | | | | | |
| $f_{OSC}$ | Oscillator frequency | | 640 | 800 | 960 | kHz |
| D | PFET duty cycle | | | | 100 | % |
| **Power MOSFET** | | | | | | |
| $R_{NFET}$ | $R_{DS(ON)}$ of N-FET | | | 150 | | mΩ |
| $R_{PFET}$ | $R_{DS(ON)}$ of P-FET | | | 160 | | mΩ |
| **Voltage Regulation** | | | | | | |
| $V_{CV}$ | Single-cell CV charging mode | 0°C <=$T_A$<=70°C | 4.16 | 4.20 | 4.24 | V |
| | 2-cell CV charging mode | | 8.32 | 8.40 | 8.48 | |
| | 3-cell CV charging mode | | 12.48 | 12.60 | 12.72 | |
| $\Delta V_{RCH}$ | Single-cell Voltage threshold for Recharge | 0°C <=$T_A$<=70°C | 50 | 100 | 150 | mV |
| | 2-cell Voltage threshold for Recharge | | 100 | 200 | 300 | |
| | 3-cell Voltage threshold for Recharge | | 150 | 300 | 450 | |
| $V_{TRK}$ | Single-cell TC charging mode voltage threshold | 0°C <=$T_A$<=70°C | 2.2 | 2.5 | 2.8 | V |
| | 2-cell TC charging mode voltage threshold | | 4.4 | 5.0 | 5.6 | |
| | 3-cell TC charging mode voltage threshold | | 6.6 | 7.5 | 8.4 | |
| **Battery Connect Detection** | | | | | | |
| $V_{DET}$ | NTC voltage threshold for Battery detect | NTC Falling Edge | 80% | | 90% | $V_{IN}$ |
| $t_{DET}$ | Detect delay time | | | 30 | | ms |
| **Charging Current** | | | | | | |
| | Internal charging current accuracy for Constant Current Mode | $I_{CC}$=25mV/$R_S$ | -10% | | 10% | |
| | Internal charging current accuracy for Trickle Current Mode | $I_{TC}$=2.5mV/$R_S$ | -50% | | 50% | |
| **Charge Termination** | | | | | | |
| $I_{TERM}$ | Charge Termination Current | | | 10% | | $I_{CC}$ |
| $T_{TERM}$ | Termination delay time | | | 30 | | ms |
| **Output Voltage OVP** | | | | | | |
| $V_{OVP}$ | Output voltage OVP threshold | | 108% | 113% | 118% | $V_{CV}$ |
| **Output Short Protection** | | | | | | |
| $V_{SHOT}$ | Output short protection threshold | $V_{BAT}$ falling edge | 1.70 | 2.00 | 2.30 | V |
| $f_{FBK}$ | Frequency fold back | $V_{BAT}$<2V | | 12.5% | | $f_{OSC}$ |
| $I_{LM}$ | Power FET current limit | | | 4.0 | | A |
| **Timer** | | | | | | |
| $T_{TC}$ | Trickle current charging timeout | $C_{TIM}$=330nF | 0.425 | 0.5 | 0.575 | hour |
| $T_{CC}$ | Constant current charging timeout | | 3.825 | 4.5 | 5.175 | hour |

| | | | | | | |
|---|---|---|---|---|---|---|
| T$_{MC}$ | Charging mode change delay time | | | | 30 | | ms |
| T$_{RCHG}$ | Recharge time delay | | | | 30 | | ms |
| **Battery Thermal Protection NTC** | | | | | | | |
| UTP | Under temperature protection | | 70% | 75% | 80% | V$_{IN}$ |
| | Under temperature protection hysteresis | Falling edge | | 5% | | |
| OTP | Over temperature protection | | 28% | 30% | 32% | |
| | Over temperature protection hysteresis | Rising edge | | 2% | | |
| **Automatic Shutdown** | | | | | | | |
| ΔV$_{ASD}$ | ASD voltage threshold hysteresis | Measured from V$_{IN}$ to V$_{BAT}$ | | 80 | 240 | mV |
| **Thermal shutdown** | | | | | | | |
| TSD | Thermal shutdown temperature | Rising Threshold | | 160 | | ℃ |
| TSDHYS | Thermal shutdown temperature hysteresis | | | 20 | | ℃ |

**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**: θ$_{JA}$ is measured in the natural convection at T$_A$ = 25°C on a low effective four-layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

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

# Basic Li-Ion Battery Charge Operation Flow Chart

POR

Battery Detect? — N → Buck CV Mode; Reset and Disable Timer; All the Protections Active;

OK

Protection Test? — N → Stop Charge & wait w/o latch; Indicate Status; Timer Hold-on;

OK

$V_{BAT} < V_{TRK}$ — Y → Reset & Start Timer for Trickle Current Charge

N

Battery Detect? — N

OK

Protection Test? — N → Stop Charge & wait w/o latch; Indicate Status; Timer Hold-on;

OK

Reset and Start Timer for Constant Current Charge

Trickle Current Charge / Indicate Status

Protection Test? — N → Stop Charge & wait w/o latch; Indicate Status; Timer Hold-on;

OK

$V_{BAT} < V_{TRK}$ — N / Y — TC Timeout? — N / Y

Constant Current Charge Mode / Indicate Status

Protection Test? — N → Stop Charge & wait w/o latch; Indicate Status; Timer Hold-on;

OK

CC Timeout? — Y → $V_{BAT} < V_{RCH}$ — Y → Disable Charge and latch / Indicate Status

N

$V_{BAT} < V_{TRK}$ — Y

N

$I_{CHG} < I_{TERM}$ — N / Y

Charge Off and wait w/o latch / Indicate Status

$V_{BAT} < V_{RCHG}$ — Y / N

OK

Battery Detect? — N

OK

Protection Test? — N → Stop Charge & wait w/o latch; Indicate Status; Timer Hold-on;

Battery Replaced or Re-power on? — N / Y

# General Function Description

SY6912A is a 4.0-23 input, 2A multi-cell synchronous buck Li-Ion battery charger, suitable for portable application. Select pin is convenient for multi-cell charging. Integrated 800kHz synchronous buck regulator consists of 25V rating FETs with extremely low on-resistance to achieve high charging efficiency and simple circuit design.

### Charging Status Indication Description

1. **Charging-In-Process** – Pull and keep STAT pin to Low;
2. **Charging Done** – Pull and keep STAT pin to High;
3. **Fault Mode** – Output high and low voltage alternatively with 0.5Hz frequency when $C_{TIM}$ is 330nF.

Connect a LED from VIN to STAT pin, **LED ON** indicates **Charging-in-Process**, **LED OFF** indicates **Charging Done**, **LED Flash** indicates **Fault Mode**.

## Buck Regulator Operation Description

If the Li-Ion battery is removed suddenly, the voltage on NTC pin increases higher than 90% Vin. Then, it operates as a normal peak current mode controlled synchronous buck converter and the output voltage on BAT pin is regulated at $V_{CV}$. In this operation mode, the constant output current loop is still active, however the charging timeout operation, termination function and the trickle current charging are disabled.

## Protection Description

**Thermal Protection-**Thermal shutdown is active for both battery and IC. IC resumes normal work when the temperature backs in normal range again.
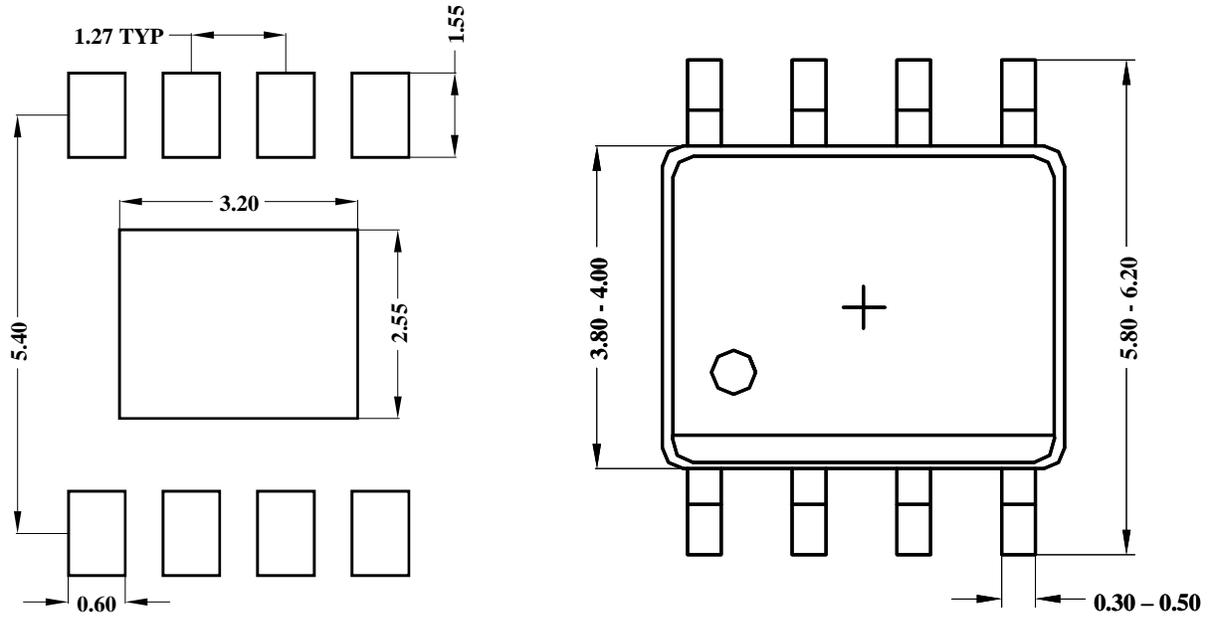
**Short Circuit Protection-** When $V_{BAT}$ voltage is lower than the short circuit protection threshold, short circuit protection is active. In charger operation mode, the switching frequency is folded back to 12.5% of the default value and $V_C$ is folded back to 20% of the maximum value. The trickle charging timer is still active and would timeout the IC finally. In Buck operation mode, the switching frequency is folded back to 12.5% of the default value, and the $V_C$ initiates softstart periodically.

**Over Current Protection-**The internal current loop with different constant current capability is always active no matter in Buck mode or Battery Charging mode for the over current protection.
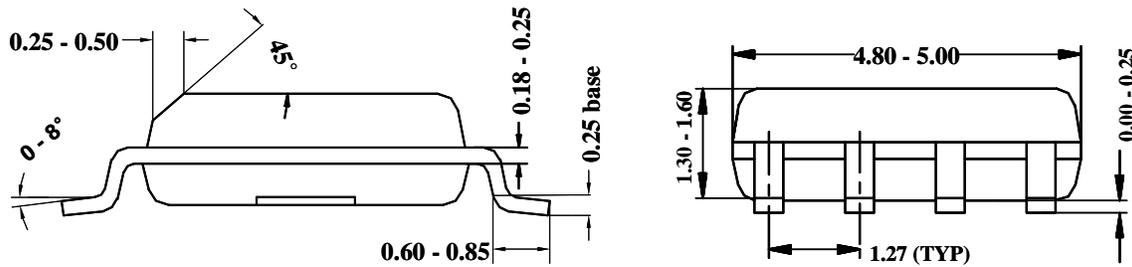
**Over Voltage Protection-**When $V_{BAT}$ voltage is higher than the over voltage protection threshold no matter with or without battery connected, IC shuts down and recovers to normal work when $V_{BAT}$ backs to normal level. Input voltage has UVLO and OVP, which would make IC shutdown and recover to normal work when the $V_{IN}$ backs to normal range.

**Timeout Protection-**Programmable timeout protection is for both Trickle Current Charging Mode and Constant Current Charging Mode. Once timeout is active, IC stops the charging operation and latches off. Only power or battery re-plug in can get the latch logic reset and the IC restarted.

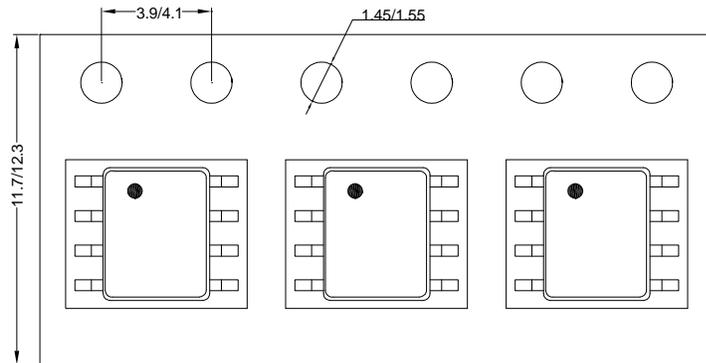# SO8E Package outline & PCB layout design



**Recommended Pad Layout**

1.27 TYP

1.55

3.20

2.55

5.40

0.60

3.80 - 4.00

5.80 - 6.20

0.30 – 0.50

0.25 - 0.50

45°

0.18 - 0.25

0.25 base

0 - 8°

0.60 - 0.85

4.80 - 5.00

1.30 - 1.60

0.00 - 0.25

1.27 (TYP)

**Notes:  All dimensions are in millimeters.**
**All dimensions don't include mold flash & metal burr.**

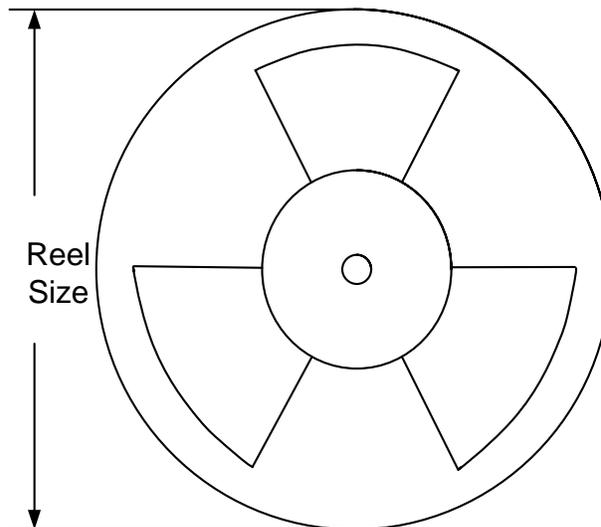# Taping & Reel Specification

## 1. Taping orientation

SO8E



Feeding direction ⟶

## 2. Carrier Tape & Reel specification for packages



| Package types | Tape width (mm) | Pocket pitch(mm) | Reel size (Inch) | Trailer length(mm) | Leader length (mm) | Qty per reel |
|---|---|---|---|---|---|---|
| SO8E | 12 | 8 | 13" | 400 | 400 | 2500 |

## 3. Others: NA