

1 Cell Li-ion Battery Linear Charger IC with Constant-Current/Constant-Voltage

GENERAL DESCRIPTION

The XC6802 series is a constant-current/constant-voltage linear charger IC for single cell lithium-ion batteries. The XC6802 includes a reference voltage source, battery voltage monitor, driver transistor, constant-current/constant-voltage charge circuit, over heat protection circuit, phase compensation circuit. The battery charge termination voltage is internally set to $4.2V \pm 0.7\%$ and the trickle charge voltage and accuracy is $2.9V \pm 3\%$. In trickle charge mode, a safe charge to a battery is possible because approximately 1/10 out of setting charge current is supplied to the battery. With an external R_{SEN} resistor, the charge current can be set freely up to 800mA (MAX.), therefore, the series is ideal for various battery charge applications. The series' charge status output pin, /CHG pin, is capable of checking the IC's charging state while connecting with an external LED.

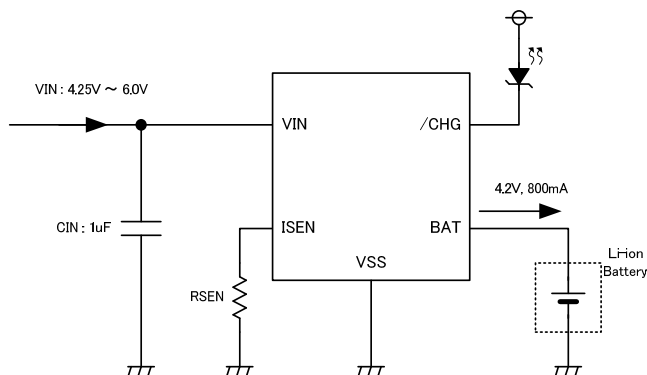
APPLICATIONS

Charging docks, charging cradles
MP3 players, portable audio players
Cellular phones, PDAs
Bluetooth headsets

FEATURES

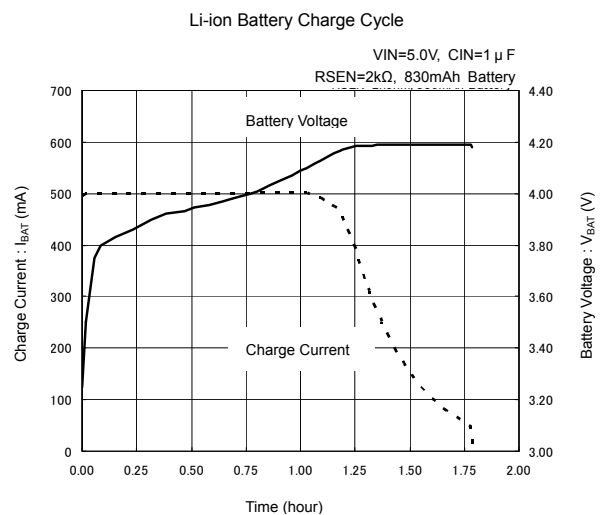
Operating Voltage Range : 4.25V ~ 6.0V
Charge Current : Externally set up to 800mA (MAX.)
Charge Termination Voltage : $4.2V \pm 0.7\%$
Trickle Charge Voltage : $2.9V \pm 3\%$
Supply Current (Stand-by) : $15 \mu A$ (TYP.)
Packages : SOT-89-5, SOT-25, USP-6C
Constant-current/constant-voltage operation with thermal shutdown
Automatic recharge
Charge status output pin
Soft-start function (Inrush limit current)

TYPICAL APPLICATION CIRCUIT

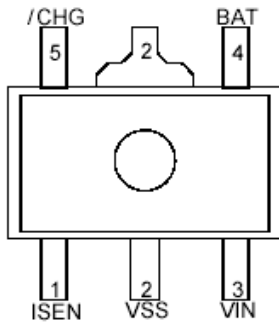


TYPICAL PERFORMANCE CHARACTERISTICS

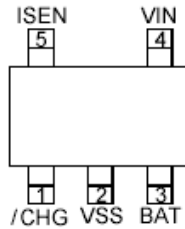
Battery Charge Cycle



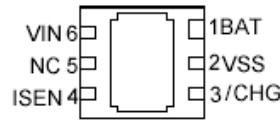
PIN CONFIGURATION



SOT-89-5
(TOP VIEW)



SOT-25
(TOP VIEW)



USP-6C
(BOTTOM VIEW)

* The dissipation pad for the USP-6C package should be solder-plated in recommended mount pattern and metal masking so as to enhance mounting strength and heat release. If the pad needs to be connected to other pins, it should be connected to the V_{SS} (No. 2) pin.

PIN ASSIGNMENT

| PIN NUMBER | | | PIN NAME | FUNCTION |
|------------|----------|--------|----------|---------------------------|
| SOT-25 | SOT-89-5 | USP-6C | | |
| 1 | 5 | 3 | /CHG | Charge Status Output Pin |
| 2 | 2 | 2 | V_{SS} | Ground |
| 3 | 4 | 1 | BAT | Charge Current Output Pin |
| 4 | 3 | 6 | V_{IN} | Input Voltage Pin |
| 5 | 1 | 4 | ISEN | Charge Current Setup Pin |
| - | - | 5 | NC | No Connection |

PRODUCT CLASSIFICATION

Ordering Information

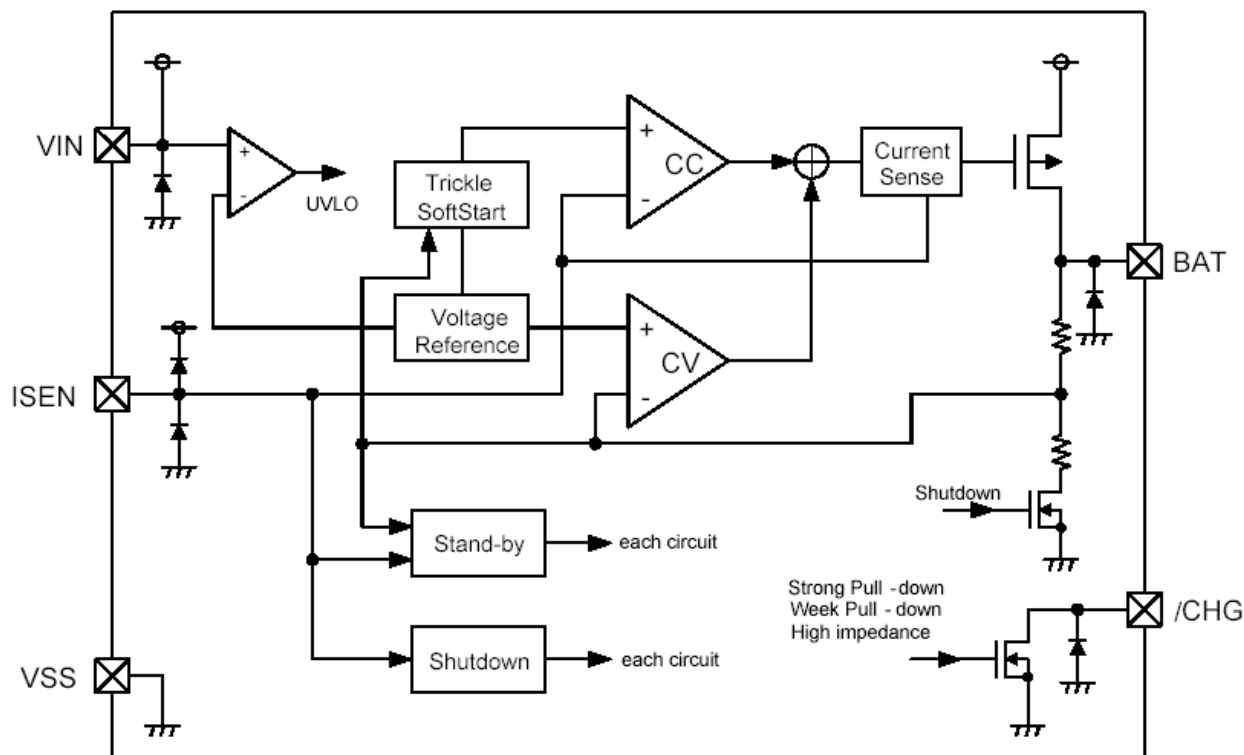
XC6802A42X -③^(*)

| DESIGNATOR | DESCRIPTION | SYMBOL | DESCRIPTION |
|------------|---------------------------|--------|------------------------------------|
| -③ | Packages Taping Type * | PR | SOT-89-5 |
| | | PR-G | SOT-89-5 (Halogen & Antimony free) |
| | | MR | SOT-25 |
| | | MR-G | SOT-25 (Halogen & Antimony free) |
| | | ER | USP-6C |
| | | ER-G | USP-6C (Halogen & Antimony free) |

⁽¹⁾ The "-G" suffix indicates that the products are Halogen and Antimony free as well as being fully RoHS compliant.

⁽²⁾ The device orientation is fixed in its embossed tape pocket. For reverse orientation, please contact your local Torex sales office or representative. (Standard orientation: R- , Reverse orientation: L-)

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

| Ta=25 | | | |
|-----------------------------|----------|---|------|
| PARAMETER | SYMBOL | RATINGS | UNIT |
| VIN Pin Voltage | VIN | V _{SS} - 0.3 ~ + 6.5 | V |
| ISEN Pin Voltage | VSEN | V _{SS} - 0.3 ~ V _{IN} + 0.3 | V |
| BAT Pin Voltage | VBAT | V _{SS} - 0.3 ~ + 6.5 | V |
| /CHG Pin Voltage | V/CHG | V _{SS} - 0.3 ~ + 6.5 | V |
| BAT Pin Current | IBAT | 900 | mA |
| Power Dissipation | SOT-89-5 | 500 | mW |
| | | 1300 (PCB mounted)* | |
| | SOT-25 | 250 | |
| | | 600 (PCB mounted)* | |
| | USP-6C | 120 | |
| | | 1000 (PCB mounted)* | |
| Operating Temperature Range | Topr | - 40 ~ + 85 | |
| Storage Temperature Range | Tstg | - 55 ~ + 125 | |

* The power dissipation figure shown is PCB mounted. Please refer to page 15 to 17 for details.

ELECTRICAL CHARACTERISTICS

XC6802A42x

Ta=25

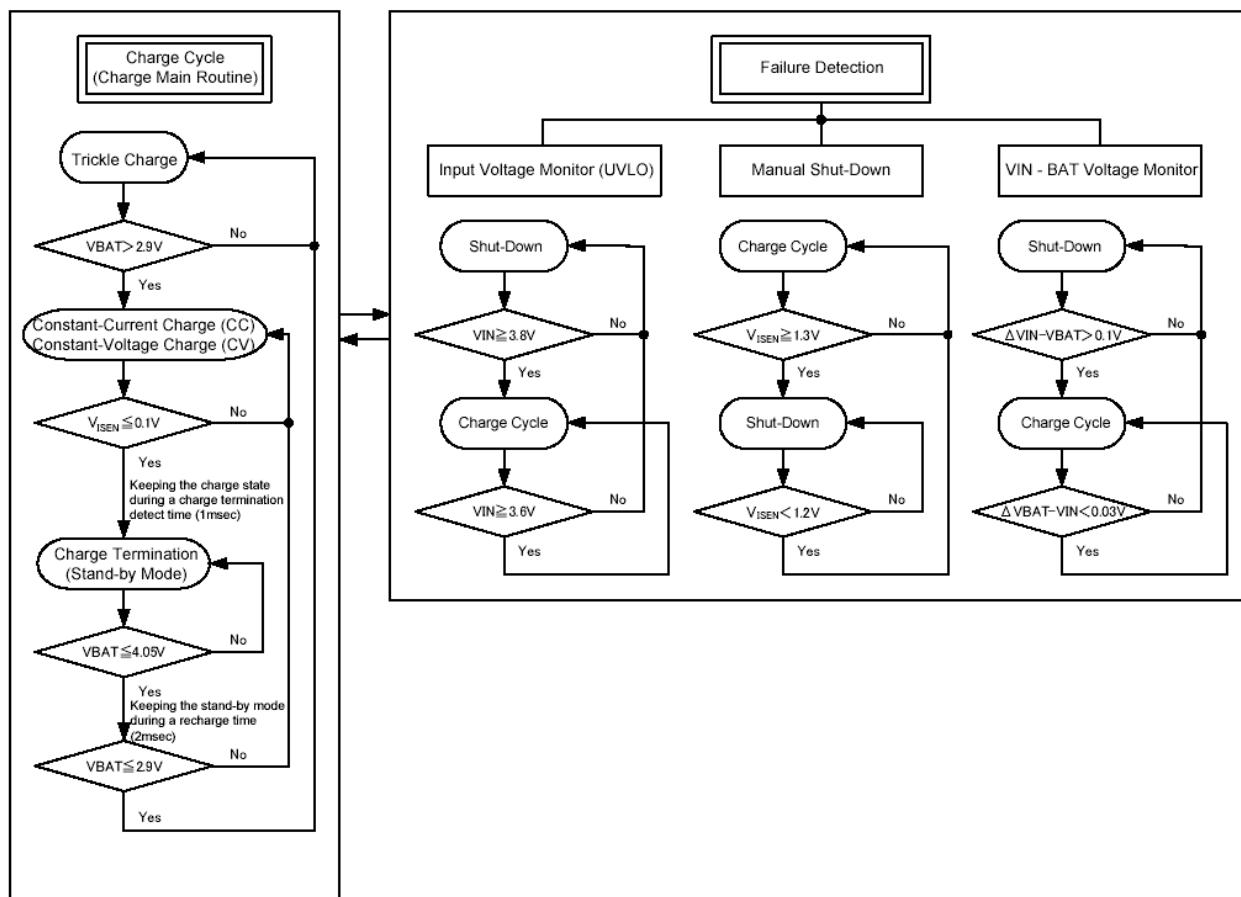
| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNIT | CIRCUIT |
|--|---------------------------|--|--------|------|--------|-------|---------|
| Input Voltage | V _{IN} | | 4.25 | - | 6.0 | V | - |
| Supply Current | I _{SS} | Charge mode, R _{SEN} =10kΩ | - | 15 | 35 | μA | |
| Stand-by Current | I _{STBY} | Stand-by mode | - | 15 | 35 | μA | |
| Shut-down Current | I _{SHUT} | Shut-down mode (R _{SEN} =NC, V _{IN} <V _{BAT} or V _{IN} <V _{UVLO}) | - | 10 | 23 | μA | |
| Float Voltage 1 | V _{FLOAT1} | T _A =25, I _{BAT} =40mA | ×0.993 | 4.2 | ×1.007 | V | |
| Float Voltage 2 ^(*) | V _{FLOAT2} | 0 T _A 50, I _{BAT} =40mA | ×0.99 | 4.2 | ×1.01 | V | - |
| Maximum Battery Current ^(*) | I _{BATMAX} | | | | 800 | mA | - |
| Battery Current 1 | I _{BAT1} | R _{SEN} =10kΩ, CC mode | 93 | 100 | 107 | mA | |
| Battery Current 2 | I _{BAT2} | R _{SEN} =2kΩ, CC mode | 465 | 500 | 523 | mA | |
| Battery Current 3 | I _{BAT3} | Stand-by mode, V _{BAT} =4.2V | - | - | 2 | μA | |
| Battery Current 4 | I _{BAT4} | Shut-down mode (R _{SEN} =NC) | - | - | 1 | μA | |
| Battery Current 5 | I _{BAT5} | Sleep mode, V _{IN} =0V | - | - | 1 | μA | |
| Trickle Charge Current 1 | I _{TRIKL1} | V _{BAT} <V _{TRIKL} , R _{SEN} =10kΩ | 6 | 10 | 14 | mA | |
| Trickle Charge Current 2 | I _{TRIKL2} | V _{BAT} <V _{TRIKL} , R _{SEN} =2kΩ | 30 | 50 | 70 | mA | |
| Trickle Voltage | V _{TRIKL} | R _{SEN} =10kΩ, V _{BAT} Rising | 2.913 | 2.9 | 2.987 | V | |
| Trickle Voltage Hysteresis Width | V _{TRIKL_HYS} | - | 58 | 90 | 116 | mV | |
| UVLO Volatge | V _{UVLO} | V _{IN} : L → H | 3.686 | 3.8 | 3.914 | V | |
| UVLO Hysteresis Width | V _{UVLO_HYS} | - | 150 | 190 | 280 | mV | |
| Manual Shut-down Voltage | V _{SD} | I _{SEN} : L → H | 1.4 | - | - | V | |
| Manual Shut-down Voltage Hysteresis Width | V _{SD_HYS} | - | - | 100 | - | mV | |
| Shut-down Release Voltage | V _{ASD} | V _{IN} : L → H | 70 | 100 | 140 | mV | |
| V _{IN} -V _{BAT} Shut-down Voltage Hysteresis Width | V _{ASD_HYS} | - | - | 70 | - | mV | |
| C/10 Charge Termination Current Threshold 1 | I _{TERM1} | R _{SEN} =10kΩ | 0.07 | 0.10 | 0.13 | mA/mA | |
| C/10 Charge Termination Current Threshold 2 | I _{TERM2} | R _{SEN} =2kΩ | 0.07 | 0.10 | 0.13 | mA/mA | |
| I _{SEN} Pin Voltage | V _{ISEN} | R _{SEN} =10kΩ, CC mode | - | 1.0 | - | V | |
| /CHG Pin Weak Pull-Down Current | I _{/CHG1} | V _{BAT} =4.3, V _{/CHG} =5V | 8 | 20 | 50 | μA | |
| /CHG Pin Strong Pull-Down Current | I _{/CHG2} | V _{BAT} =4.0V, V _{/CHG} =1V | 4 | 10 | 20 | mA | |
| /CHG Pin Output LOW Voltage | V _{/CHG} | I _{/CHG} = 5mA | - | 0.35 | 0.7 | V | |
| Recharge Battery Threshold Voltage | ΔV _{RECHRG} | V _{FLOAT1} -V _{RECHRG} | 100 | 150 | 200 | mV | |
| ON Resistance | R _{ON} | I _{BAT} =100mA | - | 450 | 900 | mΩ | |
| Soft-Start Time | t _{SS} | | 100 | 150 | 200 | μs | |
| Recharge Battery Time | t _{RECHRG} | | 0.4 | 2 | 4 | ms | |
| Battery Termination Detect Time | t _{TERM} | I _{BAT} falling (less than charge current /10) | 0.3 | 1 | 3.5 | ms | |
| Current Sense Pin Pull-Up Current | I _{ISEN_pull_up} | - | - | 1.3 | - | μA | |
| Thermal Shut-Down Detect Temperature | T _{TSD} | Junction temperature | - | 115 | - | - | |
| Thermal Shut-Down Release Temperature | T _{TSR} | Junction temperature | - | 95 | - | - | |

* Unless otherwise stated, V_{IN}=5.0V.

NOTE: *1: The figures under the condition of 0°C T_A 50°C are guaranteed by design calculation.

*2: When the R_{SEN} resistance is set, the battery current shall not be exceeded to 800mA.

OPERATIONAL EXPLANATION



<Charge Cycle>

If the BAT pin voltage is less than 2.9V, the charger enters trickle charge mode. In this mode, a safe battery charge is possible because approximately only 1/10 of the charge current which was set by the I_{SEN} pin, is supplied to the battery. When the BAT pin voltage rises above 2.9V, the charger enters constant-current mode (CC mode) and the battery is charged by the programmed charge current. When the BAT pin voltage reaches 4.2V, the charger enters constant-voltage mode (CV mode) automatically. After this, the charge current starts to drop and when it reaches a level which is 1/10 of the programmed charge current, the charge terminates.

<Setting Charge Current>

The charge current can be set by connecting a resistor between the I_{SEN} pin and the V_{SS} pin. The battery charge current, I_{BAT}, is 1000 times the current out of the I_{SEN} pin. Therefore, the charge current, I_{BAT}, is calculated by the following equations:

$$I_{BAT} = (V_{ISEN} / R_{SEN}) \times 1000 \quad (V_{ISEN} = 1.0V: \text{Current sense pin voltage})$$

However I_{BAT} 800mA

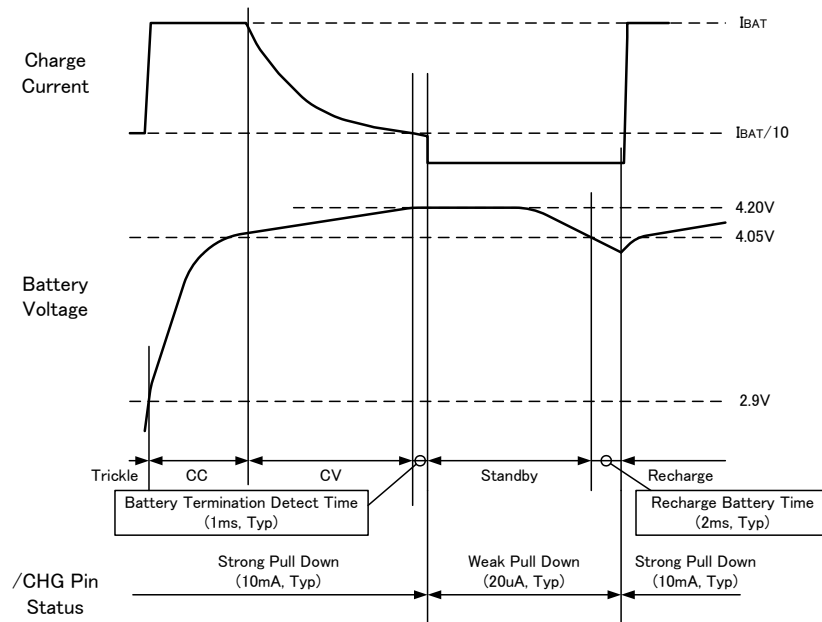
<Charge Termination>

The battery charge is terminated when the charge current decreases to 1/10 of the full charging level after the battery pin voltage reaches a float voltage. An internal comparator monitors the I_{SEN} pin voltage to detect the charge termination. When the comparator monitors the I_{SEN} pin voltage is less than 100mV (charge termination detect) for 1ms (charge termination detect time), the IC enters stand-by mode. A driver transistor turns off during the stand-by mode. In this state, a failure detection circuit and a monitoring circuit of the battery pin voltage operates and supply current is reduced to 10 μA.

<Automatic Recharge>

In stand-by mode battery voltage falls. When the voltage level at the battery pin drops to 4.05V or less, the charge cycle automatically re-starts after a delay of 2ms. As such, no external activation control is needed.

OPERATIONAL EXPLANATION (Continued)



<Charge Condition Status>

The /CHG pin constantly monitors the charge states classified as below:

- Strong pull-down: $I_{/CHG}=10\text{mA}$ (TYP.) in a charge cycle,
- Weak pull-down: $I_{/CHG}=20\ \mu\text{A}$ (TYP.) in a stand-by mode,
- High impedance: in shutdown mode.

<Connection of Shorted BAT Pin>

Even if the BAT pin is shorted to the V_{SS} , a trickle charge mode starts to operate for protecting the IC from destruction caused by over current.

<Under-voltage Lockout (UVLO)>

The UVLO circuit keeps the charger in shut-down mode until the input voltage, V_{IN} , rises more than the UVLO voltage. Moreover, in order to protect the battery charger, the UVLO circuit keeps the charger in shut-down mode when a voltage between the input pin voltage and BAT pin voltage falls to less than 30mV. The charge will not restart until the voltage between the input pin voltage and BAT pin voltage rises more than 100mV. During the shut-down mode, the driver transistor turns off but a failure detection circuit operates, and supply current is reduced to $10\ \mu\text{A}$.

<Soft-Start Function>

To protect against inrush current from the input to the battery, soft-start time is set in the circuit optimally ($100\ \mu\text{s}$, TYP.).

<Manual Shut-Down>

During the charge cycle, the IC can be shifted to the shut-down mode by floating the I_{SEN} pin. For this, a drain current to the battery is reduced to less than $2\ \mu\text{A}$ and a shut-down current of the IC is reduced to less than $10\ \mu\text{A}$. A new charge cycle starts when reconnecting the current sense resistor.

<Opened BAT Pin>

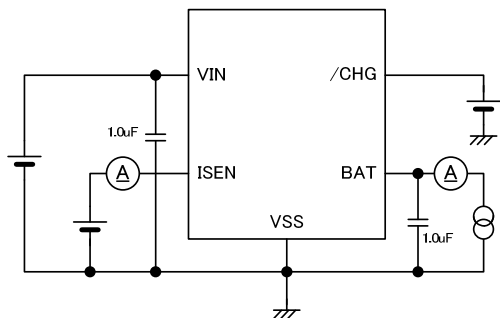
When the BAT pin is left open, the IC needs to be shut-down once after monitoring the CHG pin by a microprocessor etc and keeping the I_{SEN} pin in H level.

<Backflow Prevention Between the BAT Pin and the VIN Pin>

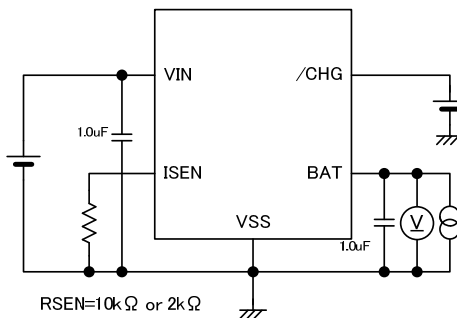
A backflow prevention circuit protects against current flowing from the BAT pin to the V_{IN} pin even the BAT pin voltage is higher than the V_{IN} pin voltage.

TEST CIRCUITS

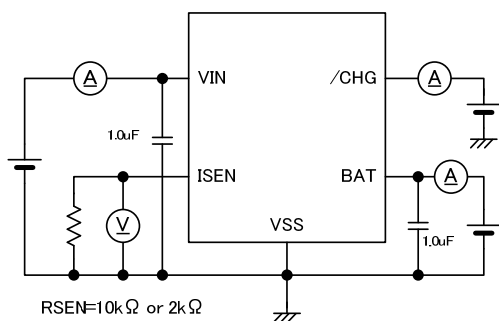
1. ON Resistance, Shut-down Voltage, I_{SEN} Pull-up current



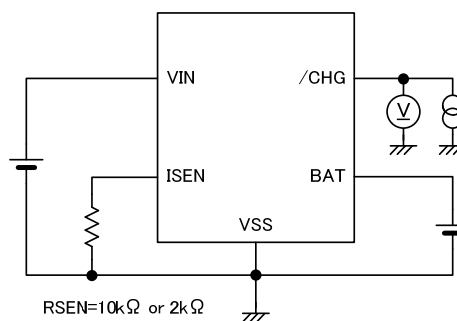
2. Battery Termination Detect Time, Recharge Battery Time
C/10 Charge Termination Current Threshold, Battery Termination Voltage



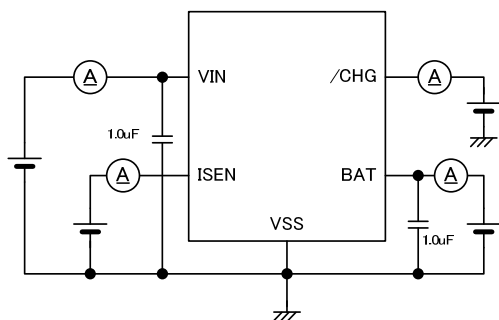
3. Trickle Charge Current, Battery Current, I_{SEN} Pin Voltage
Trickle Charge Voltage, UVLO, Recharge Battery Threshold Voltage
 $V_{IN}-V_{BAT}$ Shut-down Voltage, /CHG Pin Current
Supply Current, Stand-by Current, Shut-down Current



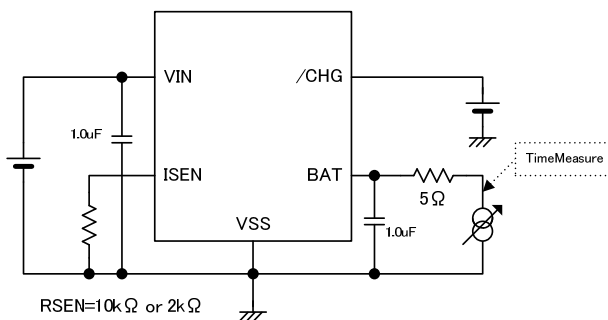
4. /CHG Pin, Output Low Voltage



5. Battery Current 4

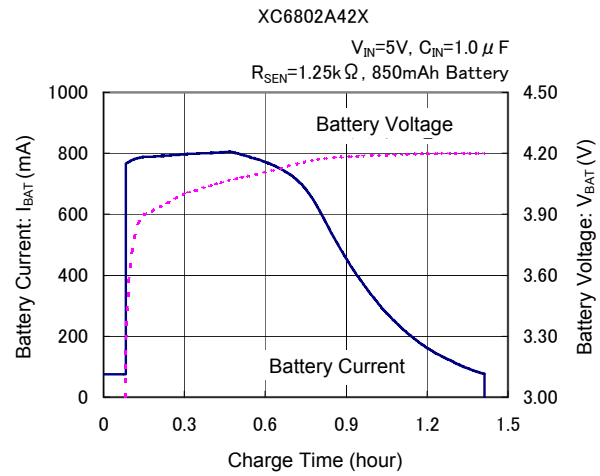
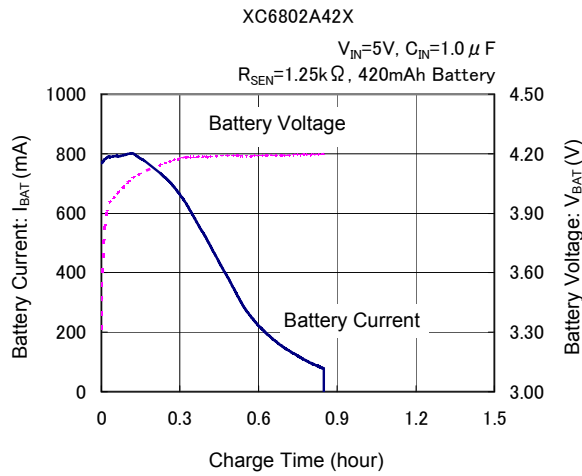


6. Soft-Start

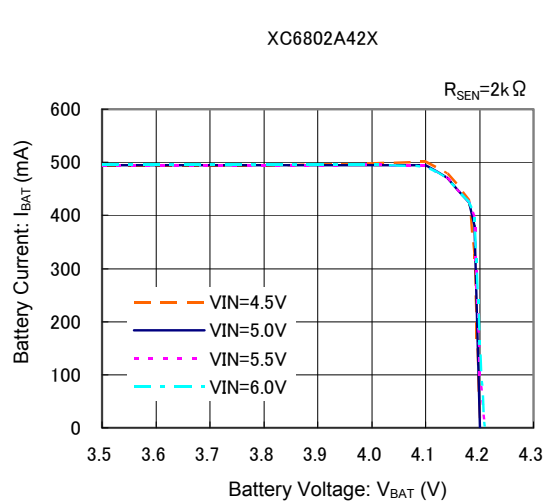
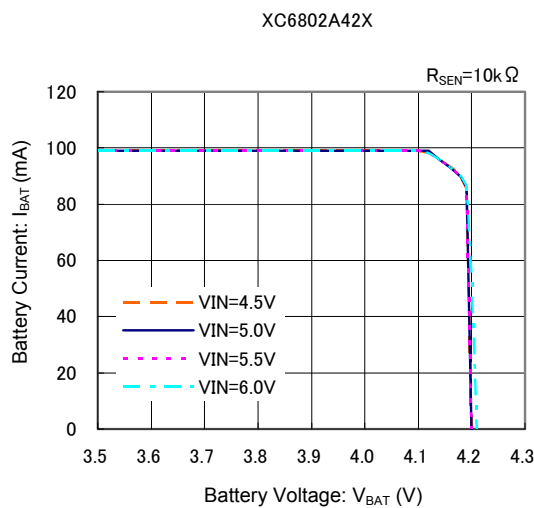
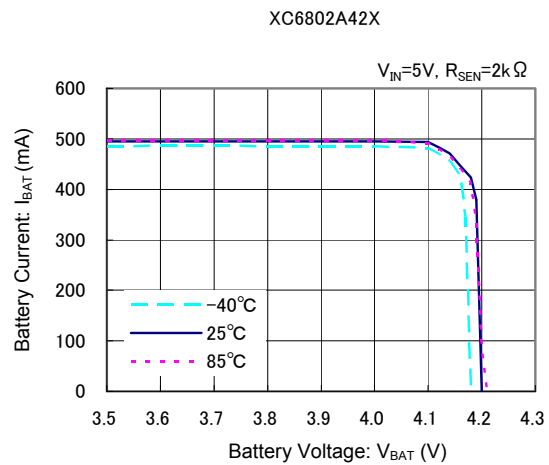
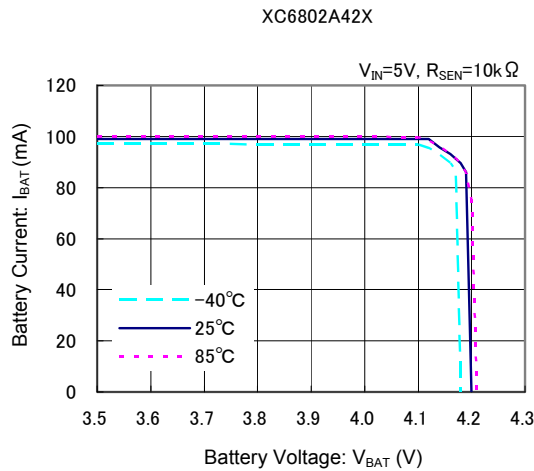


TYPICAL PERFORMANCE CHARACTERISTICS

(1) Charge Cycle

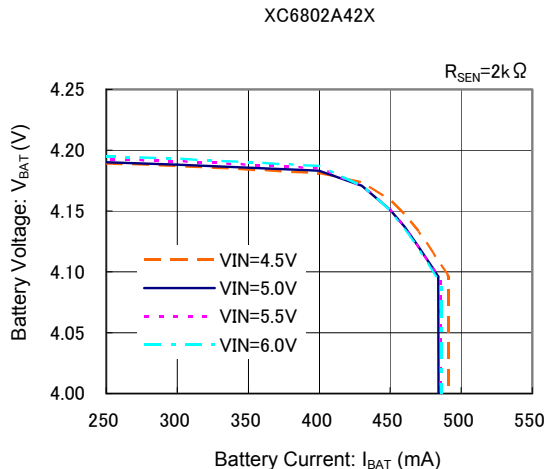
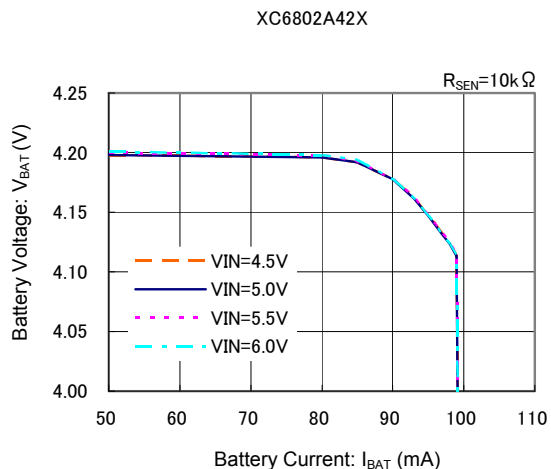
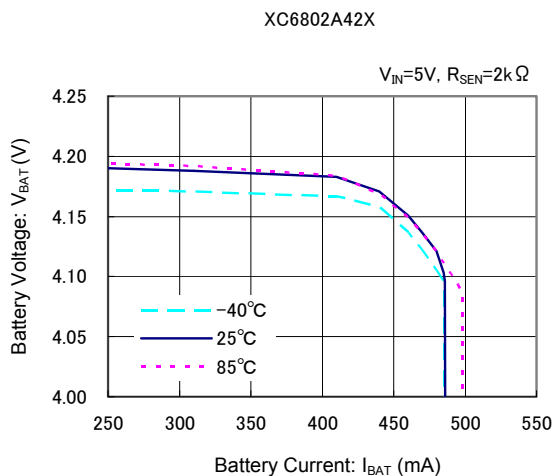
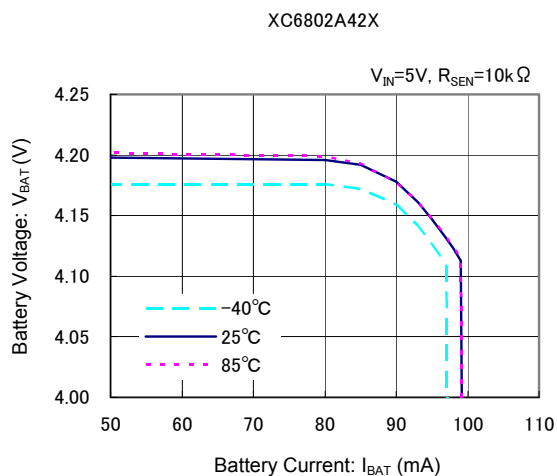


(2) Battery Current vs. Battery Voltage

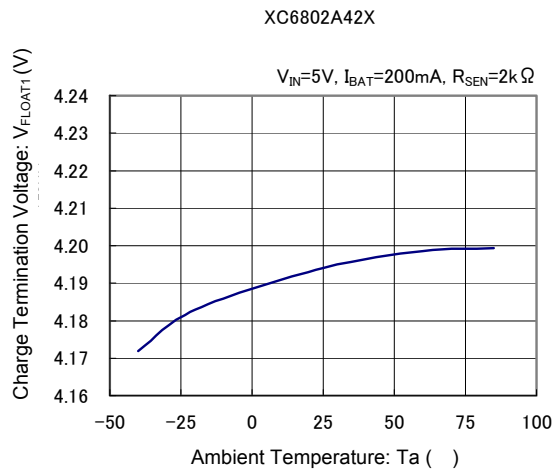
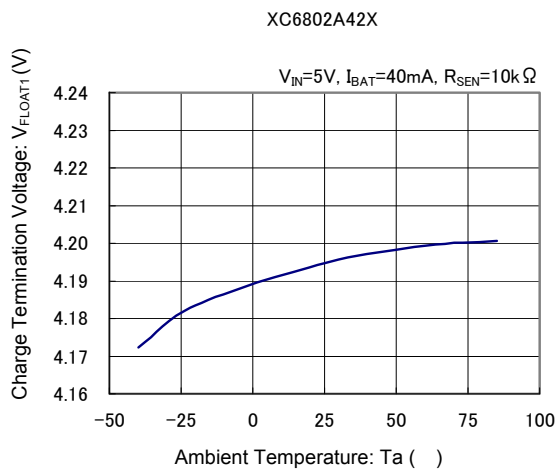


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(3) Battery Voltage vs. Battery Current

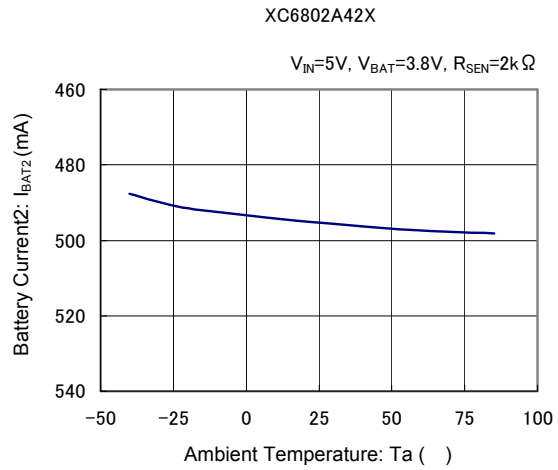
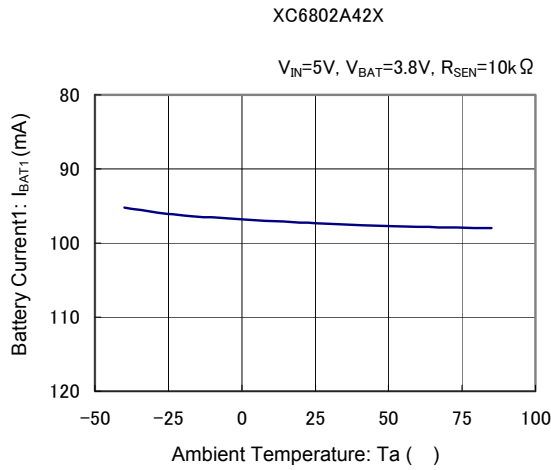


(4) Charge Termination Voltage vs. Ambient Temperature

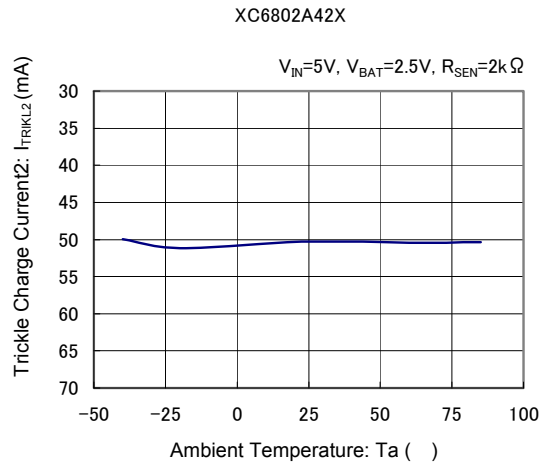
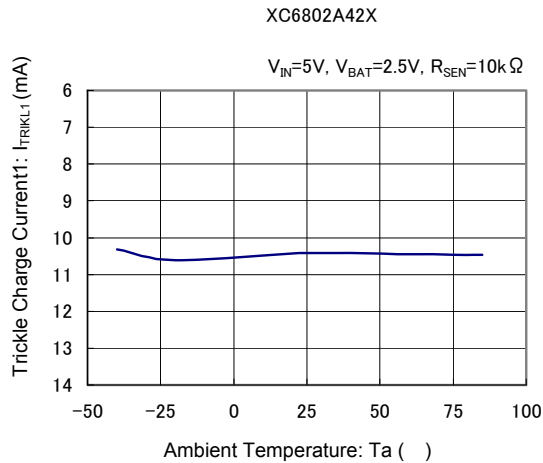


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

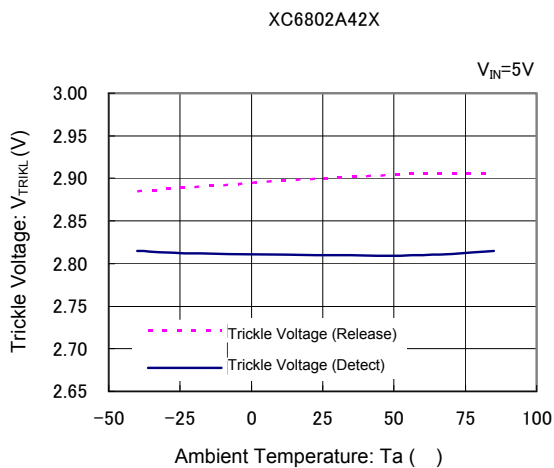
(5) Battery Current vs. Ambient Temperature



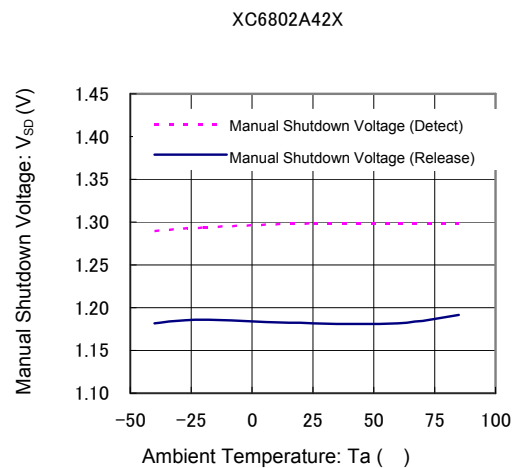
(6) Trickle Charge Current vs. Ambient Temperature



(7) Trickle Voltage vs. Ambient Temperature

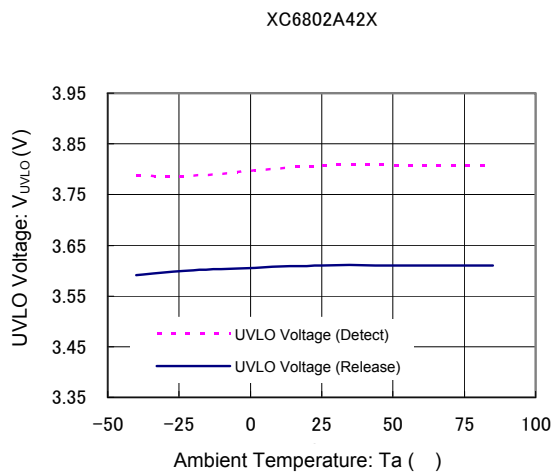


(8) Manual Shutdown Voltage vs. Ambient Temperature

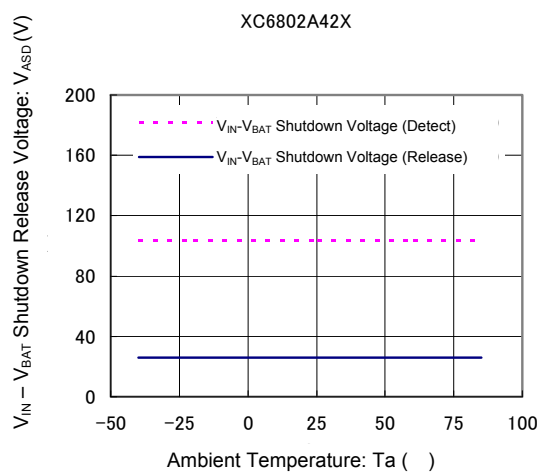


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

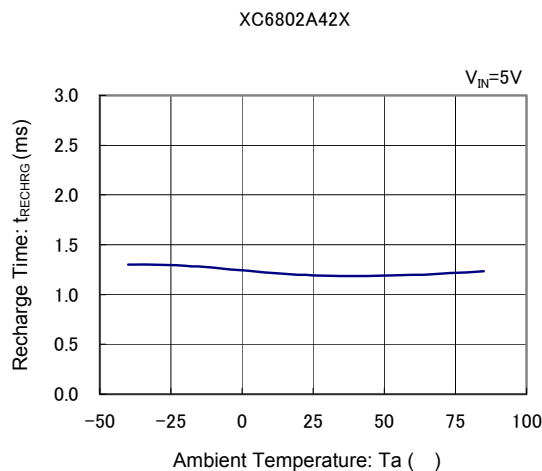
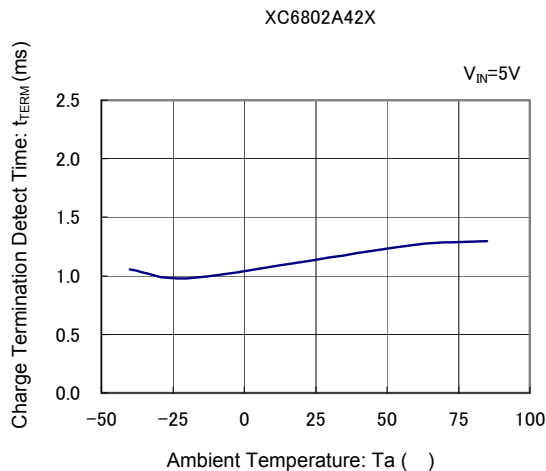
(9) UVLO Voltage vs. Ambient Temperature



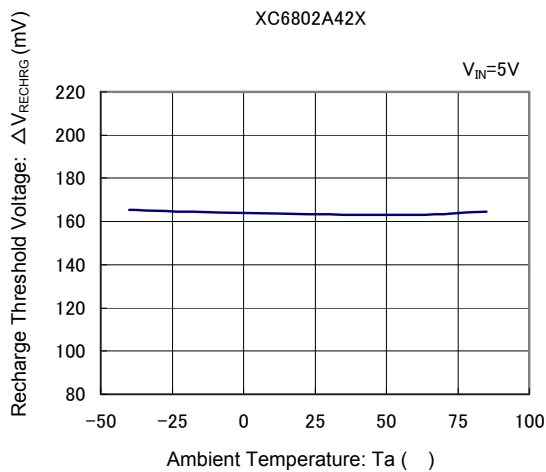
(10) $V_{IN} - V_{BAT}$ Shutdown Voltage vs. Ambient Temperature



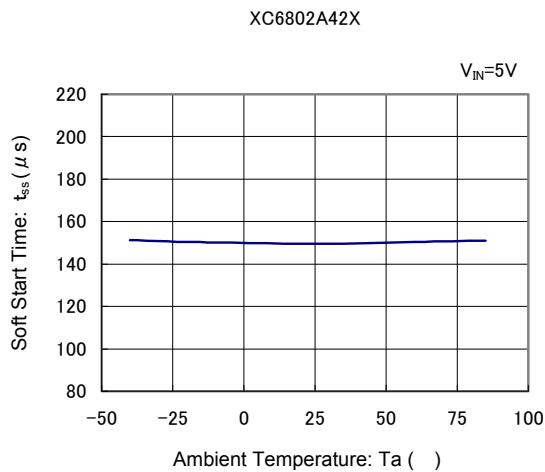
(11) Charge Termination Detect Time vs. Ambient Temperature (12) Recharge Time vs. Ambient Temperature



(13) Recharge Threshold Voltage vs. Ambient Temperature

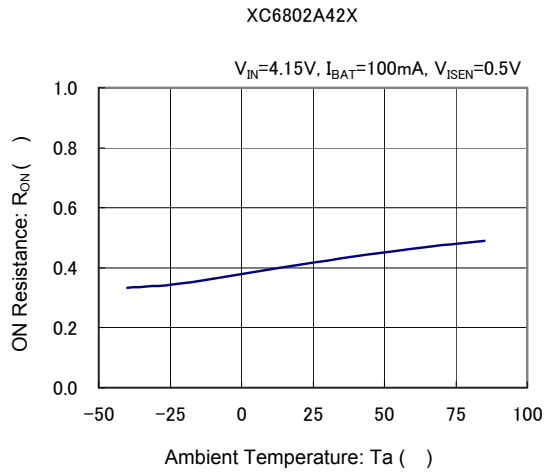


(14) Soft Start Time vs. Ambient Temperature

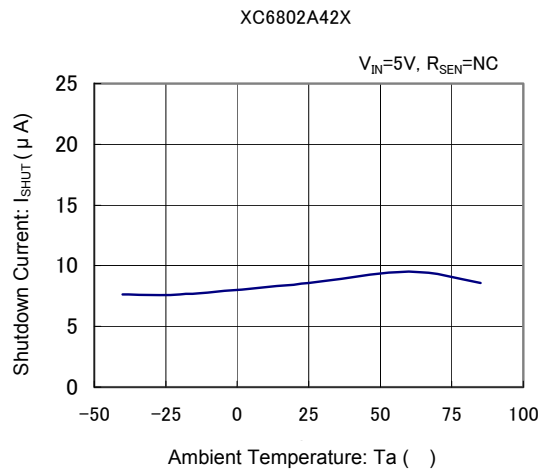


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

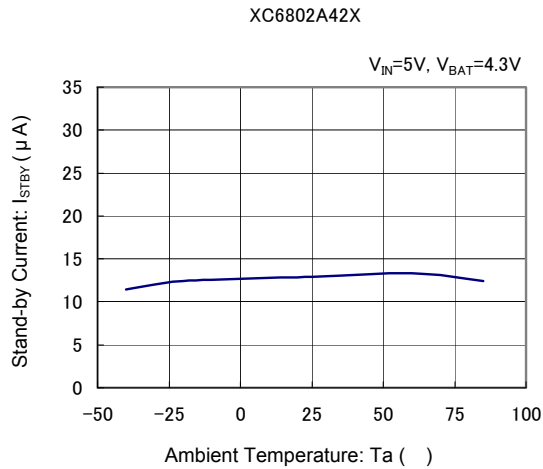
(15) ON Resistance vs. Ambient Temperature



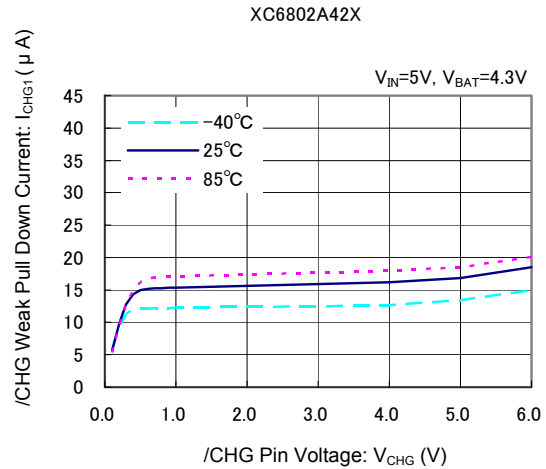
(16) Shutdown Current vs. Ambient Temperature



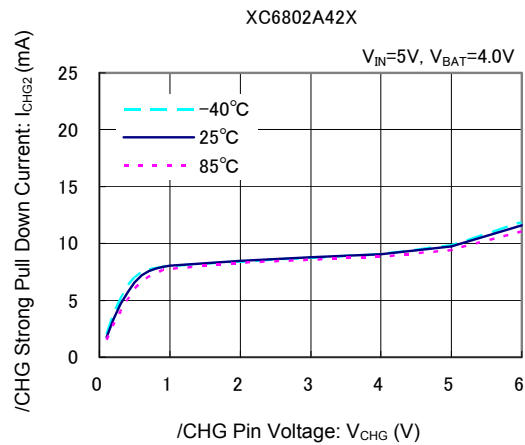
(17) Stand-by Current vs. Ambient Temperature



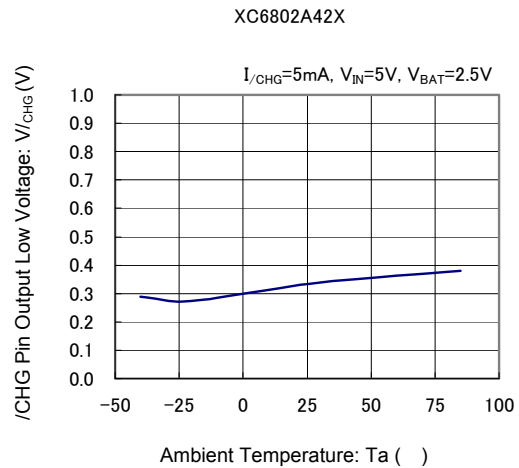
(18) /CHG Weak Pull Down Current vs. /CHG Pin Voltage



(19) /CHG Strong Pull Down Current vs. /CHG Pin Voltage

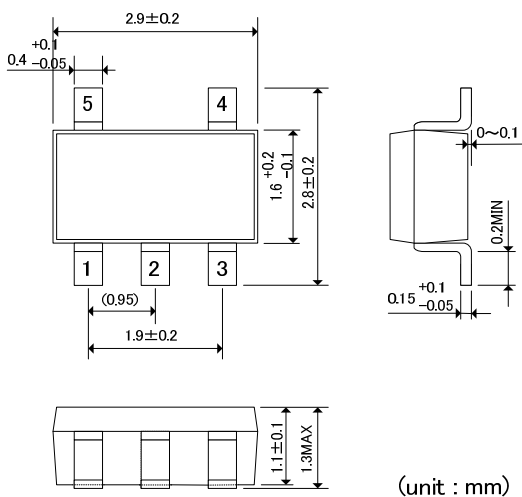


(20) /CHG Pin Output Low Voltage vs. Ambient Temperature

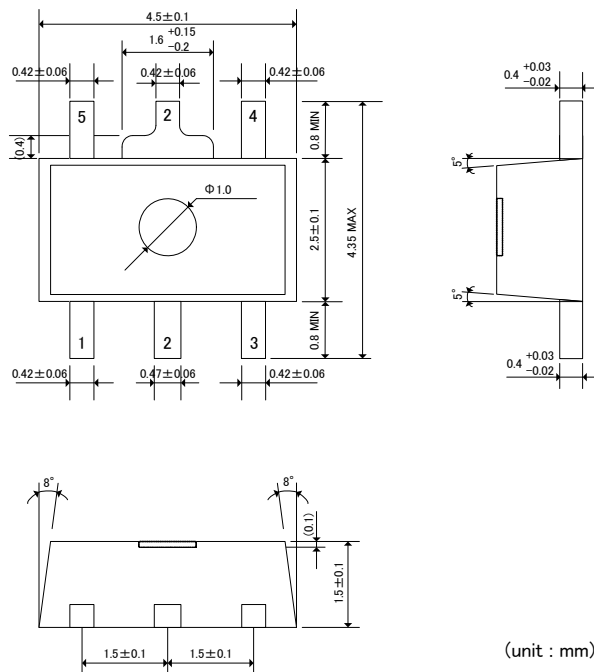


PACKAGING INFORMATION

SOT-25

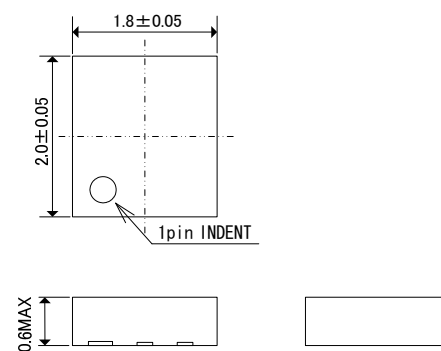


SOT-89-5

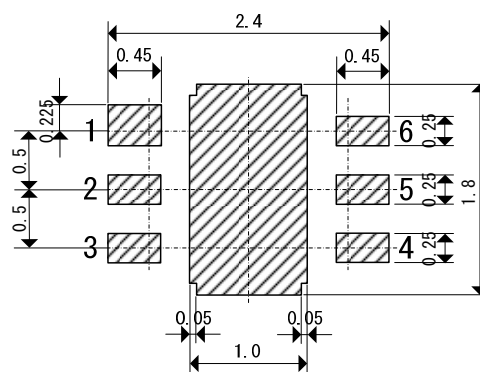


USP-6C

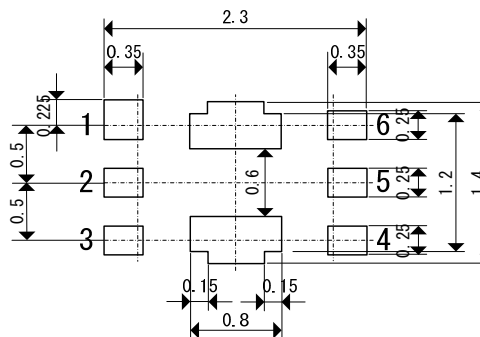
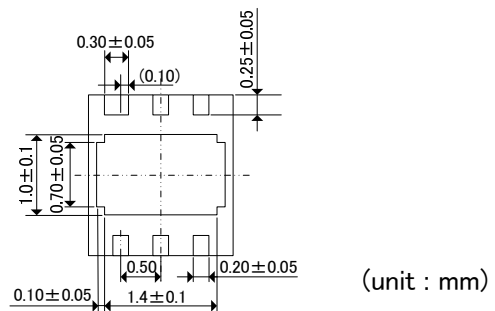
< Package Dimensions >



USP-6C Reference Pattern Layout

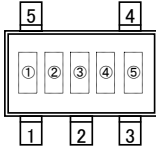


USP-6C Reference Metal Mask Design



MARKING RULE

SOT25



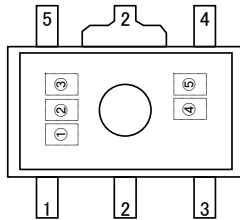
Represents product series

| MARK | PRODUCT SERIES |
|------|----------------|
| N | XC6802***** |

Standard product, Represent the 7th digits

| MARK | PRODUCT SERIES |
|------|----------------|
| A | XC6802A***** |

SOT89-5



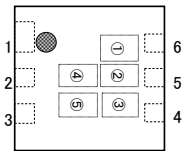
Custom product, the last 2 digits

| MARK | SEQUENCE No. | PRODUCT SERIES |
|------|--------------|----------------|
| 0 | 001 | XC6802S001** |

Standard product, Represents the 8th digits

| MARK | PRODUCT SERIES |
|------|----------------|
| 4 | XC6802*4**** |

USP6C



Custom product, the last 1 digits

| MARK | SEQUENCE No. | PRODUCT SERIES |
|------|--------------|----------------|
| 1 | 001 | XC6802S001** |

Represents production lot number

01 to 09, 0A to 0Z, 11 to 9Z, A1 to A9, AA to Z9, ZA to ZZ in order.
(G, I, J, O, Q, W excepted)

*No character inversion used.

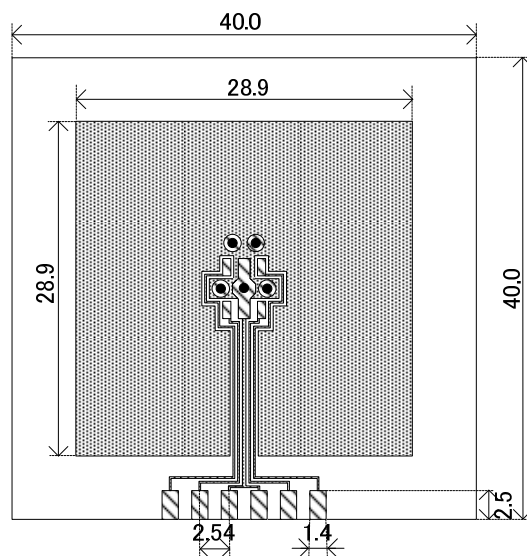
PACKAGING INFORMATION (Continued)

SOT-89-5 Power Dissipation

Power dissipation data for the SOT-89-5 is shown in this page.
The value of power dissipation varies with the mount board conditions.
Please use this data as one of reference data taken in the described condition.

1. Measurement Condition (Reference data)

- Condition: Mount on a board
- Ambient: Natural convection
- Soldering: Lead (Pb) free
- Board: Dimensions 40 x 40 mm (1600 mm² in one side)
Copper (Cu) traces occupy 50% of the board area
In top and back faces
Package heat-sink is tied to the copper traces
- Material: Glass Epoxy (FR-4)
- Thickness: 1.6 mm
- Through-hole: 5 x 0.8 Diameter

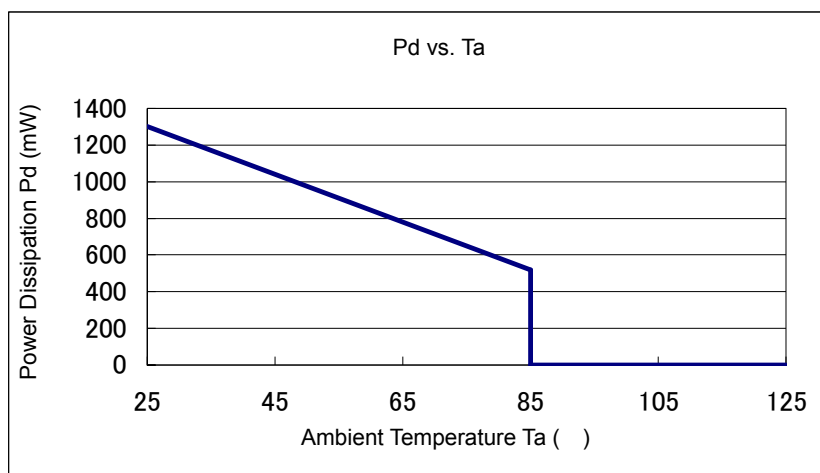


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Operating temperature

Board Mount ($T_j \text{ max} = 125$)

| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 1300 | 76.92 |
| 85 | 520 | |



PACKAGING INFORMATION (Continued)

SOT-25 Power Dissipation

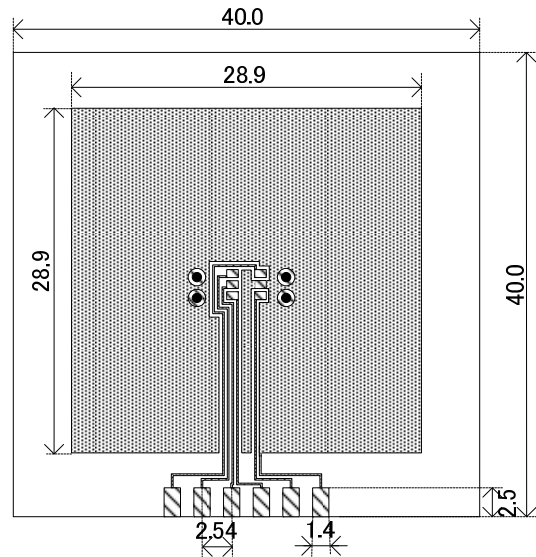
Power dissipation data for the SOT-25 is shown in this page.

The value of power dissipation varies with the mount board conditions.

Please use this data as one of reference data taken in the described condition.

1. Measurement Condition (Reference data)

- Condition: Mount on a board
- Ambient: Natural convection
- Soldering: Lead (Pb) free
- Board: Dimensions 40 x 40 mm (1600 mm² in one side)
Copper (Cu) traces occupy 50% of the board area
In top and back faces
Package heat-sink is tied to the copper traces
(Board of SOT-26 is used.)
- Material: Glass Epoxy (FR-4)
- Thickness: 1.6 mm
- Through-hole: 4 x 0.8 Diameter

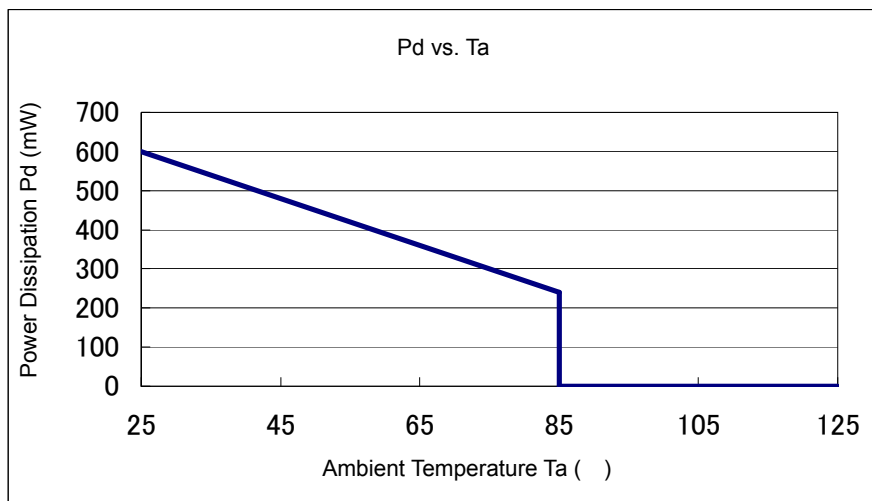


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Operating temperature

Board Mount ($T_j \text{ max} = 125 \text{ }^\circ\text{C}$)

| Ambient Temperature ($^\circ\text{C}$) | Power Dissipation Pd (mW) | Thermal Resistance ($^\circ\text{C}/\text{W}$) |
|--|---------------------------|--|
| 25 | 600 | 166.67 |
| 85 | 240 | |



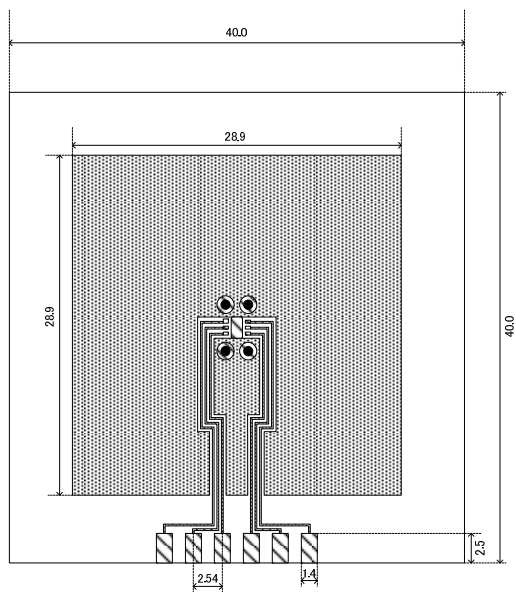
PACKAGING INFORMATION (Continued)

USP-6C Power Dissipation

Power dissipation data for the USP-6C is shown in this page.
The value of power dissipation varies with the mount board conditions.
Please use this data as one of reference data taken in the described condition.

1. Measurement Condition (Reference data)

- Condition: Mount on a board
- Ambient: Natural convection
- Soldering: Lead (Pb) free
- Board: Dimensions 40 x 40 mm (1600 mm² in one side)
Copper (Cu) traces occupy 50% of the board area
In top and back faces
Package heat-sink is tied to the copper traces
- Material: Glass Epoxy (FR-4)
- Thickness: 1.6 mm
- Through-hole: 4 x 0.8 Diameter

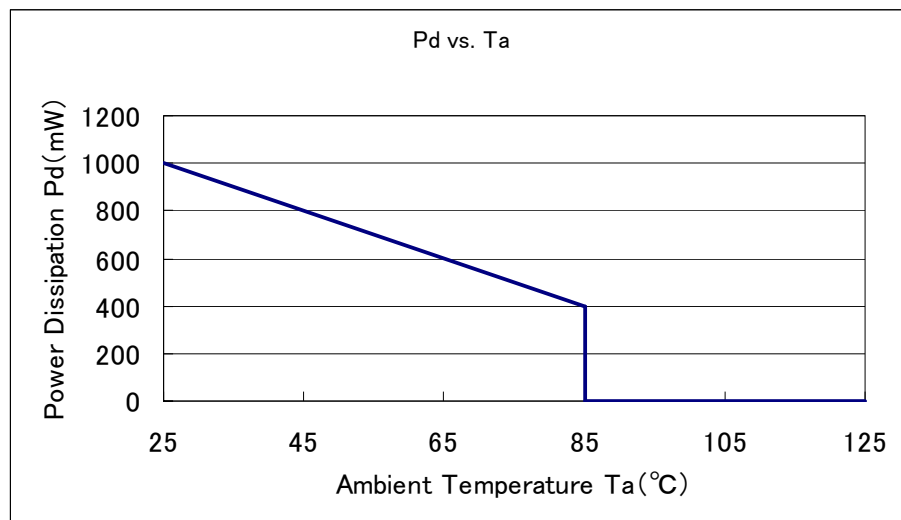


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Operating temperature

Board Mount ($T_j \text{ max} = 125$)

| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 1000 | 100 |
| 85 | 400 | |



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