

## 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.

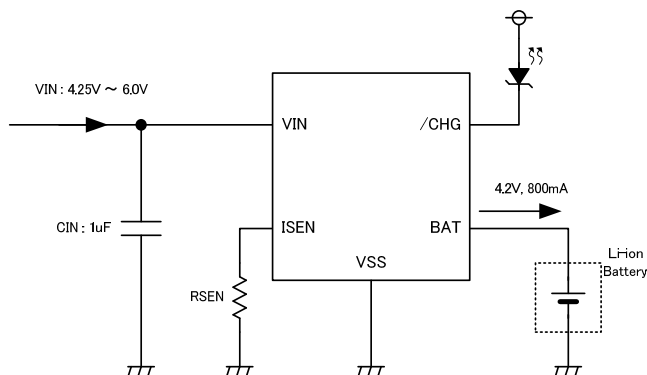
### APPLICATIONS

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

### FEATURES

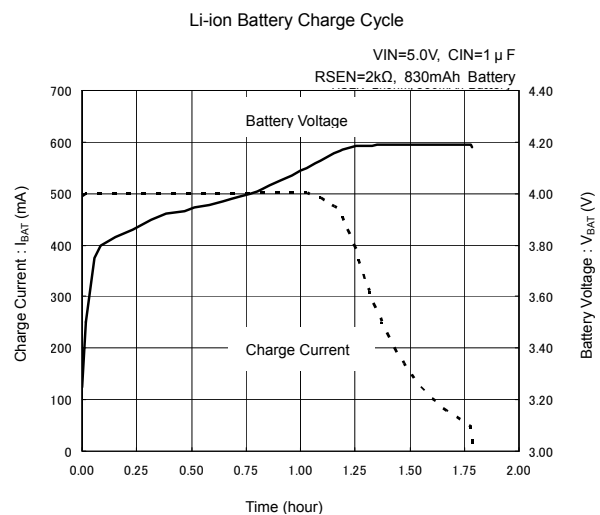
Operating Voltage Range : 4.25V ~ 6.0V  
Charge Current : Externally set up to 800mA (MAX.)  
Charge Termination Voltage :  $4.2V \pm 0.7\%$   
Trickle Charge Voltage :  $2.9V \pm 3\%$   
Supply Current (Stand-by) :  $15 \mu A$  (TYP.)  
Packages : SOT-89-5, SOT-25, USP-6C  
Constant-current/constant-voltage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

### TYPICAL APPLICATION CIRCUIT

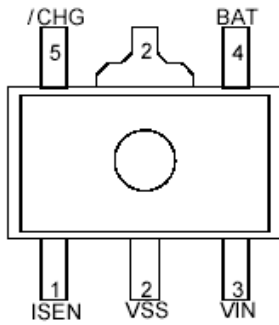


### TYPICAL PERFORMANCE CHARACTERISTICS

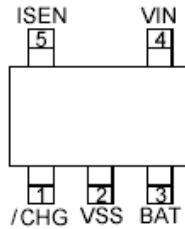
#### Battery Charge Cycle



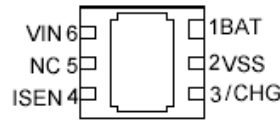
## PIN CONFIGURATION



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

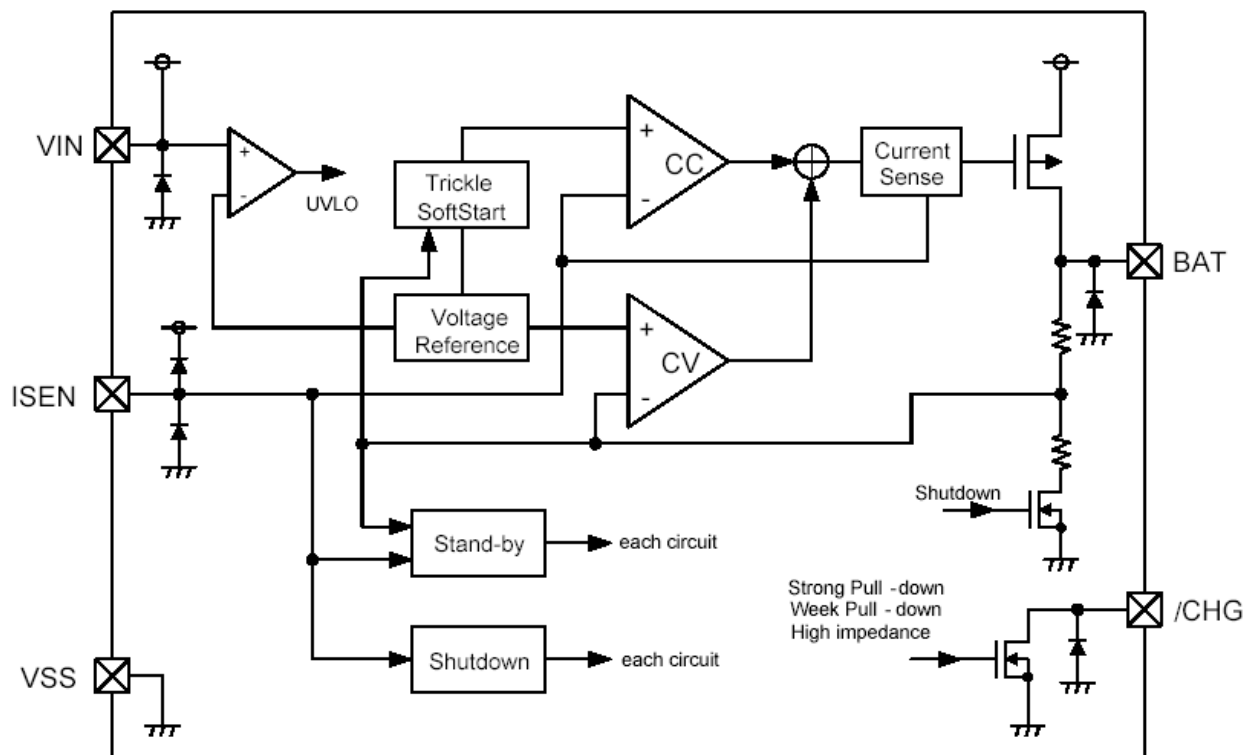
XC6802A42X -③<sup>(\*)</sup>

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)

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

<sup>(2)</sup> 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
V <sub>IN</sub> Pin Voltage	V <sub>IN</sub>	V <sub>SS</sub> - 0.3 ~ + 6.5	V
I <sub>SEN</sub> Pin Voltage	V <sub>SEN</sub>	V <sub>SS</sub> - 0.3 ~ V <sub>IN</sub> + 0.3	V
BAT Pin Voltage	V <sub>BAT</sub>	V <sub>SS</sub> - 0.3 ~ + 6.5	V
/CHG Pin Voltage	V <sub>/CHG</sub>	V <sub>SS</sub> - 0.3 ~ + 6.5	V
BAT Pin Current	I <sub>BAT</sub>	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	T <sub>opr</sub>	- 40 ~ + 85	
Storage Temperature Range	T <sub>stg</sub>	- 55 ~ + 125	

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

## ELECTRICAL CHARACTERISTICS

XC6802A42x

Ta=25

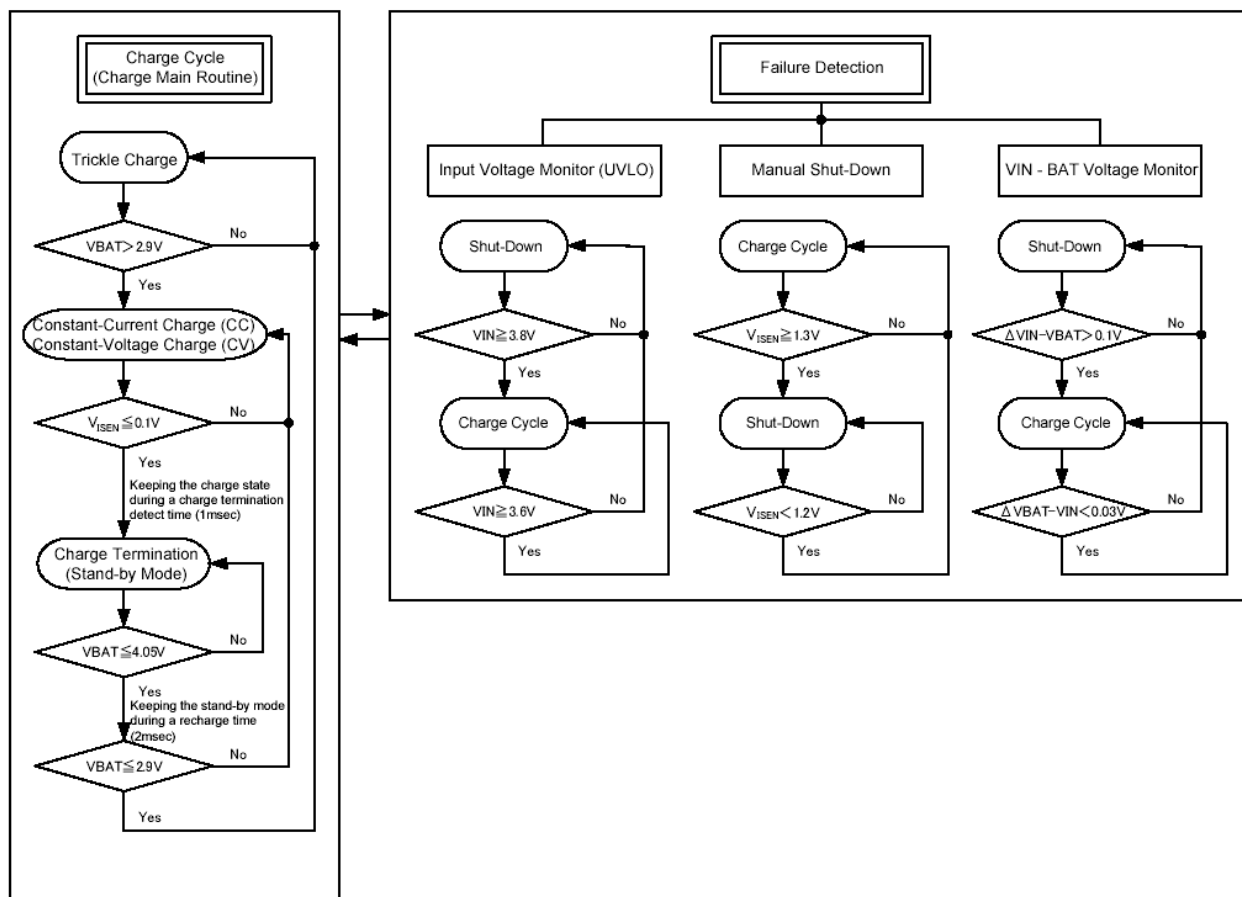
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT	CIRCUIT
Input Voltage	V <sub>IN</sub>		4.25	-	6.0	V	-
Supply Current	I <sub>SS</sub>	Charge mode, R <sub>SEN</sub> =10kΩ	-	15	35	μA	
Stand-by Current	I <sub>STBY</sub>	Stand-by mode	-	15	35	μA	
Shut-down Current	I <sub>SHUT</sub>	Shut-down mode (R <sub>SEN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

\* Unless otherwise stated, V<sub>IN</sub>=5.0V.

NOTE: \*1: The figures under the condition of 0°C T<sub>A</sub> 50°C are guaranteed by design calculation.

\*2: When the R<sub>SEN</sub> 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<sub>SEN</sub> 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<sub>SEN</sub> pin and the V<sub>SS</sub> pin. The battery charge current, I<sub>BAT</sub>, is 1000 times the current out of the I<sub>SEN</sub> pin. Therefore, the charge current, I<sub>BAT</sub>, 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<sub>BAT</sub> 800mA

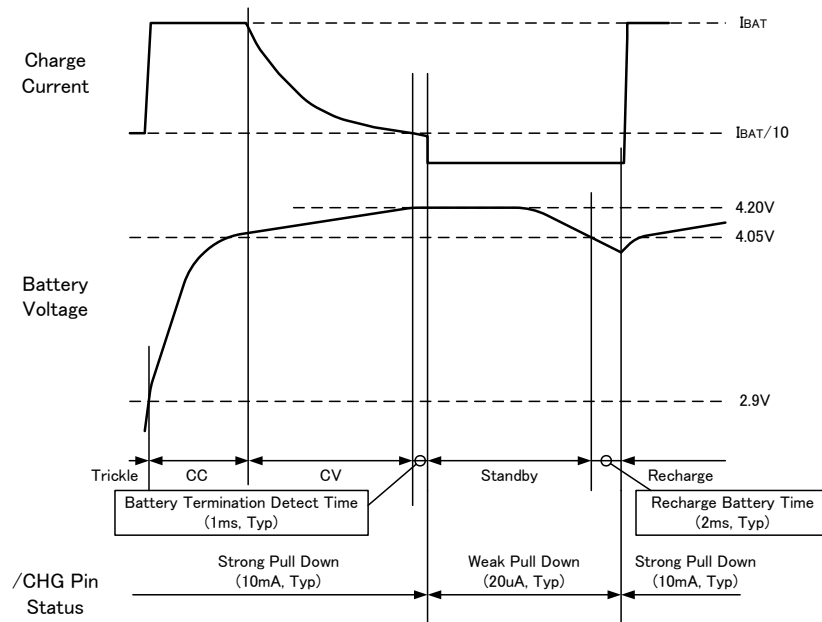
### <Charge Termination>

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<sub>SEN</sub> pin voltage to detect the charge termination. When the comparator monitors the I<sub>SEN</sub> 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>

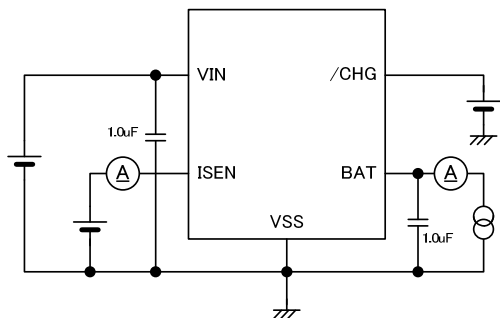
When the BAT pin is left open, the IC needs to be shut-down once after monitoring the CHG pin by a microprocessor etc and keeping the  $I_{SEN}$  pin in H level.

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

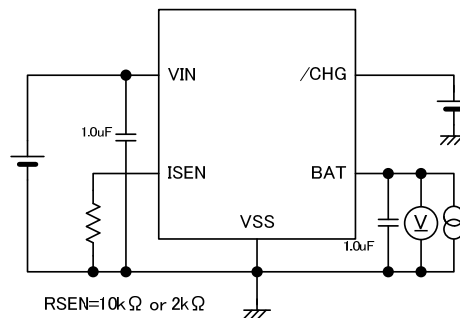
A backflow prevention circuit protects against current flowing from the BAT pin to the  $V_{IN}$  pin even the BAT pin voltage is higher than the  $V_{IN}$  pin voltage.

## TEST CIRCUITS

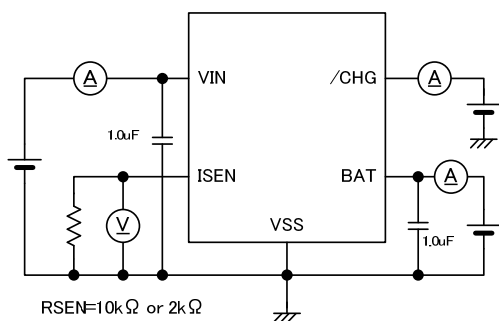
1. ON Resistance, Shut-down Voltage,  $I_{SEN}$  Pull-up current



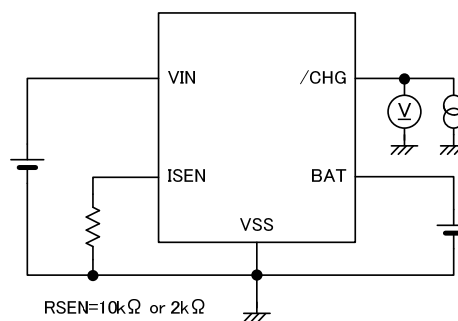
2. Battery Termination Detect Time, Recharge Battery Time  
C/10 Charge Termination Current Threshold, Battery Termination Voltage



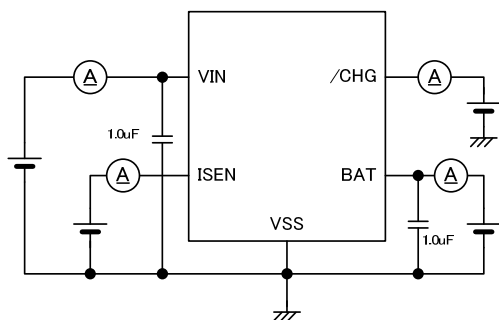
3. Trickle Charge Current, Battery Current,  $I_{SEN}$  Pin Voltage  
Trickle Charge Voltage, UVLO, Recharge Battery Threshold Voltage  
 $V_{IN}-V_{BAT}$  Shut-down Voltage, /CHG Pin Current  
Supply Current, Stand-by Current, Shut-down Current



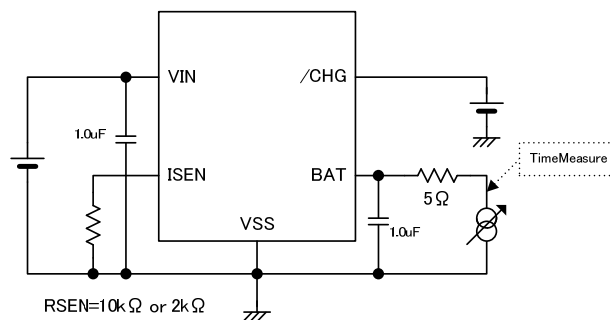
4. /CHG Pin, Output Low Voltage



5. Battery Current 4

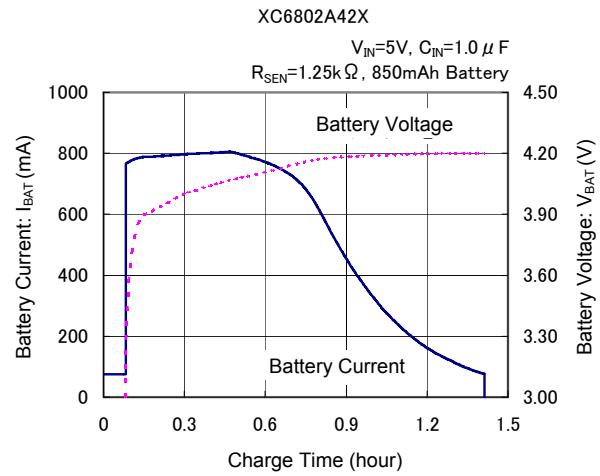
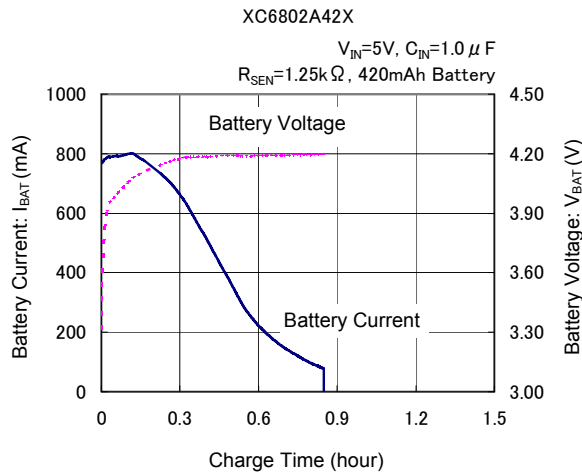


6. Soft-Start

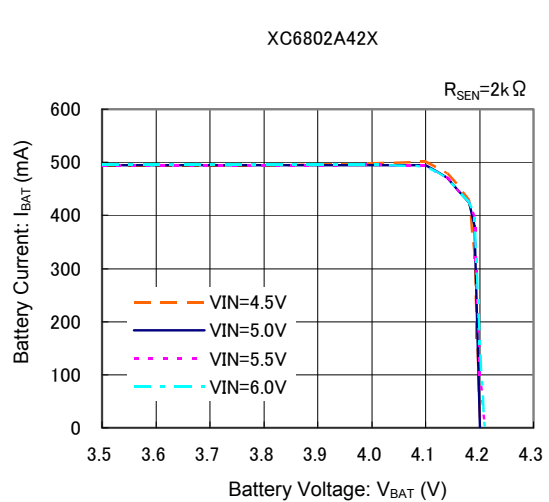
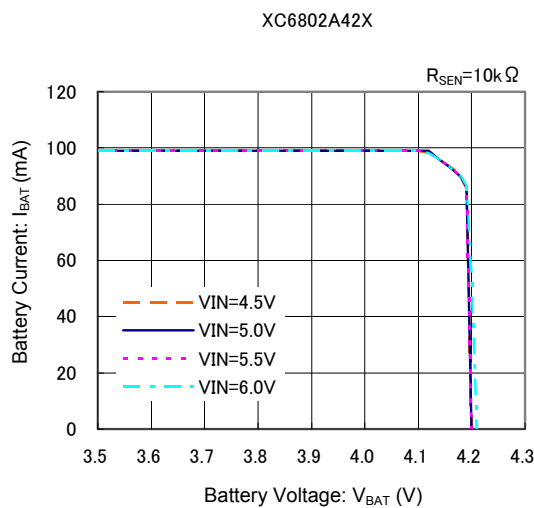
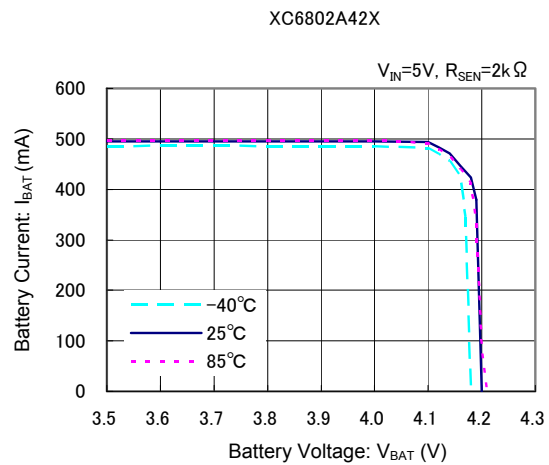
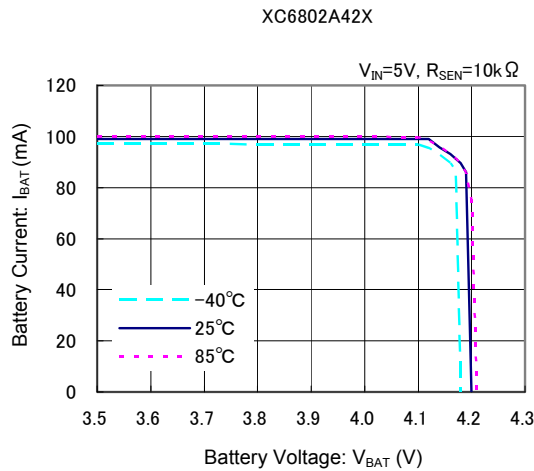


## TYPICAL PERFORMANCE CHARACTERISTICS

### (1) Charge Cycle



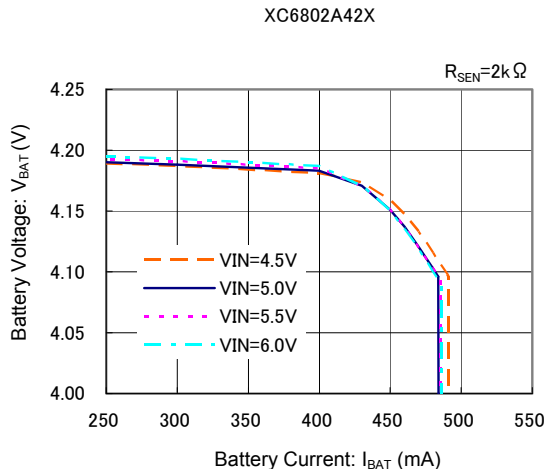
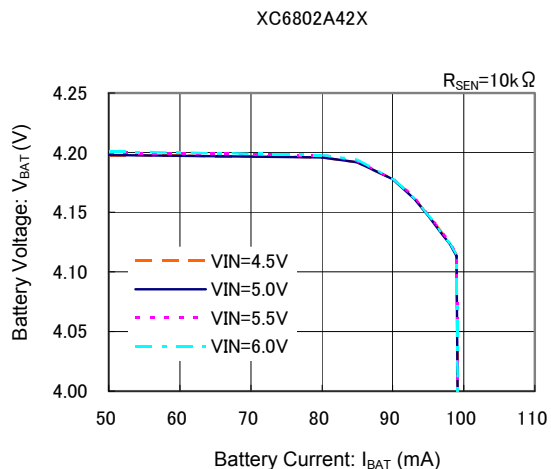
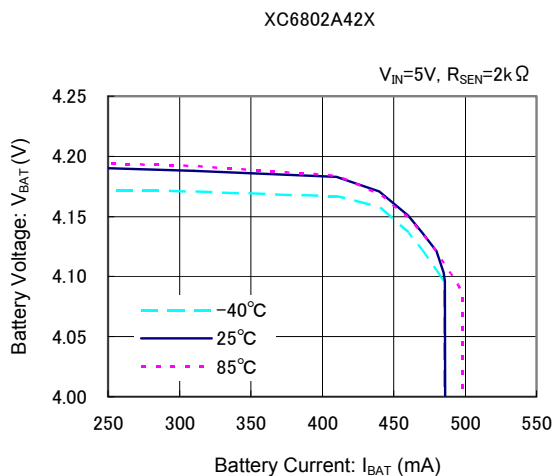
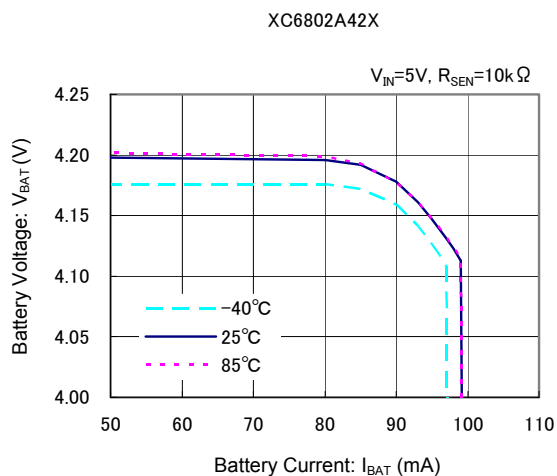
### (2) Battery Current vs. Battery Voltage



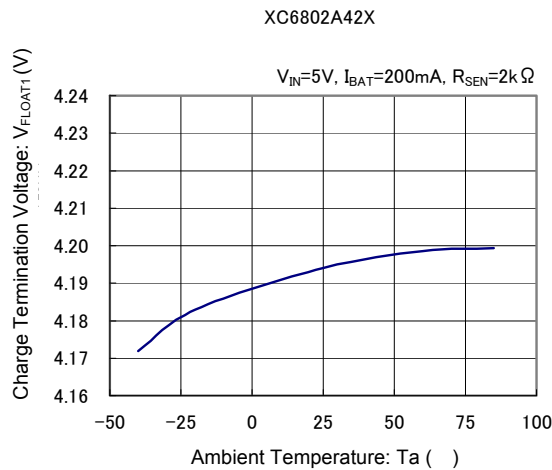
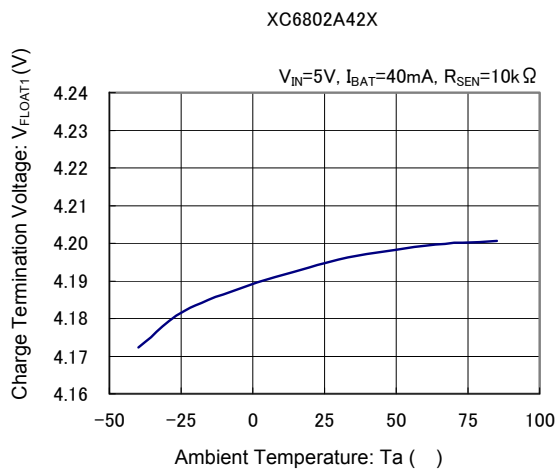


## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

### (3) Battery Voltage vs. Battery Current

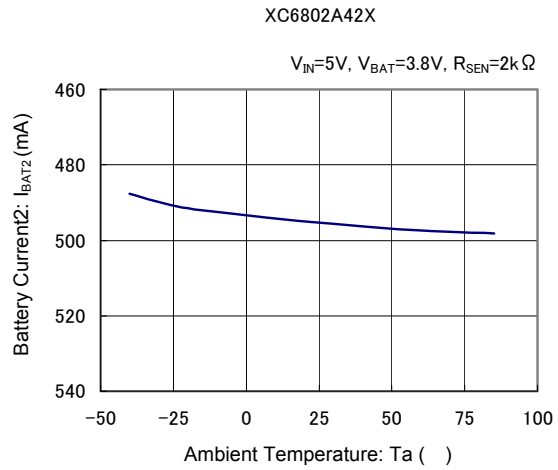
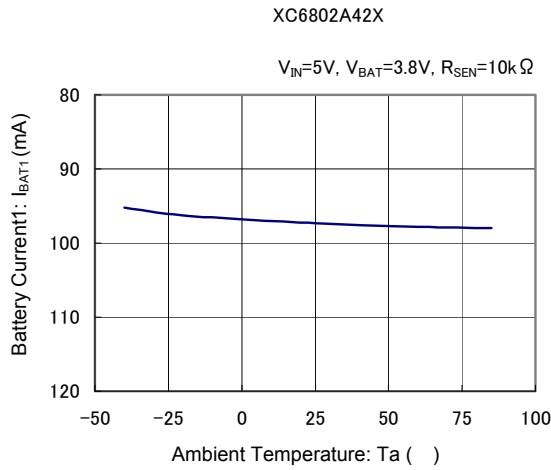


### (4) Charge Termination Voltage vs. Ambient Temperature

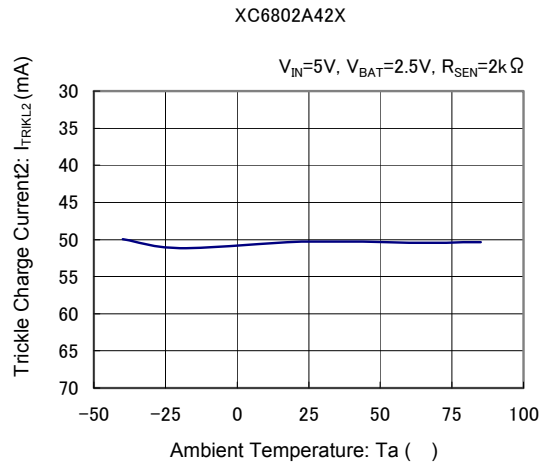
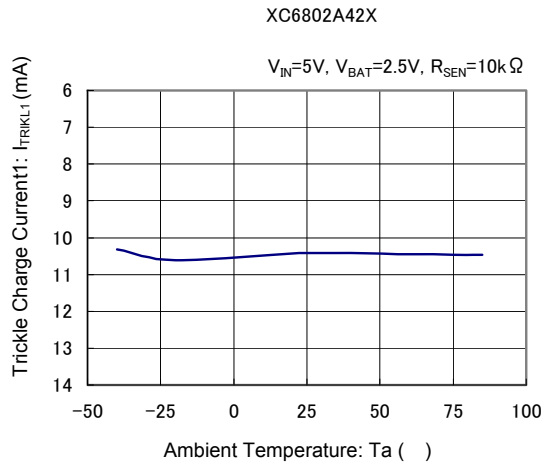


## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

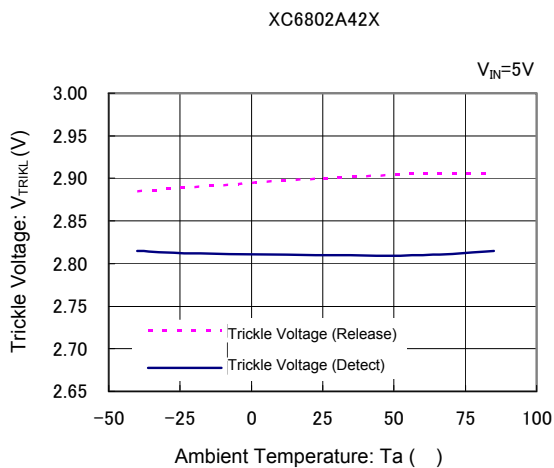
(5) Battery Current vs. Ambient Temperature



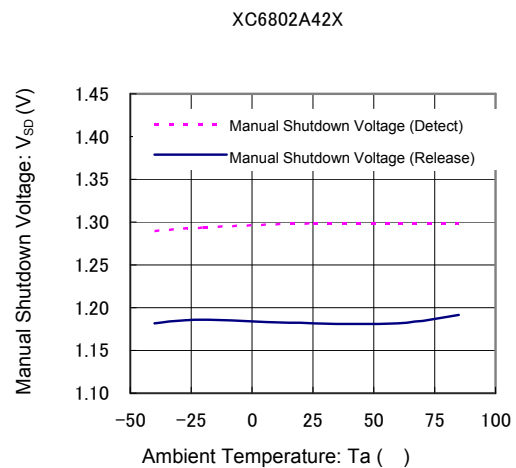
(6) Trickle Charge Current vs. Ambient Temperature



(7) Trickle Voltage vs. Ambient Temperature

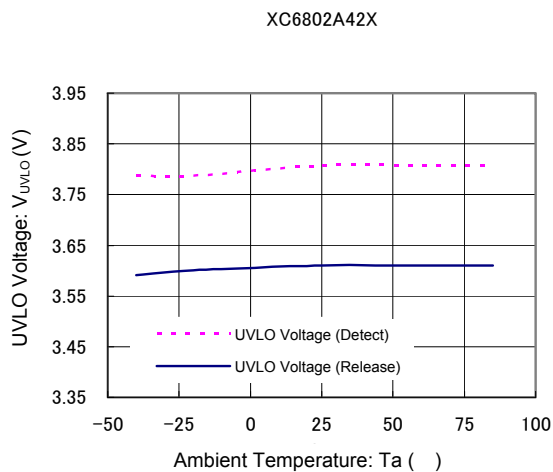


(8) Manual Shutdown Voltage vs. Ambient Temperature

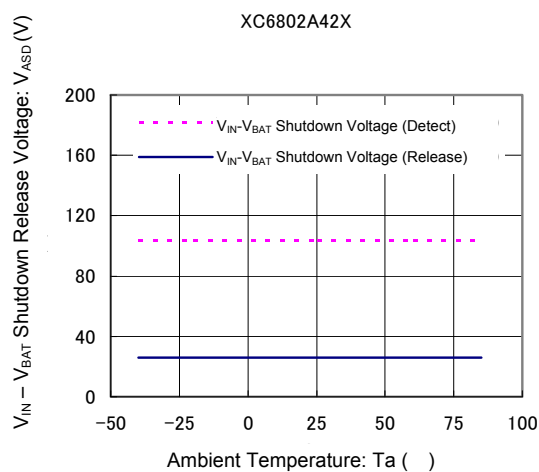


## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

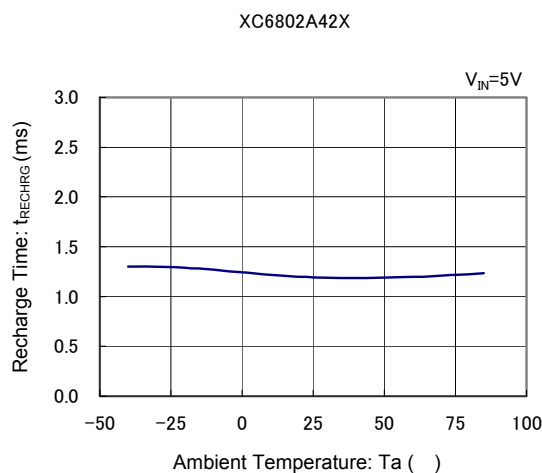
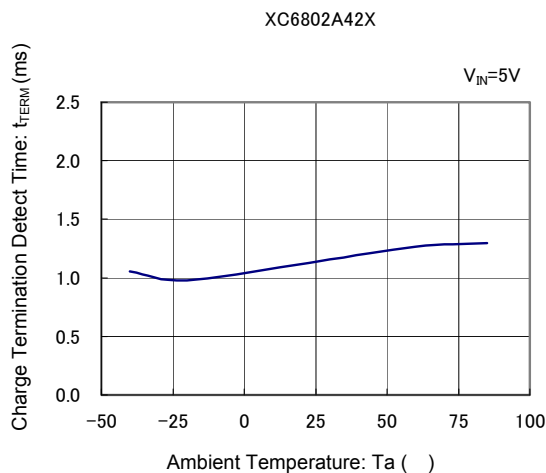
(9) UVLO Voltage vs. Ambient Temperature



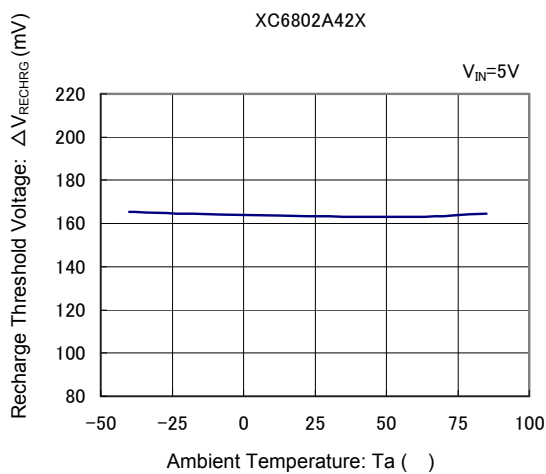
(10)  $V_{IN} - V_{BAT}$  Shutdown Voltage vs. Ambient Temperature



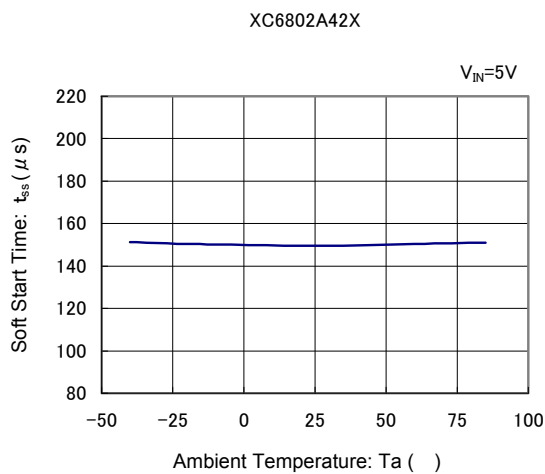
(11) Charge Termination Detect Time vs. Ambient Temperature (12) Recharge Time vs. Ambient Temperature



(13) Recharge Threshold Voltage vs. Ambient Temperature

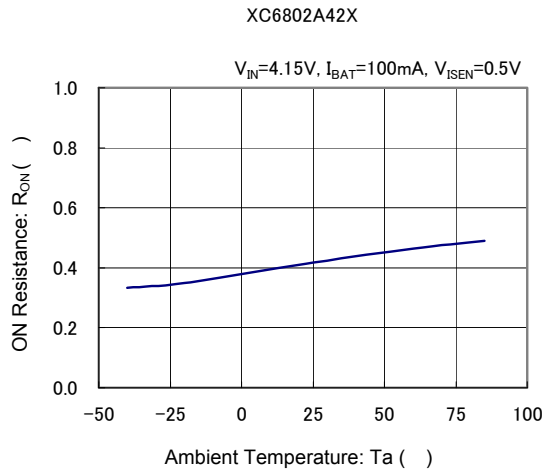


(14) Soft Start Time vs. Ambient Temperature

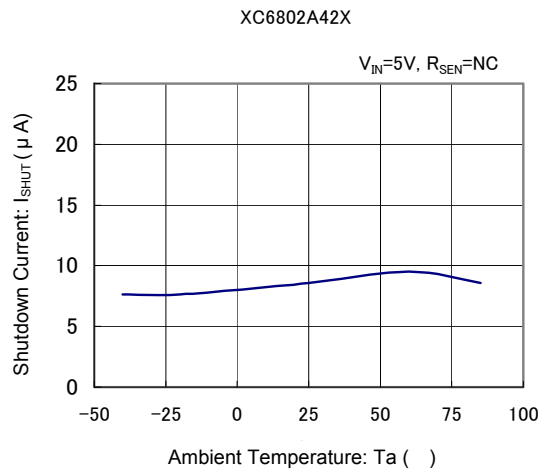


## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

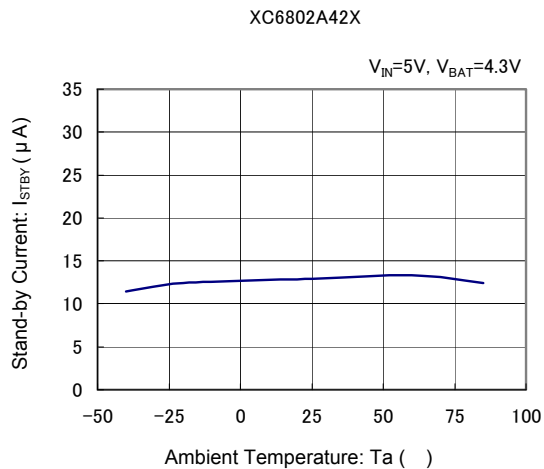
(15) ON Resistance vs. Ambient Temperature



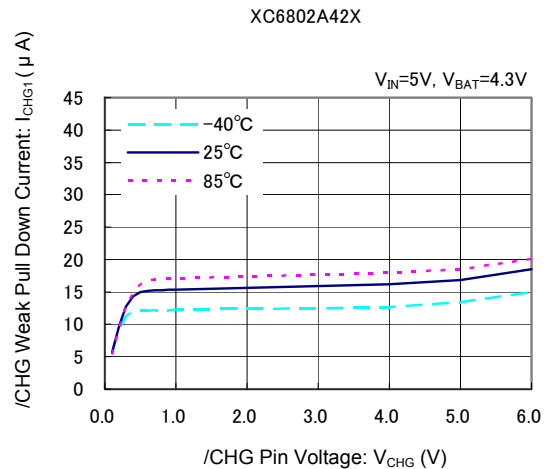
(16) Shutdown Current vs. Ambient Temperature



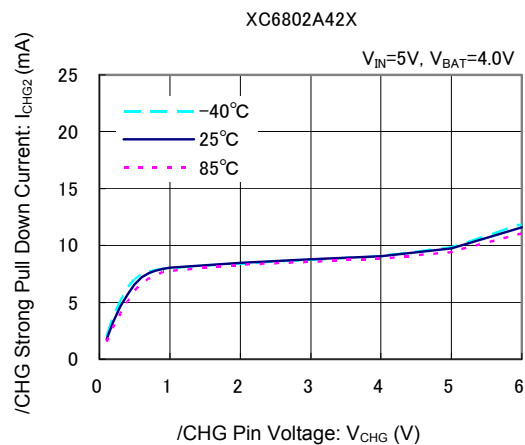
(17) Stand-by Current vs. Ambient Temperature



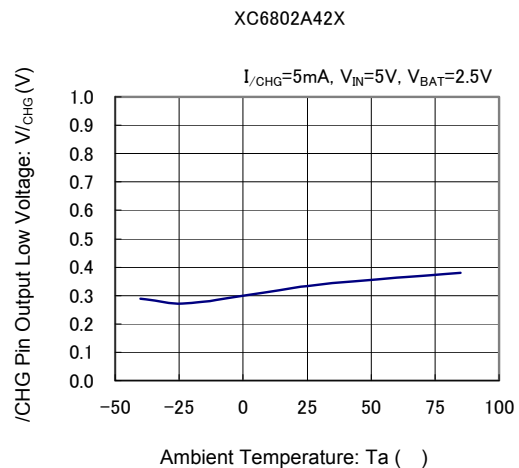
(18) /CHG Weak Pull Down Current vs. /CHG Pin Voltage



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

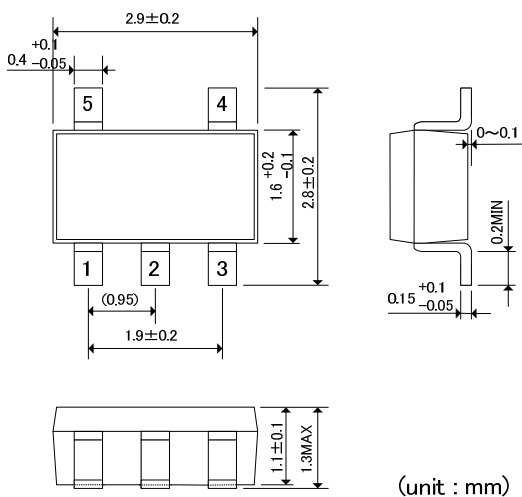


(20) /CHG Pin Output Low Voltage vs. Ambient Temperature

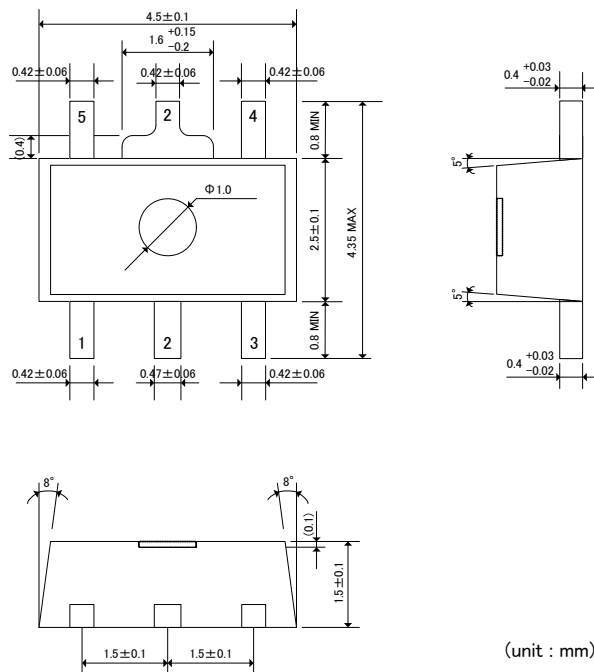


## PACKAGING INFORMATION

### SOT-25

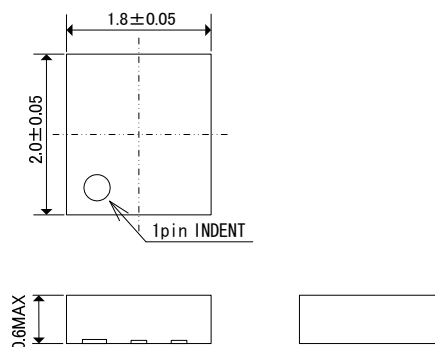


### SOT-89-5

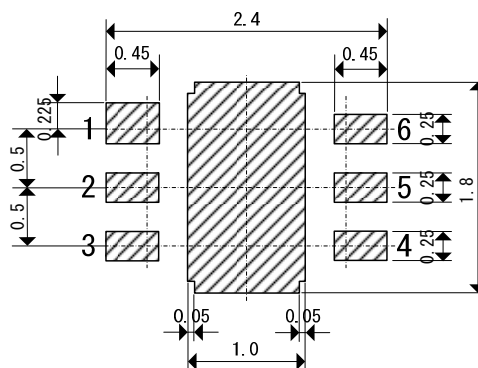


### USP-6C

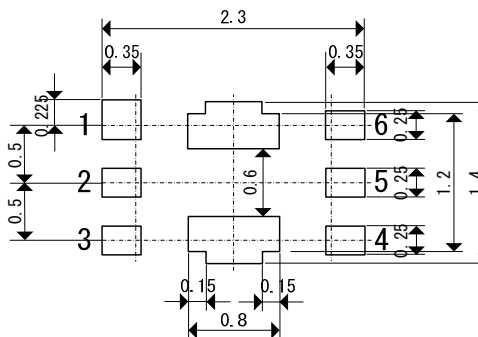
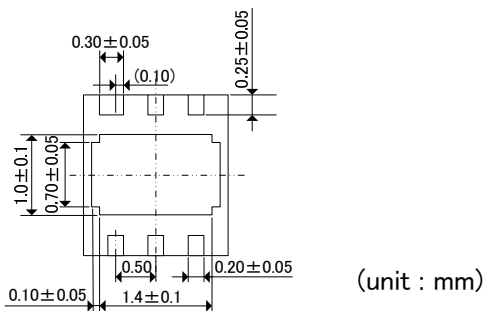
< Package Dimensions >



### USP-6C Reference Pattern Layout

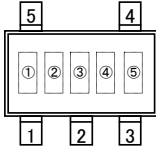


### USP-6C Reference Metal Mask Design



## MARKING RULE

### SOT25



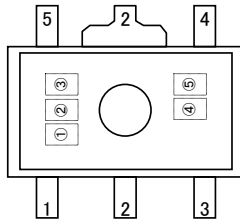
Represents product series

MARK	PRODUCT SERIES
N	XC6802*****

Standard product, Represent the 7<sup>th</sup> digits

MARK	PRODUCT SERIES
A	XC6802A*****

### SOT89-5



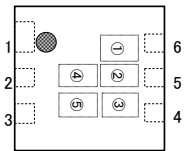
Custom product, the last 2 digits

MARK	SEQUENCE No.	PRODUCT SERIES
0	001	XC6802S001**

Standard product, Represents the 8<sup>th</sup> 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.

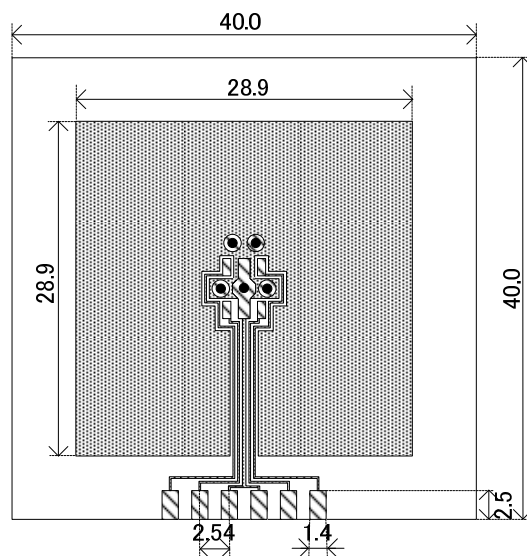
## PACKAGING INFORMATION (Continued)

### 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 mm<sup>2</sup> 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

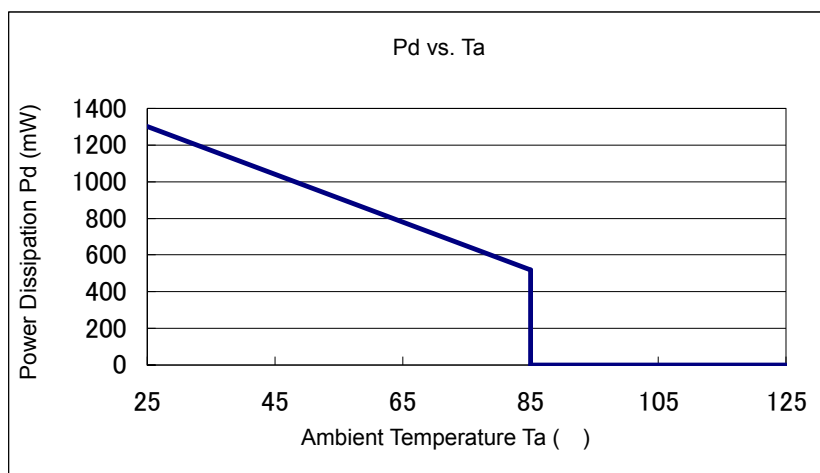


Evaluation Board (Unit: mm)

#### 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

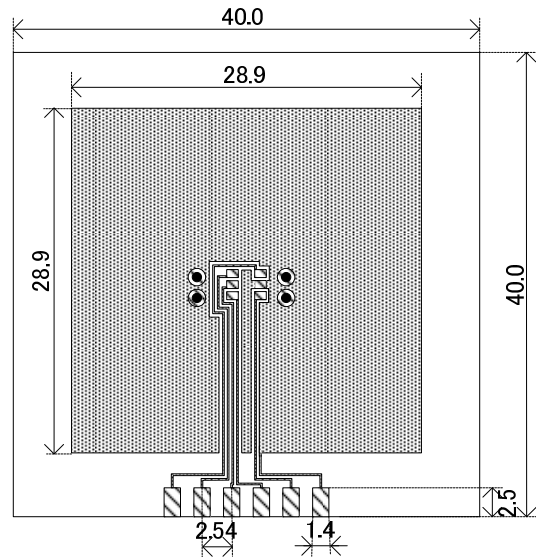
Power dissipation data for the SOT-25 is shown in this page.

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 mm<sup>2</sup> 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

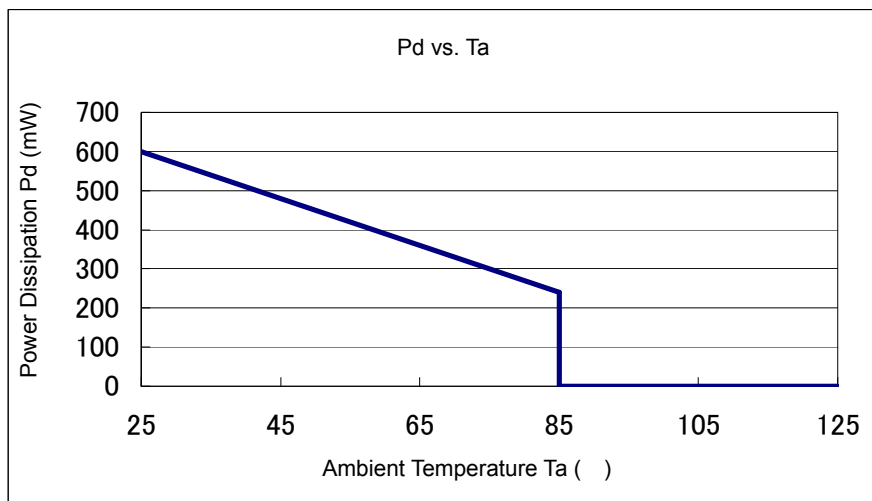


Evaluation Board (Unit: mm)

#### 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 ( $^\circ\text{C/W}$ )
25	600	166.67
85	240	





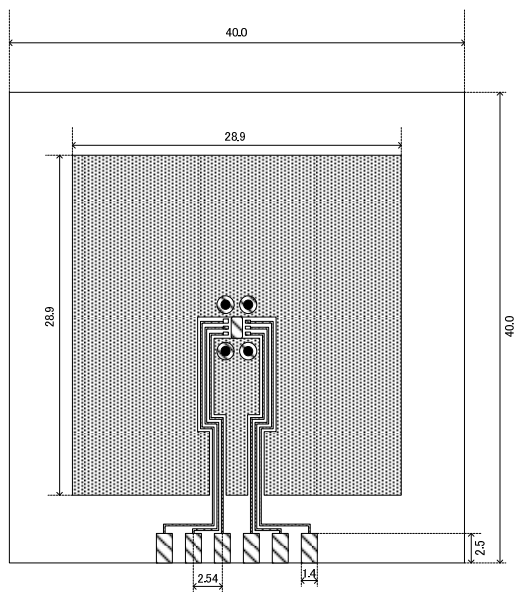
## PACKAGING INFORMATION (Continued)

### 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 mm<sup>2</sup> 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

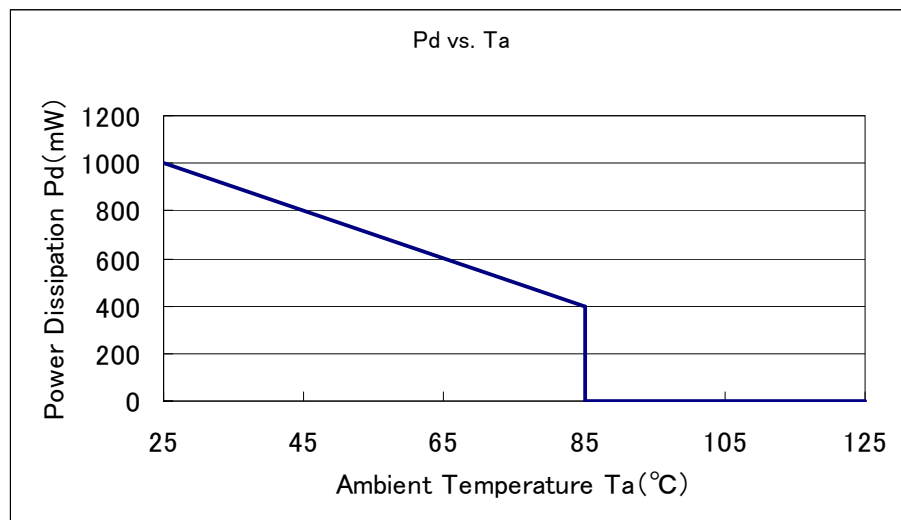


Evaluation Board (Unit: mm)

#### 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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