# SHIKUES Low Power Consumption, High Precision, HighESD 1-Cell Li-ion and Li-Polymer Battery Voltage and Current Protection IC

## Description

- SHIKUES battery protection ICs are featured for accurately monitoring Li-ionor Li-Polymer battery voltage and current when charging and discharging the batteries. When over charge, over discharge and short circuit conditions happened, SHIKUES battery protection ICswill control the charging or discharging output pins to control charge or discharge MOSFETsto cut off the charging or discharging path accordingly to protect the batteries frombeing damaged.
- SHIKUES battery protection ICs monitor the charge/discharge/short circuit current byexternal current sensing resistor, to provide very precise current sensing control.
- SHIKUES battery protection IC embeds with high ESD protection circuit to prevent from ESDissues in mass production and in use.
- SHIKUES battery protection IC power consumption when normal operation is low. For power saving, SHIKUES battery protection IC provides 2 power saving modes : Standby mode and Power Down mode.

## Features

### Voltage detection and release

Overcharge Detection Voltage
Overcharge Release Voltage
Overdischarge Detection Voltage
Overdischarge Release Voltage

### Current detection and release

Discharge Overcurrent Detection Voltage
Charge Overcurrent Detection Voltage
Load Short-Circuit Detection Voltage

### 0V Battery Charge Inhibition Battery Voltage

### Operation Modes

| | | |
|---|---|---|
| Normal Mode | 2.5uA (Typ.) | 4.0uA (Max.) |
| Standby Mode | 1.0uA (Typ.) | 1.5uA (Max.) |
| Power Down Mode | | 0.1uA (Max.) |

### Operation Temperature Range : Ta = -40°C to +85°C

## Applications

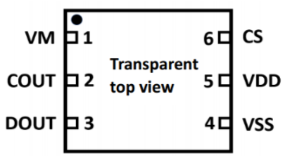
- Smart Phones
- Tablet PCs
- Handheld Data Terminals
- Portable Devices

## Package Type

- DFN 1.6 x 1.6 x 0.75 (mm)

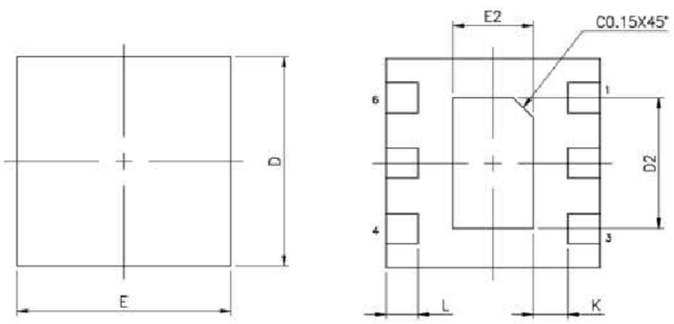
## Pin Assignment

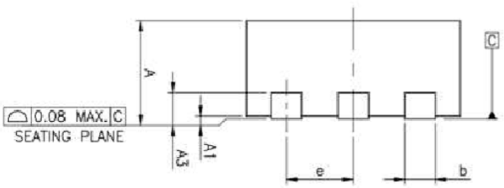
### ■ DFN 1.6 x 1.6




| Pin No. | Symbol | Function |
|---|---|---|
| 1 | VM | Input pin for charger negative voltage |
| 2 | COUT | Charge FET Gate Drive Output |
| 3 | DOUT | Discharge FET Gate Drive Output |
| 4 | VSS | Ground |
| 5 | VDD | Input pin for positive power supply voltage |
| 6 | CS | Overcurrent detection input pin |

## Package Outline Drawing




| SYMBOLS \ units | MIN. | NOM. | MAX. |
|---|---|---|---|
| | mm | mm | mm |
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.00 | 0.02 | 0.05 |
| A3 | 0.20 REF. | | |
| b | 0.18 | 0.23 | 0.28 |
| D | 1.60 BSC | | |
| E | 1.60 BSC | | |
| e | 0.50 BSC | | |
| L | 0.19 | 0.24 | 0.29 |
| K | 0.20 | — | — |

| PAD SIZE | E2 | | | D2 | | |
|---|---|---|---|---|---|---|
| E2XD2 \ unit | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| | mm | mm | mm | mm | mm | mm |
| 31X47 MIL | 0.55 | 0.60 | 0.65 | 0.95 | 1.00 | 1.05 |

# Specifications

## Absolute Maximum Ratings

| Parameter | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Supply Voltage | VDD | -0.3 | 6 | V |
| Negative Voltage Input | $V_{VM}$ | VDD-28 | VDD+0.3 | V |
| Charge FET Control | $V_{COUT}$ | VDD-28 | VDD+0.3 | V |
| Discharge FET Control | $V_{DOUT}$ | -0.3 | VDD+0.3 | V |
| Current Sense Input | $V_{CS}$ | -0.3 | VDD+0.3 | V |
| Storage Temperature | $T_{stg}$ | -55 | +125 | °C |

## Recommend Operating Condition

| Parameter | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Operation Temperature | $T_{opr}$ | -40 | +85 | °C |
| Operating Voltage | $V_{OP}$ | 1.5 | 5.5 | V |

## ESD Ratings

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Human Body Model | HBM | +-3500 | V |
| Machine Model | MM | +-300 | V |
| Charged Device Model | CDM | +-2000 | V |
| Latch-up | | +-300 | mA |

# Product Name Structure

1. Product Name

1.1 DFN 1.6 x 1.6 x 0.75

SKPI3860 MXYZ – IAT0 A

**Environmental code：**

A： Lead-free, Halogen-free

**Package abbreviation and IC packing specifications：**

1. IA： Package Type
   - 1.1 I： DFN. From A to Z
   - 1.2 A： 1.6*1.6*0.75. From A to Z
2. T0：Packing Type
   - 2.1 T： Tape & Reel, U: Tube, T: Tray
   - 2.2 0： Reserved, From 0 to 9

**Serial code：**

1. M： Mass Production, T: Test Chip
2. X： Main Mask Version. From A to Z
3. Y： Specification Version Code. From 0 to 9, A to Z, a to z
4. Z： Specification Version Code. From 0 to 9, A to Z, a to z

# Product Line Up

## Detection/Release

| Part Number | Features | Overcharge Detection Voltage | Overcharge Release Voltage | Overdischarge Detection Voltage | Overdischarge Release Voltage | Discharge Overcurrent Detection Voltage | Charge Overcurrent Detection Voltage | Load Short Circuit Detection Voltage | 0V Battery Charge Inhibition Battery Voltage | 0V Battery Charge Permission Battery Voltage | 0V Battery Charge Inhibition Battery Voltage Enable/Disable | 0V Battery Charge Permission Battery Voltage Enable/Disable | Overcharge Release Voltage Latch Enable/Disable | Overcharge Release Voltage Hysteresis Enable/Disable | Power Down Mode Enable/Disable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Symbol | Vdet1 | $V_{det1Rel}$ | Vdet2 | $V_{det2Rel}$ | Vdet3 | Vdet4 | Vshort | $V_{0INH}$ | $V_{0CHG}$ | $V_{0INH}$ | $V_{0CHG}$ | $V_{det1RelEn}$ | $V_{det1RelHEn}$ | $M_{PD}$ |
| | Unit | V | V | V | V | mV | mV | mV | V | V | | | | | |
| SKPI3860MD00IAT0A | | 4.475 | 4.275 | 2.5 | 2.9 | 15 | -15 | 33 | 0.9 | -- | enable | disable | disable | enable | disable |

## Delay Times

| Part Number | Features | Overcharge Detection Delay Time | Overcharge Release Delay Time | Overdischarge Detection Delay Time | Overdischarge Release Delay Time | Discharge Overcurrent Detection Delay Time | Discharge Overcurrent Release Delay Time | Charge Overcurrent Detection Delay Time | Charge Overcurrent Release Delay Time | Load Short Circuit Detection Delay Time |
|---|---|---|---|---|---|---|---|---|---|---|
| | Symbol | tVdet1 | $tV_{det1Rel}$ | tVdet2 | $tV_{det2Rel}$ | tVdet3 | $tV_{det3Rel}$ | tVdet4 | $tV_{det4Rel}$ | tVshort |
| | Unit | s | ms | ms | ms | ms | ms | ms | ms | us |
| SKPI3860MD00IAT0A | | 1.0 | 16 | 19 | 1.5 | 68 | 6 | 16 | 4.5 | 250 |

## Electrical Characteristic

Ta=25°C, unless otherwise noted

| Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Current Consumption** | | | | | |
| $I_{normal}$ | VDD= 3.5V,$V_{CS}$=0V,$V_{VM}$=0V | | 2.5 | 4 | uA |
| $I_{standby}$ | VDD= 1.5V,$V_{CS}$= 0V,$V_{VM}$= 1.5V | | 1 | 1.5 | uA |
| $I_{power\_down}$ | VDD= 1.5V,$V_{CS}$= 0V,$V_{VM}$= 1.5V | | | 0.1 | uA |
| **Resistances** | | | | | |
| $R_{VMD}$ : VM pin Pull-up resistance | VDD= 1.8V, $V_{CS}$=0V, $V_{VM}$=0V | | 312 | 624 | kΩ |
| $R_{VMS}$ : VM pin Pull-down resistance | VDD= 3.5V, $V_{CS}$ =0V, $V_{VM}$=1V | | 23 | 46 | kΩ |
| $R_{COH}$ : COUT pin Pull-up resistance | VDD= 3.5V, $V_{CS}$ =0V, $V_{VM}$ =0V, $V_{COUT}$=3V | | 4.5 | 9 | kΩ |
| $R_{COL}$ : COUT pin Pull-down resistance | VDD= 4.5V, $V_{CS}$ =0V, $V_{VM}$=0V, $V_{COUT}$=3V | | 3.1 | 6.2 | kΩ |
| $R_{DOH}$ : DOUT pin Pull-up resistance | VDD= 3.5V, $V_{CS}$ =0V, $V_{VM}$=0V, $V_{DOUT}$=3V | | 1.6 | 3.2 | kΩ |
| $R_{DOL}$ : DOUT pin Pull-down resistance | VDD= 1.8V, $V_{CS}$ =0V, $V_{VM}$=0V, $V_{DOUT}$=0.5V | | 2.1 | 4.2 | kΩ |
| $R_{CS}$ : CS pin Input resistance | VDD=3.5V, $V_{CS}$=0.05V, $V_{VM}$ =0V | | 117 | 234 | kΩ |
| **0V Battery Charge Permission Function** | | | | | |
| $V_{0CHG}$ | | 0.5 | 0.9 | 1.3 | V |
| **0V Battery Charge Inhibition Function** | | | | | |
| $V_{0INH}$ | | 0.5 | 0.9 | 1.3 | V |

## • Battery Protection Accuracy

Ta=25°C, unless otherwise noted

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Overcharge Detection Voltage | Vdet1 | | -0.015 | Vdet1 | +0.015 | V |
| Overcharge Release Voltage | $V_{det1Rel}$ | | -0.020 | $V_{det1Rel}$ | +0.020 | V |
| Overdischarge Detection Voltage | Vdet2 | | -0.025 | Vdet2 | +0.025 | V |
| Overdischarge Release Voltage | $V_{det2Rel}$ | | -0.030 | $V_{det2Rel}$ | +0.030 | V |
| Discharge Overcurrent Detection Voltage (Expressed as the voltage across the resistor) | Vdet3 | | -0.001 | Vdet3 | +0.001 | V |
| Discharge Overcurrent Release Voltage | $V_{det3Rel}$ | Release condition: VM voltage low than Discharge Overcurrent Release Voltage to release | -0.3 | $V_{det3Rel}$ | +0.3 | V |
| Charge Overcurrent Detection Voltage (Expressed as the voltage across the resistor) | Vdet4 | | -0.001 | Vdet4 | +0.001 | V |
| Charge Overcurrent Release Voltage | $V_{det4Rel}$ | Release condition: VM voltage high than Charge Overcurrent Release Voltage to release | -0.1 | $V_{det4Rel}$ | +0.1 | V |
| Load Short Circuit Detection Voltage (Expressed as the voltage across the resistor) | Vshort | | -0.005 | Vshort | +0.005 | V |
| Load Short Circuit Release Voltage | $V_{SCRel}$ | Release condition: VM voltage low than to Load Short Circuit Release Voltage release | -0.3 | $V_{SCRel}$ | +0.3 | V |
| 0V Battery Charge Inhibition Battery Voltage | $V_{0INH}$ | | -0.400 | $V_{0INH}$ | +0.400 | V |
| 0V Battery Charge Permission Battery Voltage | $V_{0CHG}$ | | -0.400 | $V_{0CHG}$ | +0.400 | V |

## • Battery Protection Detection & Release Delay Time Accuracy

Ta=25°C, unless otherwise noted

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Overcharge Detection Delay Time | tVdet1 | -30% | tVdet1 | +30% | s |
| Overcharge Release Delay Time | $tV_{det1Rel}$ | -30% | $tV_{det1Rel}$ | +30% | ms |
| Overdischarge Detection Delay Time | tVdet2 | -30% | tVdet2 | +30% | ms |
| Overdischarge Release Delay Time | $tV_{det2Rel}$ | -30% | $tV_{det2Rel}$ | +30% | ms |
| Discharge Overcurrent Detection Delay Time | tVdet3 | -30% | tVdet3 | +30% | ms |
| Discharge Overcurrent Release Delay Time | $tV_{det3Rel}$ | -30% | $tV_{det3Rel}$ | +30% | ms |
| Charge Overcurrent Detection Delay Time | tVdet4 | -30% | tVdet4 | +30% | ms |
| Charge Overcurrent Release Delay Time | $tV_{det4Rel}$ | -30% | $tV_{det4Rel}$ | +30% | ms |
| Load Short Circuit Detection Delay Time | tVshort | -50% | tVshort | +50% | us |

## • Battery Protection Threshold Options

| Parameter | Symbol | Options | | | | | | Unit |
|---|---|---|---|---|---|---|---|---|
| Overcharge Detection Voltage | Vdet1 | 4.40 | 4.45 | 4.475 | 4.50 | 4.535 | 4.545 | V |
| Overcharge Release Voltage | $V_{det1Rel}$ | Vdet1 - 0.2V | | | Vdet1 | | | V |
| Overdischarge Detection Voltage | Vdet2 | 2.1 | | 2.3 | 2.36 | 2.4 | 2.5 | V |
| Overdischarge Release Voltage ( Must be over the Overdischarge Detection Voltage) | $V_{det2Rel}$ | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 2.9 | V |
| Discharge Overcurrent Detection Voltage | Vdet3 | 17 | 15 | 13 | 11 | 9 | 7 | mV |
| Discharge Overcurrent Release Voltage | $V_{det3Rel}$ | VDD-0.75 | | | | | | V |
| Charge Overcurrent Detection Voltage | Vdet4 | -19 | -17 | -15 | -13 | -11 | -9 | mV |
| Charge Overcurrent Release Voltage | $V_{det4Rel}$ | 0.25 | | | | | | V |
| Load Short Circuit Detection Voltage | Vshort | 33 | | | 31 | | | mV |
| Load Short Circuit Release Voltage | $V_{SCRel}$ | VDD-0.75 | | | | | | V |
| 0V Battery Charge Inhibition Battery Voltage | $V_{0INH}$ | 1.6 | | | 0.9 | | | V |
| 0V Battery Charge Permission Battery Voltage | $V_{0CHG}$ | 1.6 | | | 0.9 | | | V |

## • Battery Protection Detection & Release Delay Time Option *1

| Parameter | Symbol | Option | Unit |
|---|---|---|---|
| Overcharge Detection Delay Time | tVdet1 | 1.0 | s |
| Overcharge Release Delay Time | $tV_{det1Rel}$ | 16 | ms |
| Overdischarge Detection Delay Time | tVdet2 | 19 | ms |
| Overdischarge Release Delay Time | $tV_{det2Rel}$ | 1.5 | ms |
| Discharge Overcurrent Detection Delay Time | tVdet3 | 68 | ms |
| Discharge Overcurrent Release Delay Time | $tV_{det3Rel}$ | 6 | ms |
| Charge Overcurrent Detection Delay Time | tVdet4 | 16 | ms |
| Charge Overcurrent Release Delay Time | $tV_{det4Rel}$ | 4.5 | ms |
| Load Short Circuit Detection Delay Time | tVshort | 250 | us |

*1： Current detection delay time option has only 1 option. To increase the options, please contact with Sales.

## • Protection Mode Latch Enable Options

| Parameter | Symbol | Options | |
|---|---|---|---|
| Overcharge Release Voltage Latch Enable/Disable | $V_{det1RelEn}$ | Enable*1 | Disable |

*1： When charge over voltage latch enabled, the overcharge control will be released when the battery voltage is lower than overcharge detection voltage and VM pin is higher than 0.25V.

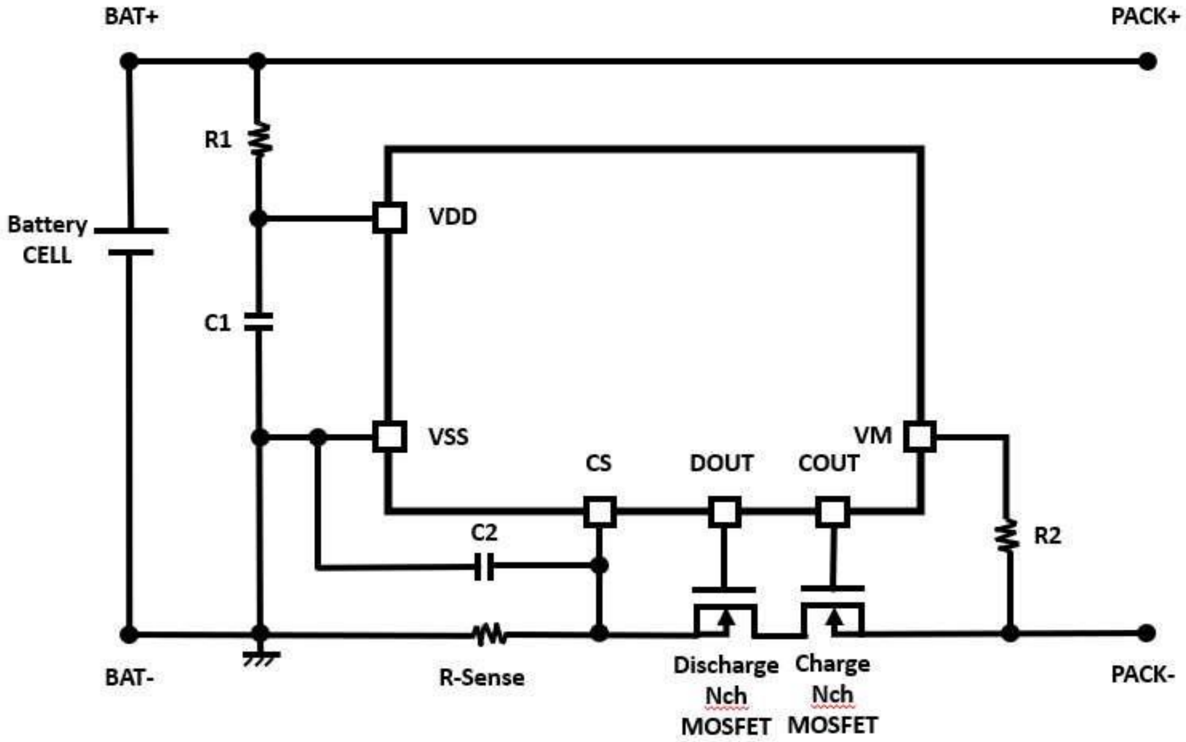
## • Hysteresis Enable Options

| Parameter | Symbol | Options | |
|---|---|---|---|
| Overcharge Release Voltage Hysteresis Enable/Disable | $V_{det1RelHEn}$ | Enable | Disable |

## • Power Down Mode Options

| Parameter | Symbol | Options | |
|---|---|---|---|
| Power Down Mode Enable/Disable | $M_{PD}$ | Enable | Disable |

## Typical Application Circuits




| Symbol | Part | Min | Typ | Max | Unit | Purpose |
|---|---|---|---|---|---|---|
| R1 | Resistor | | 100 | 1k | Ω | |
| R2 | Resistor | | 1k | 10k | Ω | For current limit of charger reverse connection |
| R-Sense | Resistor | | | | | |
| C1 | Capacitor | 0.01 | 0.1 | 1 | uF | For Input Voltage Stability |
| C2 | Capacitor | | 0.1 | | uF | For Noise Suppression |

# Test Circuits

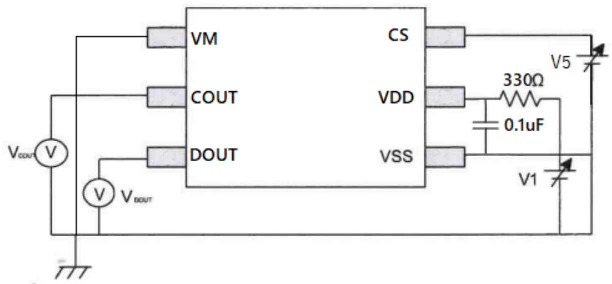
Based on different test items, the test circuits are different and shown as below. COUT pin and DOUT pin are used as control pins to turn on or turn off the external charge and discharge MOSFETs. When COUT pin or DOUT pin is output “L”, the external MOSFET is turned off. The charge or discharge paths are cut off. At this time, charging or discharging the battery is not allowed. When the abnormal situation is released, the COUT pin or DOUT pin will output “H” to turn on the MOSFET to allow the battery to be charged or discharged. Initially, the COUT and DOUT pins are output “H” to ensure the battery can be charged or discharged. VDD pin in the test circuit can be treated as battery voltage.

## 1. Overcharge detection and release

The overcharge detection voltage is measured by the test circuit 1 as shown on the right.

Test steps：

1. Set VDD voltage to 3.60V and CS to 0V.
2. Increase VDD voltage gradually.
3. When the voltage on VDD is increased, exceeds the Vdet1 detection voltage and the detection delay time (tVdet1) expired, COUT pin will transition from "H" to "L".
4. At this moment, enter the charging overvoltage protection state.
5. Then test charging overvoltage release measurement
6. Decrease VDD voltage gradually.
7. When the voltage on VDD changes and is lower than $V_{det1Rel}$ and the delay time expired $tV_{det1Rel}$, COUT pin will transition from "L" to "H".
8. There are two conditions as below.
   8.1 System connects load：
   When the battery voltage is lower than Vdet1 and VM pin voltage is higher than 0.25V(typical) and the delay time expired $tV_{det1Rel}$, overcharge condition is released.
   8.2 Charger remove：
   When the battery voltage is lower than $V_{det1Rel}$ and VM pin voltage is lower than 0.25V(typical) and the delay time expired $tV_{det1Rel}$, overcharge condition is released.



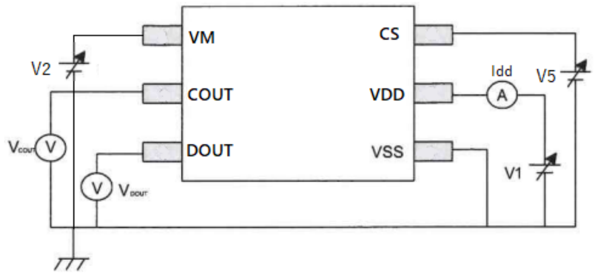

Test Circuit 1

## 2. Overdischarge detection and release

The overdischarge detection voltage is measured by the test circuit 2 as shown on the right.

Test steps：

1. Set VDD voltage to 3.60V and CS=VM to 0V.
2. Decrease VDD voltage gradually.
3. When the voltage on VDD is decreased, goes lower than the Vdet2 detection voltage and the detection delay time (tVdet2) expired, DOUT pin will transition from "H" to "L".
4. At this moment, enter the discharge overvoltage protection state.
5. Then test discharge overvoltage release measurement.
6. Increase VDD voltage gradually.
7. When the voltage on VDD changes and goes higher than $V_{det2Rel}$ and the delay time expired $tV_{det2Rel}$, DOUT pin will transition from "L" to "H".
8. At this moment, the discharge overvoltage protection state is released.



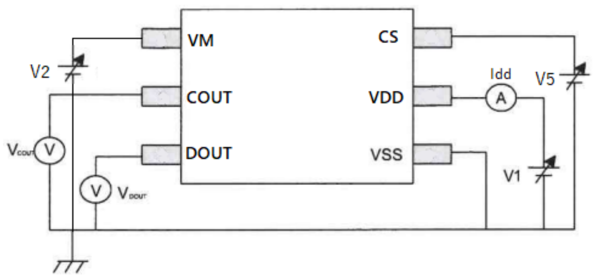

Test Circuit 2

## 3. Discharge overcurrent detection and release

The discharge overcurrent detection is measured by the test circuit 2 as shown on the right.

Test steps：

1. Set VDD voltage to 3.60V and CS=VM to 0V.
2. Increase CS voltage gradually.
3. When the voltage on CS pin is increased and the voltage $V_{CS}$ is higher than VSS plus Vdet3 and the detection delay time (tVdet3) expired, DOUT pin will transition from "H" to "L".
4. At this moment, enter the discharge overcurrent protection state.
5. Then test discharge overcurrent release measurement.
6. Set $V_{CS}$=0V, $V_{VM}$=3.60V
7. Decrease VM voltage gradually.
8. For release condition：When the VM pin voltage is lower than $V_{det3Rel}$ and the release delay time expired $tV_{det3Rel}$.
9. Discharge overcurrent condition is released.
10. The relation between VM and Rload is shown as following : $V_{VM}$=VDD X $R_{VMS}$/($R_{VMS}$+Rload)



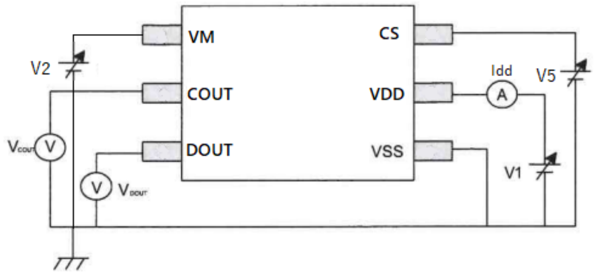

Test Circuit 2

## 4. Charge overcurrent detection and release

The charge overcurrent detection is measured by the test circuit 2 as shown on the right.

Test steps：

1. Set VDD voltage to 3.60V and CS=VM to 0V
2. Decrease CS voltage gradually.
3. When the voltage on CS pin is decreased and the voltage $V_{CS}$ is lower than VSS plus Vdet4 and the detection delay time (tVdet4) expired, COUT pin will transition from "H" to "L".
4. At this moment, enter the charging overcurrent protection state.
5. Then test charging overcurrent release measurement.
6. Set $V_{CS}$=0V
7. Increase VM voltage gradually.
8. For release condition：When the charger is removed, the system connects load, VM pin voltage is higher than $V_{det4Rel}$ and the release delay time expired $tV_{det4Rel}$. COUT pin will transition from "L" to "H".
9. Charge overcurrent condition is released.




Test Circuit 2

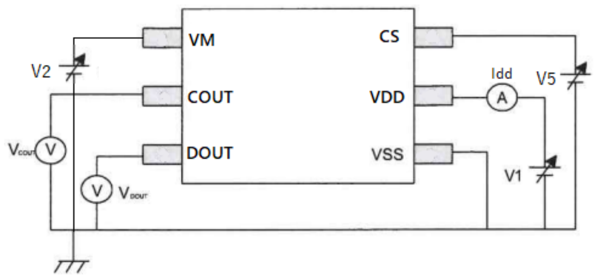
## 5. Load short circuit detection and release

The load short circuit detection is measured by the test circuit 2 as shown on the right.

Test steps：

1. Set VDD voltage to 3.60V and CS=VM to 0V
2. Increase CS voltage gradually.
3. When the voltage on CS pin is increased and the voltage $V_{CS}$ is higher than Vshort, before the detection delay time (tVshort) is expired, the voltage $V_{CS}$ keeps on increase to be higher than VSS plus Vshort and the detection delay time (tVshort) expired, DOUT pin will transition from "H" to "L".
4. At this moment, enter the short-circuit overcurrent protection state.
5. Then test short-circuit overcurrent release measurement.
6. Set $V_{CS}$=0V, $V_{VM}$=3.60V
7. Decrease VM voltage gradually.
8. When the VM pin voltage is lower than $V_{SCRel}$, DOUT pin will transition from "L" to "H".
9. Load short circuit condition is released.
10. The relation between VM and Rload is shown as following :

$V_{VM}$=VDD X $R_{VMS}$/($R_{VMS}$+Rload)



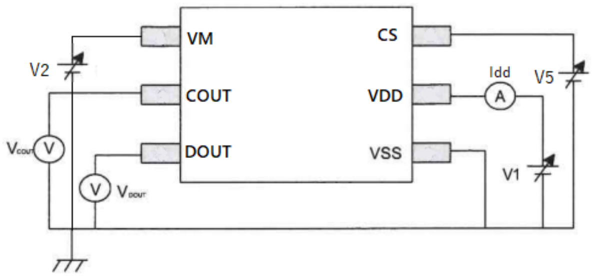

Test Circuit 2

## 6. Power consumption in normal operation mode

The normal mode power consumption is measured by the test circuit 2 as shown on the right.

Test steps：

1. Set VDD =3.50V
2. Set $V_{CS}$=$V_{VM}$=0V
3. COUT and DOUT floating.
4. Then measure the current $I_{normal}$ going into VDD pin.
5. Get the power consumption of normal mode $I_{normal}$



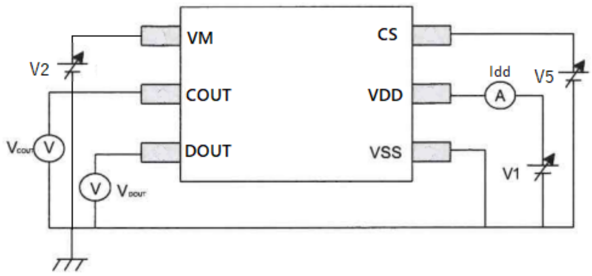

Test Circuit 2

## 7. Power consumption in standby mode

The standby mode power consumption is measured by the test circuit 2 as shown on the right.

Test steps：

1. Set VDD=$V_{VM}$=1.50V
2. Set $V_{CS}$=0V
3. COUT and DOUT floating.
4. Then measure the current $I_{standby}$ going into VDD pin.
5. Get The power consumption of standby mode $I_{standby}$.




Test Circuit 2

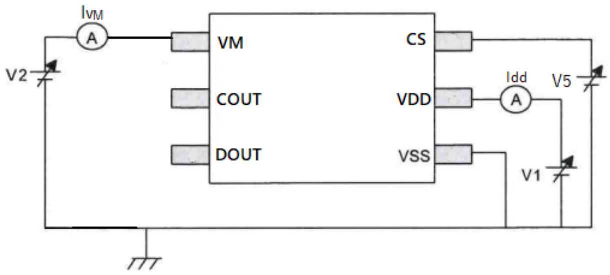
## 8. Pull-up resistance between VDD to VM pin ($R_{VMD}$)

The pull-up resistance between VDD and VM pin is measured by the test circuit 3 as shown on the right.

Test steps：

1. Set VDD=1.80V
2. Set $V_{CS}$=$V_{VM}$=0V
3. COUT and DOUT floating.
4. Then measure the current $I_{VM}$.
5. The pull-up resistance between VDD and VM pin is obtained by the relation：

   $R_{VMD}$=VDD/$I_{VM}$




Test Circuit 3

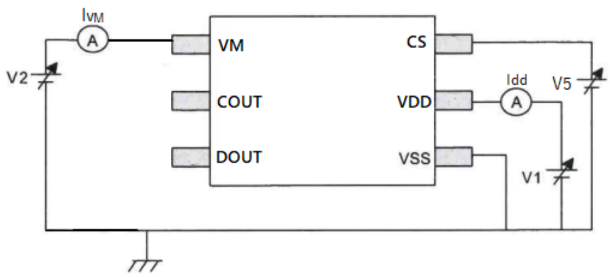
## 9. Pull-down resistance between VM to VDD pin ($R_{VMS}$)

The pull-down resistance between VDD and VM pin is measured by the test circuit 3 as shown on the right.

Test steps：

1. Set VDD=3.50V
2. Set $V_{CS}$=0V
3. Set $V_{VM}$=1.0V
4. COUT and DOUT floating.
5. Then measure the current $I_{VM}$.
6. The pull-down resistance between VDD and VM pin is obtained by the relation：

   $R_{VMS}$=$V_{VM}$/$I_{VM}$




Test Circuit 3

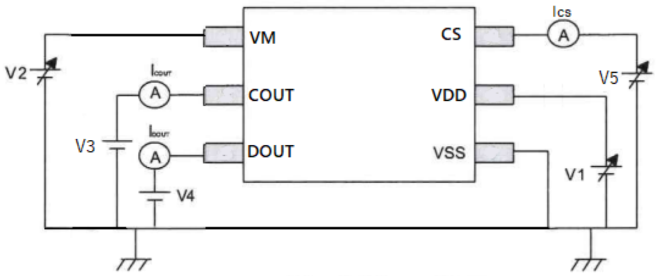
## 10. COUT pin pull-up resistance ($R_{COH}$)

The pull-up resistance on COUT pin is measured by the test circuit 4 as shown on the right.

Test steps：

1. Set VDD=3.50V
2. Set $V_{CS}$=$V_{VM}$=0V
3. Set $V_{COUT}$=3.0V
4. DOUT floating
5. Then measure the current $I_{COUT}$.
6. The COUT pin pull-up resistance is obtained by the relation：

$R_{COH}$=(VDD-$V_{COUT}$)/$I_{COUT}$




Test Circuit 4

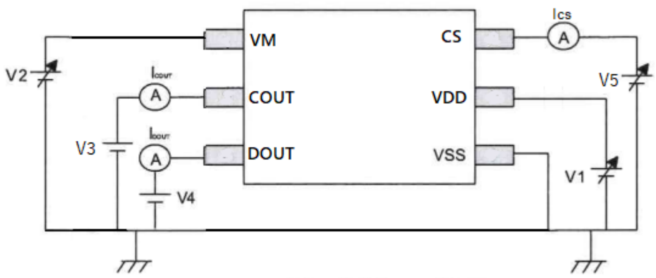
## 11. COUT pin pull-down resistance ($R_{COL}$)

The pull-down resistance on COUT pin is measured by the test circuit 4 as shown on the right.

Test steps：

1. Set VDD=4.50V
2. Set $V_{CS}$=$V_{VM}$=0V
3. Set $V_{COUT}$=3.0V
4. DOUT floating
5. Then measure the current $I_{COUT}$.
6. The COUT pin pull-down resistance is obtained by the relation：

$R_{COL}$=$V_{COUT}$/ $I_{COUT}$




Test Circuit 4

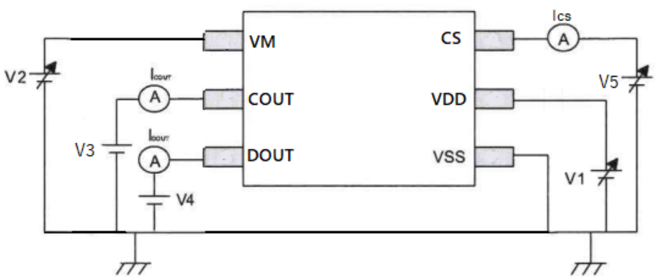
## 12. DOUT pin pull-up resistance ($R_{DOH}$)

The pull-up resistance on DOUT pin is measured by the test circuit 4 as shown on the right.

Test steps：

1. Set VDD=3.50V
2. Set $V_{CS}$=$V_{VM}$=0V
3. Set $V_{DOUT}$=3.0V
4. COUT floating.
5. Then measure the current $I_{DOUT}$.
6. The DOUT pin pull-up resistance is obtained by the relation：

$R_{DOH}$=(VDD-$V_{DOUT}$)/$I_{DOUT}$




Test Circuit 4

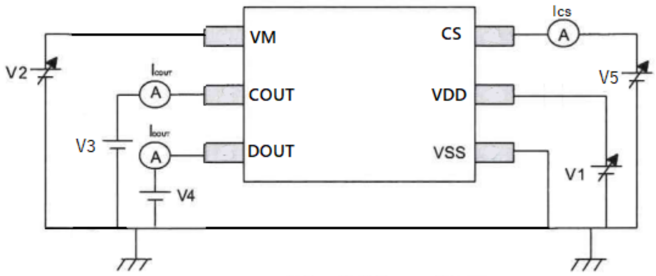
## 13. DOUT pin pull-down resistance ($R_{DOL}$)

The pull-down resistance on DOUT pin is measured by the test circuit 4 as shown on the right.

Test steps：

1. Set VDD=1.80V
2. Set $V_{CS}$=$V_{VM}$=0V
3. Set $V_{DOUT}$=0.50V
4. COUT floating
5. Then measure the current $I_{DOUT}$.
6. The DOUT pin pull-down resistance is obtained by the relation：

$R_{DOL}= V_{DOUT} / I_{DOUT}$




Test Circuit 4

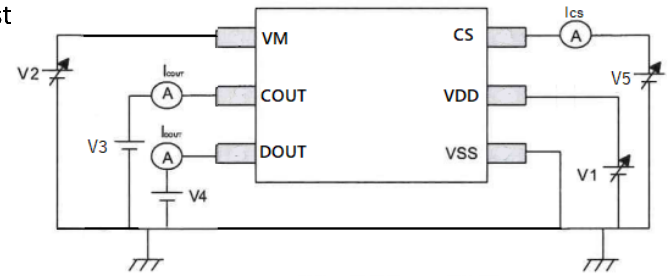
## 14. CS pin input resistance ($R_{CS}$)

The input resistance on CS pin is measured by the test circuit 4 as shown on the right.

Test steps：

1. Set VDD=3.50V
2. Set $V_{CS}$=0.05V
3. Set $V_{VM}$=0V
4. COUT and DOUT floating.
5. Then measure the current $I_{CS}$.
6. The CS pin input resistance is obtained by the relation：

$R_{CS}=V_{CS}/I_{CS}$



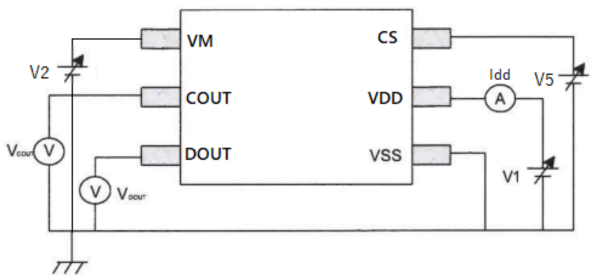

Test Circuit 4

## 15. 0V Battery charge inhibition voltage ($V_{0INH}$)

The 0V battery charge inhibition voltage threshold is measured by the test circuit 2 as shown on the right.

Test steps：

1. Set VDD=$V_{CS}$=0V
2. Set $V_{VM}$=-4.0V
3. DOUT floating.
4. Increase VDD voltage gradually, monitor $V_{COUT}$.
5. The $V_{0INH}$ equals to the VDD once $V_{COUT}$>=$V_{VM}$+0.10V.



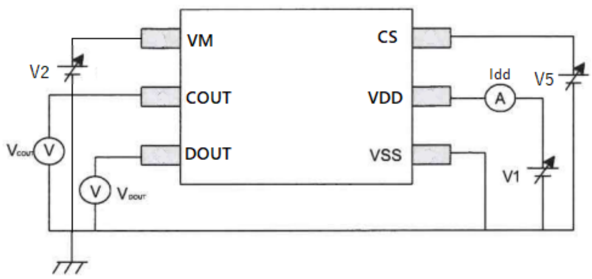

Test Circuit 2

## 16. 0V Battery charge permission voltage ($V_{0CHG}$)

The 0V battery charge permission voltage threshold is measured by the test circuit 2 as shown on the right.

Test steps：

1. Set VDD=$V_{CS}$=0V
2. Set $V_{VM}$=0V
3. DOUT floating.
4. Decrease VM voltage gradually, monitor $V_{COUT}$.
5. The $V_{0CHG}$ equals to the ｜VM｜ once $V_{COUT}$>=$V_{VM}$+0.10V



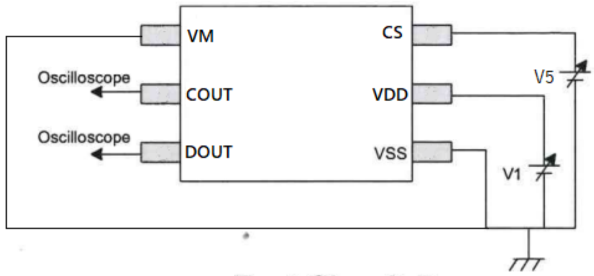

Test Circuit 2

## 17. Overcharge detection delay time (tVdet1)

The overcharge detection delay time is measured by the test circuit 5 as shown on the right.

Test steps：

1. Set VDD=3.50V
2. Set $V_{CS}=V_{VM}=0V$
3. DOUT floating
4. Then monitor COUT pin whether transition from "H" to "L".
5. Increase the VDD voltage. When VDD voltage exceeds the Vdet1 detection threshold, the internal delay time counter starts to count. When the internal delay time counts exceeds the tVdet1, COUT pin will transition from "H" to "L".
6. tVdet1 equals to the time period between VDD voltage exceeds Vdet1 and COUT transitions from "H" to "L".



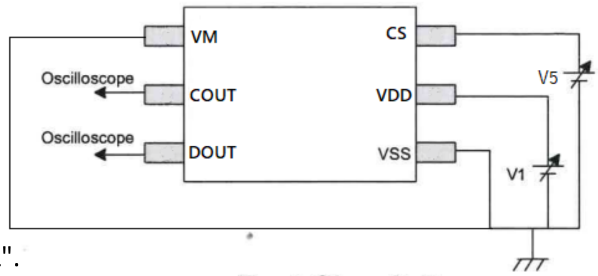

Test Circuit 5

## 18. Overdischarge detection delay time (tVdet2)

The overdischarge detection delay time is measured by the test circuit 5 as shown on the right.

Test steps：

1. Set VDD=3.50V
2. Set $V_{CS}=V_{VM}=0V$
3. COUT floating
4. Then monitor DOUT pin whether transition from "H" to "L".
5. Decrease the VDD voltage. When VDD voltage goes lower than the Vdet2 detection threshold, the internal delay time counter starts to count. When the internal delay time counts exceeds the tVdet2, DOUT pin will transition from "H" to "L".
6. tVdet2 equals to the time period between VDD voltage goes lower than Vdet2 and DOUT transitions from "H" to "L".



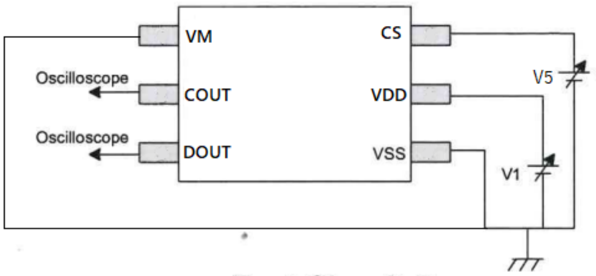

Test Circuit 5

## 19. Discharge overcurrent detection delay time (tVdet3)

The discharge overcurrent detection delay time is measured by the test circuit 5 as shown on the right.

Test steps：

1. Set VDD=3.50V
2. Set $V_{CS}$=$V_{VM}$=0V
3. COUT floating.
4. Then monitor DOUT pin whether transition from "H" to "L".
5. Increase the $V_{CS}$ voltage. When $V_{CS}$ voltage exceeds the Vdet3 detection threshold, the internal delay time counter starts to count. When the internal delay time counts exceeds the tVdet3, DOUT pin will transition from "H" to "L".
6. tVdet3 equals to the time period between $V_{CS}$ voltage exceeds Vdet3 and DOUT transitions from "H" to "L".



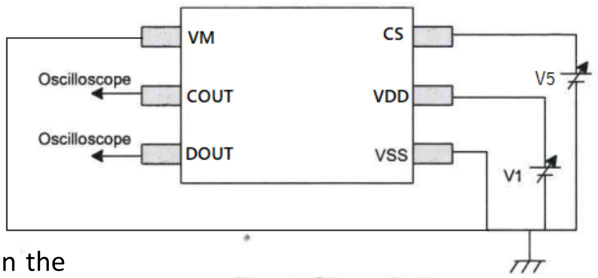

Test Circuit 5

## 20. Charge overcurrent detection delay time (tVdet4)

The charge overcurrent detection delay time is measured by the test circuit 5 as shown on the right.

Test steps：

1. Set VDD=3.50V
2. Set $V_{CS}$=$V_{VM}$=0V
3. DOUT floating.
4. Then monitor COUT pin whether transition from "H" to "L".
5. Decrease the $V_{CS}$ voltage. When $V_{CS}$ voltage goes lower than the Vdet4 detection threshold, the internal delay time counter starts to count. When the internal delay time counts exceeds the tVdet4, COUT pin will transition from "H" to "L".
6. tVdet4 equals to the time period between $V_{CS}$ voltage goes lower than Vdet4 and COUT transitions from "H" to "L".



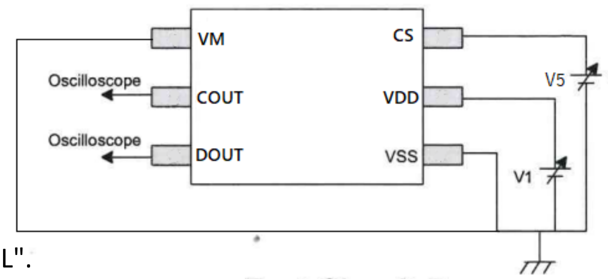

Test Circuit 5

## 21. Load short circuit detection delay time(tVshort)

The load short circuit detection delay time is measured by the test circuit 5 as shown on the right.

Test steps：

1. Set VDD=3.50V
2. Set $V_{CS}$=$V_{VM}$=0V
3. COUT floating.
4. Then monitor DOUT pin whether transition from "H" to "L".
5. Increase the $V_{CS}$ voltage. When $V_{CS}$ voltage exceeds the Vshort detection threshold, the internal delay time counter starts to count. When the internal delay time counts exceeds the tVshort, DOUT pin will transition from "H" to "L".
6. tVshort equals to the time period between $V_{CS}$ voltage exceeds Vshort and DOUT transitions from "H" to "L".




Test Circuit 5

## Product Series Specification Option

### SKPI3860MD Fuse Trim at CP stage Option

| Features | Overcharge Detection Voltage | Overdischarge Detection Voltage | Overdischarge Release Voltage (Must be over Overdischarge Detection Voltage) | Discharge Overcurrent Detection Voltage | Charge Overcurrent Detection Voltage | Load Short Circuit Detection Voltage | Overcharge Release Voltage Latch Enable/Disable | Overcharge Release Voltage Hysteresis Enable/Disable | Power Down Mode Enable/Disable |
|---|---|---|---|---|---|---|---|---|---|
| Symbol | Vdet1 | Vdet2 | $V_{det2Rel}$ | Vdet3 | Vdet4 | Vshort | $V_{det1RelEn}$ | $V_{det1RelHEn}$ | $M_{PD}$ |
| Unit | V | V | V | mV | mV | mV | | | |
| Value | 4.400 | 2.10 | 2.3 | 7 | -9 | 31 | disable | disable | disable |
| | 4.450 | 2.30 | 2.4 | 9 | -11 | 33 | enable | enable | enable |
| | 4.475 | 2.36 | 2.5 | 11 | -13 | | | | |
| | 4.500 | 2.40 | 2.6 | 13 | -15 | | | | |
| | 4.535 | 2.50 | 2.7 | 15 | -17 | | | | |
| | 4.545 | | 2.9 | 17 | -19 | | | | |
| | | | | 19 | -21 | | | | |

### SKPI3860MD Metal Option at Photo

| Features | 0V Battery Charge Inhibition Battery Voltage | 0V Battery Charge Permission Battery Voltage | 0V Battery Charge Inhibition Battery Voltage Enable/Disable | 0V Battery Charge Permission Battery Voltage Enable/Disable |
|---|---|---|---|---|
| Symbol | $V_{0INH}$ | $V_{0CHG}$ | $V_{0INH}$ | $V_{0CHG}$ |
| Unit | V | V | | |
| Value | 1.6 | 1.6 | disable | disable |
| | 0.9 | 0.9 | enable | enable |

The options in yellow color are for current SKPI3860MD00IAT0A version.

单击下面可查看定价，库存，交付和生命周期等信息

>>SHIKUES(时科)