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 ± 0.7% and the trickle charge voltage and accuracy is 2.9V ± 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 ± 0.7%
Trickle Charge Voltage	: 2.9V ± 3%
Supply Current (Stand-by)	: 15μ 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)
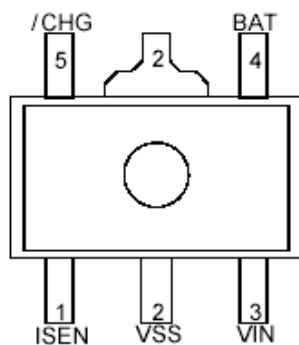
TYPICAL APPLICATION CIRCUIT
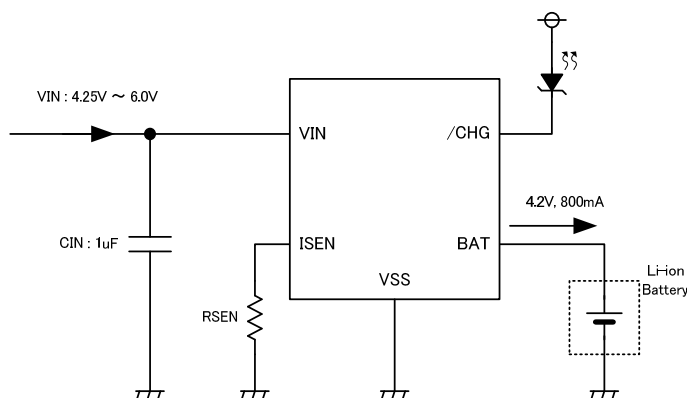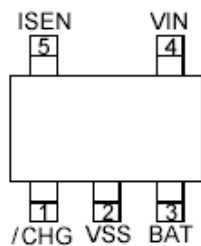

TYPICAL PERFORMANCE CHARACTERISTICS
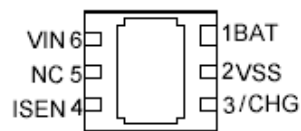
Battery Charge Cycle

Li-ion Battery Charge Cycle

VIN=5.0V, CIN=1μ F
RSEN=2kΩ, 830mAh Battery
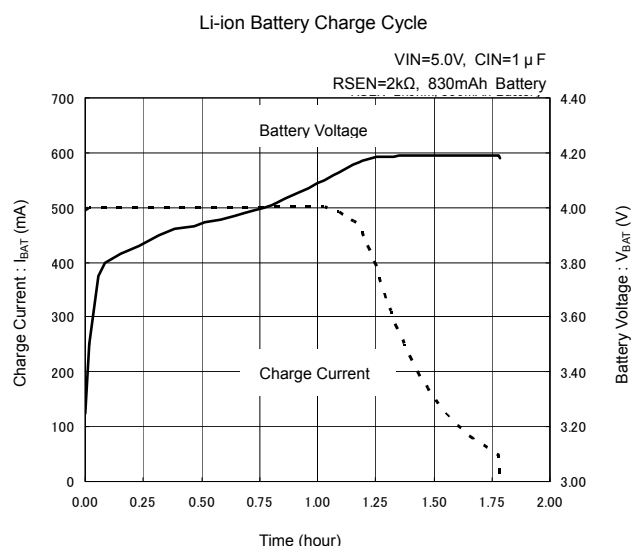
PIN CONFIGURATION

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	I_{SEN}	Charge Current Setup Pin
-	-	5	NC	No Connection

PRODUCT CLASSIFICATION

Ordering Information

XC6802A42X   −③[*1]

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
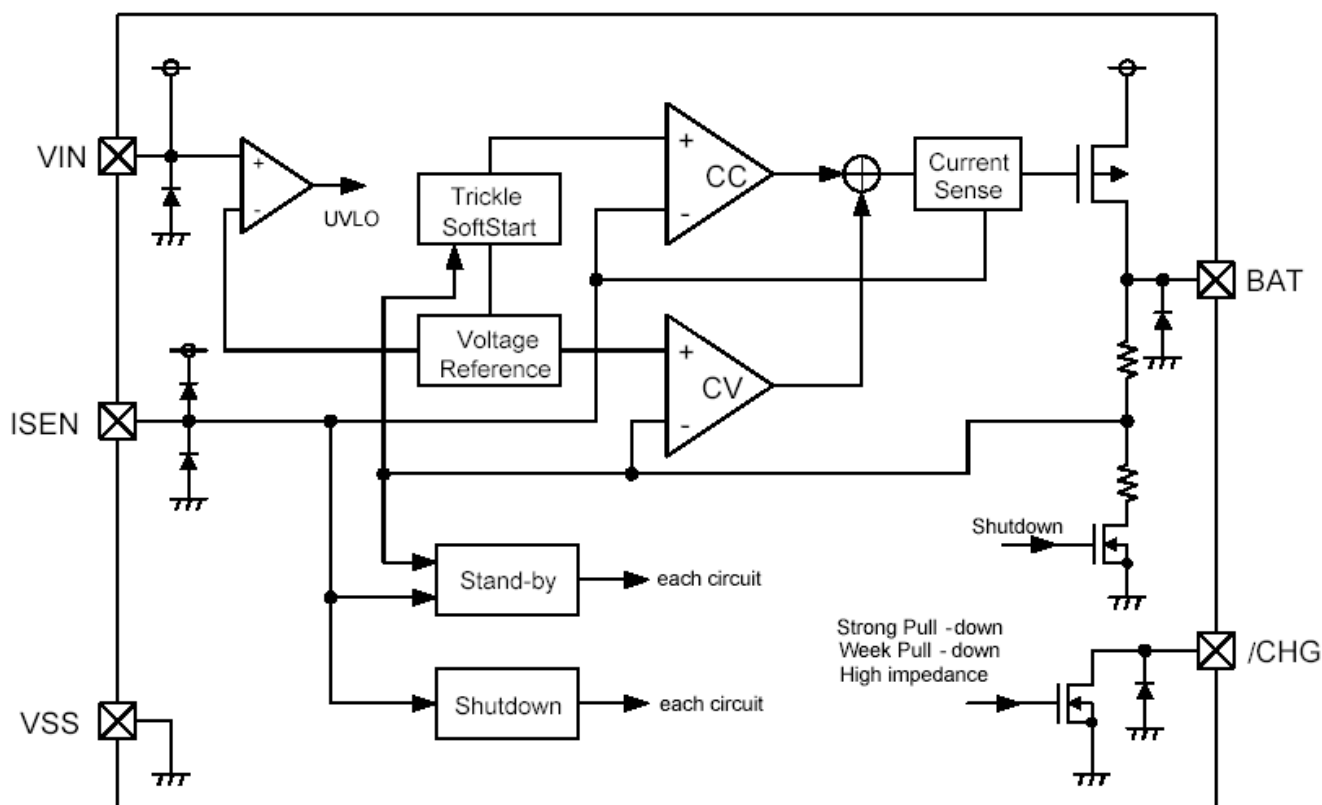
ABSOLUTE MAXIMUM RATINGS

Ta=25

PARAMETER		SYMBOL	RATINGS	UNIT
V_{IN} Pin Voltage		V_{IN}	$V_{SS} - 0.3 \sim + 6.5$	V
ISEN Pin Voltage		V_{SEN}	$V_{SS} - 0.3 \sim V_{IN} + 0.3$	V
BAT Pin Voltage		V_{BAT}	$V_{SS} - 0.3 \sim + 6.5$	V
/CHG Pin Voltage		$V_{/CHG}$	$V_{SS} - 0.3 \sim + 6.5$	V
BAT Pin Current		I_{BAT}	900	mA
Power Dissipation	SOT-89-5	Pd	500	mW
			1300（PCB mounted）*	
	SOT-25		250	
			600（PCB mounted）*	
	USP-6C		120	
			1000（PCB mounted）*	
Operating Temperature Range		Topr	$- 40 \sim + 85$	
Storage Temperature Range		Tstg	$- 55 \sim + 125$	

 * 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 (*1)	V_{FLOAT2}	0 T_A 50 , I_{BAT}=40mA	×0.99	4.2	×1.01	V	-
Maximum Battery Current (*2)	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}	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	
V_{IN}-V_{BAT} Shut-down Release Voltage	V_{ASD}	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	$I_{SEN\_pull\_up}$	-	-	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
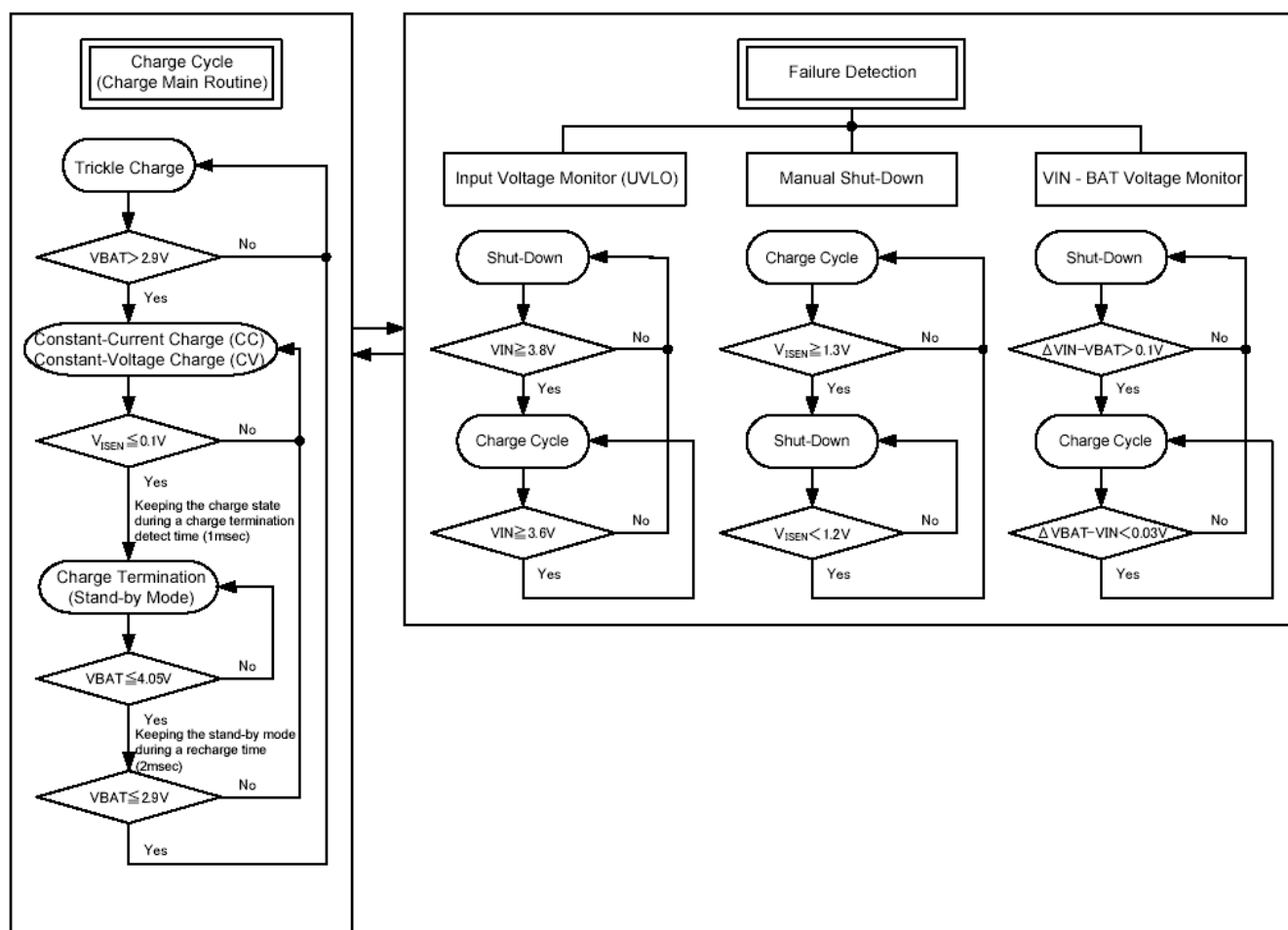
<Charge Cycle>
If the BAT pin voltage is less than 2.9V, the charger enters trickle charge mode. In this mode, a safe battery charge is possible because approximately only 1/10 of the charge current which was set by the I_{SEN} pin, is supplied to the battery. When the BAT pin voltage rises above 2.9V, 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}) x 1000 (V_{ISEN} = 1.0V: 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 10µ A.

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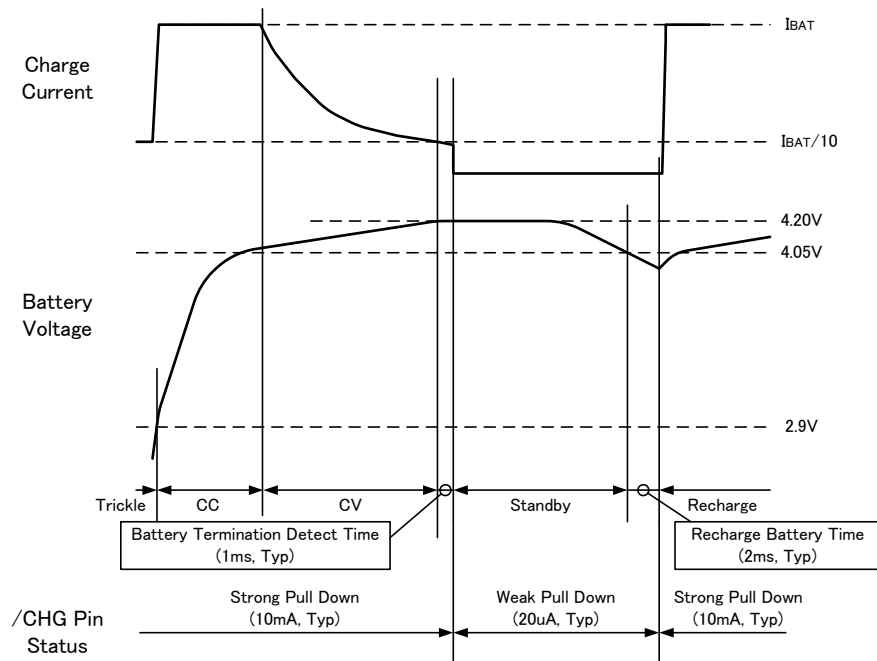
The /CHG pin constantly monitors the charge states classified as below:

Strong pull-down: $I_{/CHG}$=10mA (TYP.) in a charge cycle,

Weak pull-down: $I_{/CHG}$=20μ 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 10μ A.

<Soft-Start Function>

To protect against inrush current from the input to the battery, soft-start time is set in the circuit optimally (100μ 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 2μ A and a shut-down current of the IC is reduced to less than 10μ 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
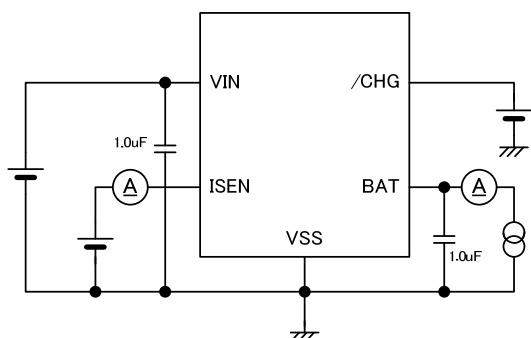
2. Battery Termination Detect Time, Recharge Battery Time
C/10 Charge Termination Current Threshold, Battery Termination Voltage
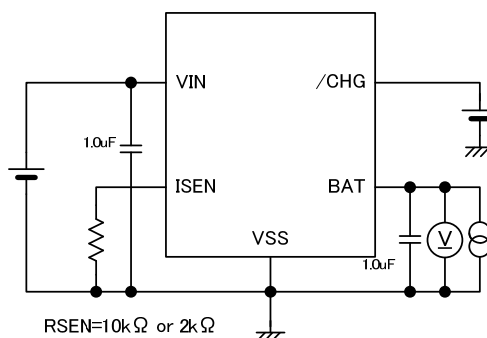
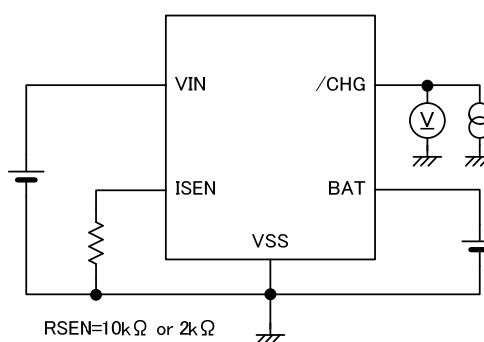3. Trickle Charge Current, Battery Current, I_{SEN} Pin Voltage

Trickle Charge Voltage, UVLO, Recharge Battery Threshold Voltage

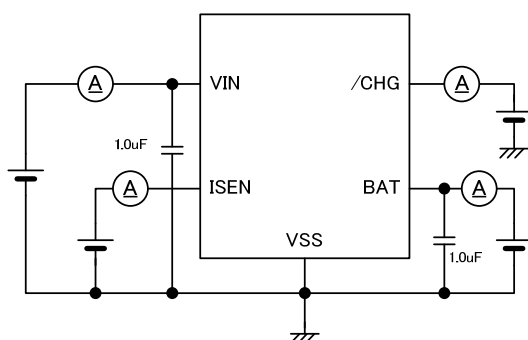V_{IN}-V_{BAT} Shut-down Voltage, /CHG Pin Current
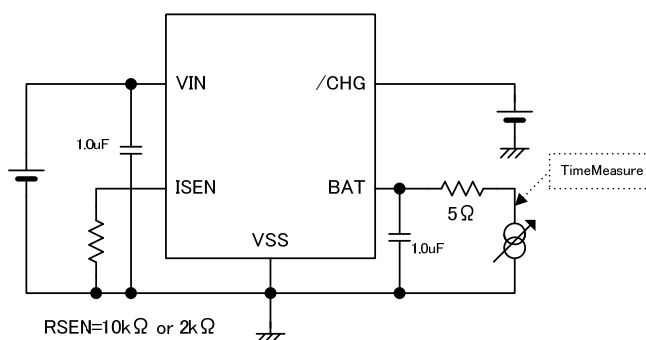
Supply Current, Stand-by Current, Shut-down Current
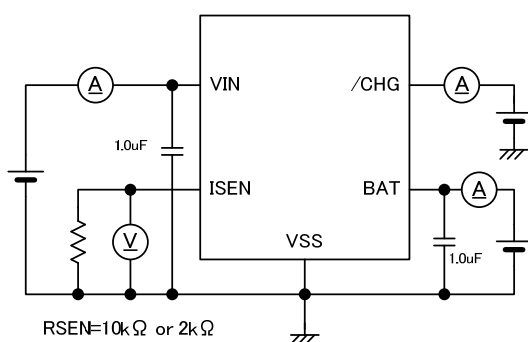
4. /CHG Pin, Output Low Voltage

5. Battery Current 4

6. Soft-Start

TYPICAL PERFORMANCE CHARACTERISTICS

(1) Charge Cycle

XC6802A42X

V_{IN}=5V, C_{IN}=1.0 μF
R_{SEN}=1.25kΩ, 420mAh Battery

XC6802A42X

V_{IN}=5V, C_{IN}=1.0 μF
R_{SEN}=1.25kΩ, 850mAh Battery
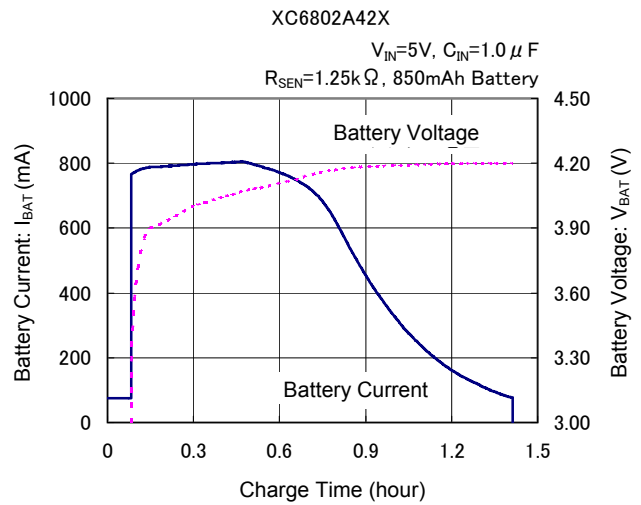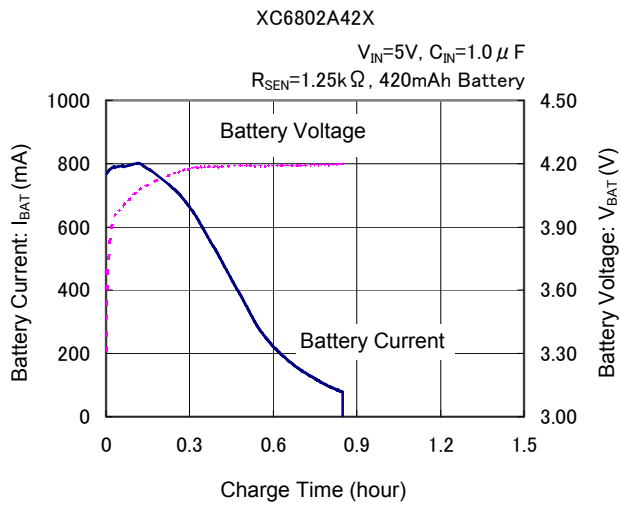
(2) Battery Current vs. Battery Voltage

XC6802A42X

V_{IN}=5V, R_{SEN}=10kΩ

XC6802A42X

V_{IN}=5V, R_{SEN}=2kΩ

XC6802A42X

R_{SEN}=10kΩ

XC6802A42X

R_{SEN}=2kΩ
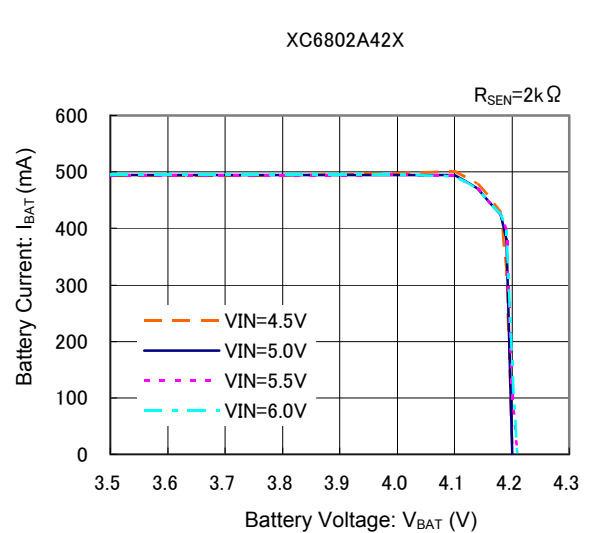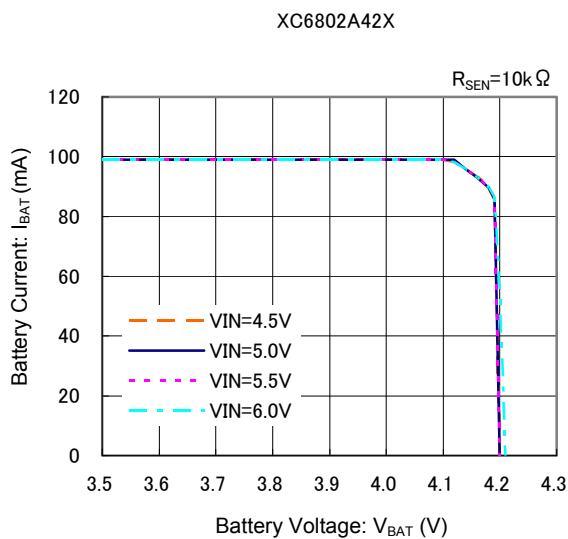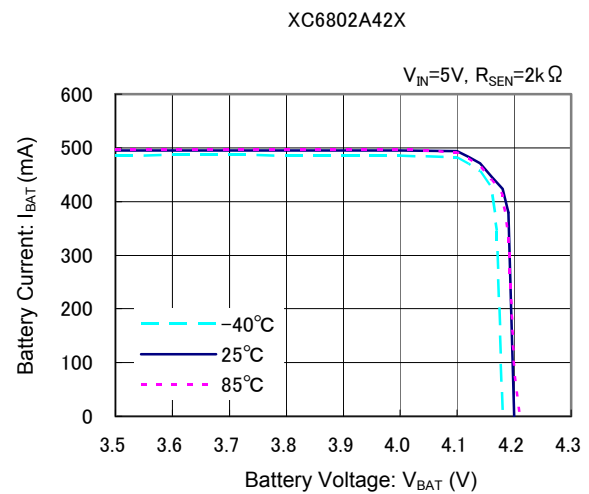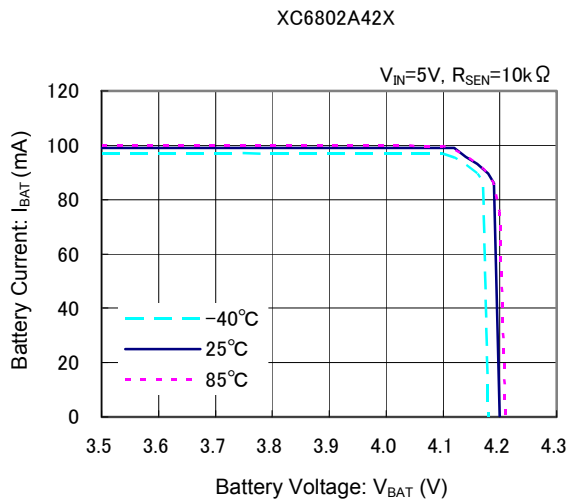
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(3) Battery Voltage vs. Battery Current

XC6802A42X

V_{IN}=5V, R_{SEN}=10kΩ

XC6802A42X

V_{IN}=5V, R_{SEN}=2kΩ

XC6802A42X

R_{SEN}=10kΩ

XC6802A42X

R_{SEN}=2kΩ
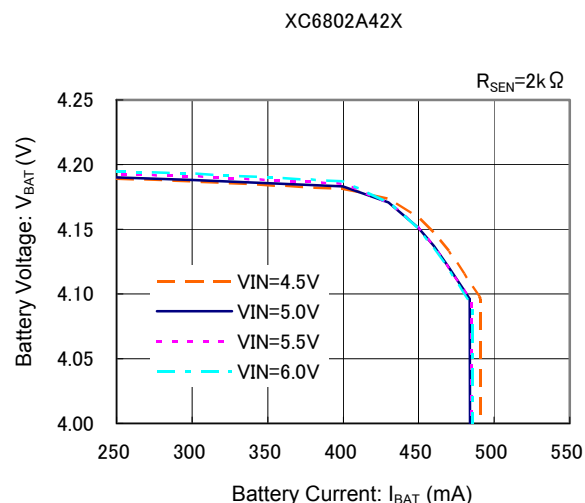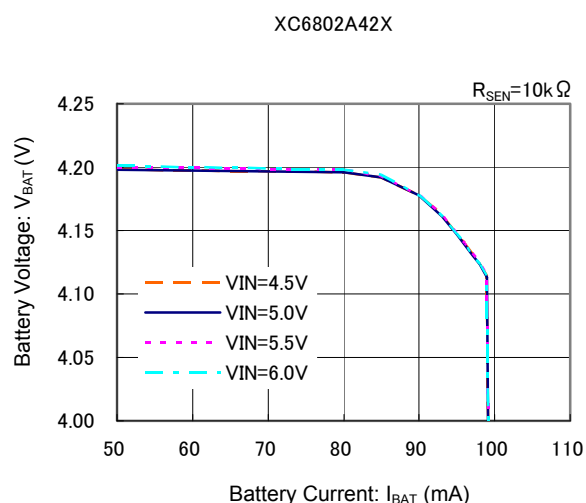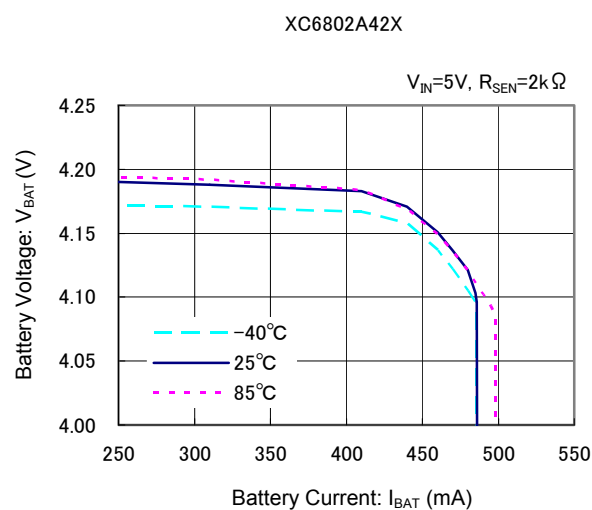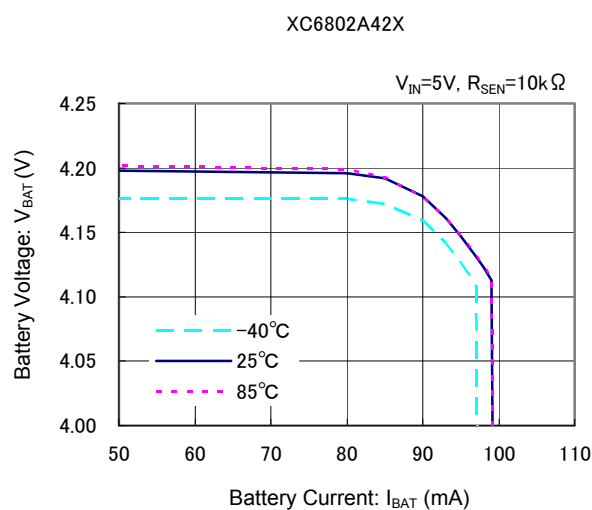
(4) Charge Termination Voltage vs. Ambient Temperature

XC6802A42X

V_{IN}=5V, I_{BAT}=40mA, R_{SEN}=10kΩ

XC6802A42X

V_{IN}=5V, I_{BAT}=200mA, R_{SEN}=2kΩ

TOIREX
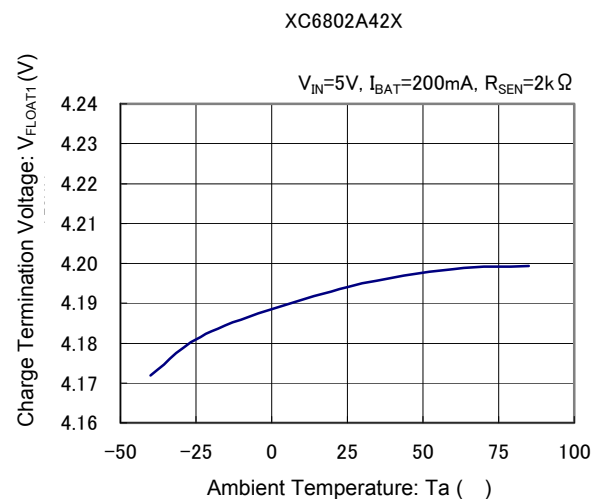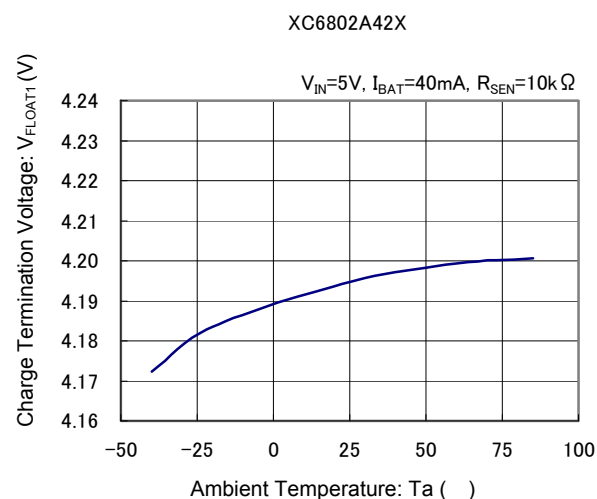
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(5) Battery Current vs. Ambient Temperature

XC6802A42X

$V_{IN}=5V$, $V_{BAT}=3.8V$, $R_{SEN}=10k\Omega$

XC6802A42X

$V_{IN}=5V$, $V_{BAT}=3.8V$, $R_{SEN}=2k\Omega$
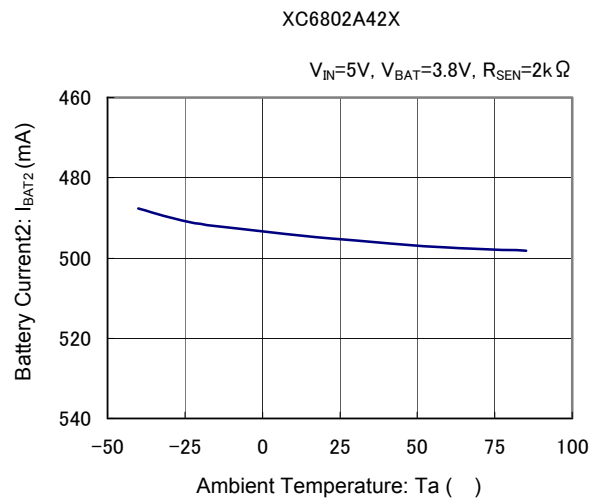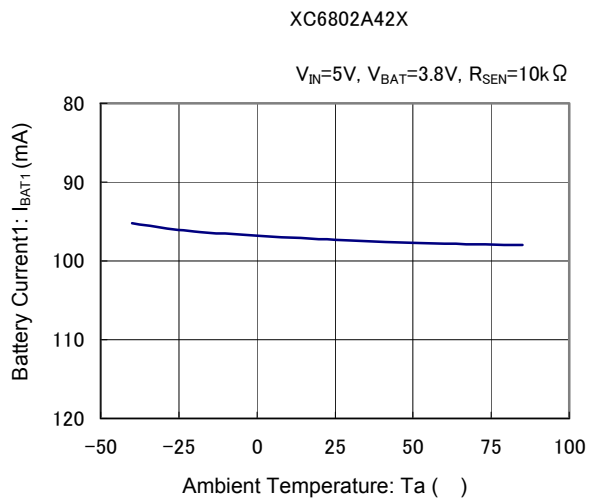
(6) Trickle Charge Current vs. Ambient Temperature

XC6802A42X

$V_{IN}=5V$, $V_{BAT}=2.5V$, $R_{SEN}=10k\Omega$

XC6802A42X

$V_{IN}=5V$, $V_{BAT}=2.5V$, $R_{SEN}=2k\Omega$
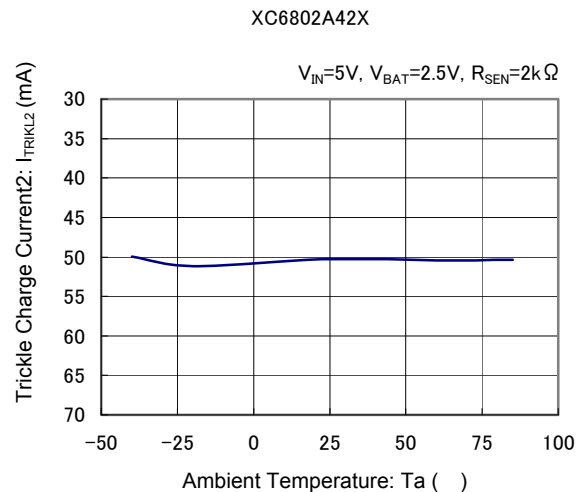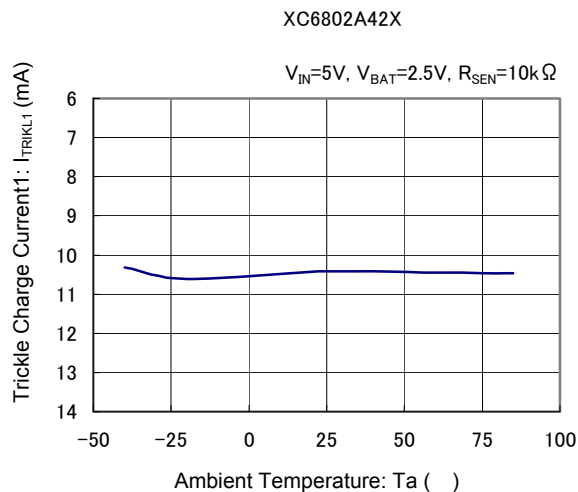
(7) Trickle Voltage vs. Ambient Temperature

XC6802A42X

$V_{IN}=5V$
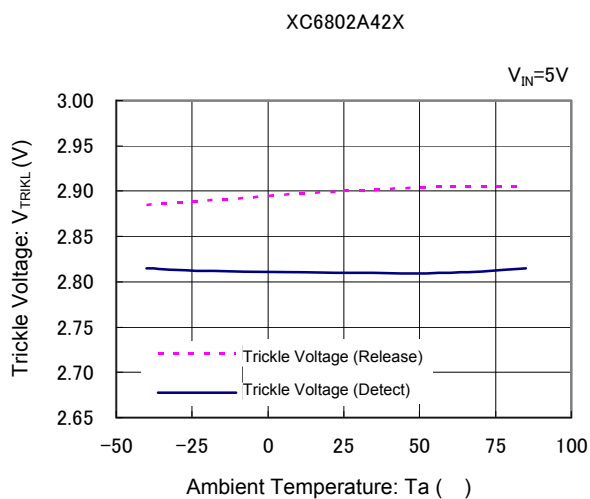
(8) Manual Shutdown Voltage vs. Ambient Temperature

XC6802A42X
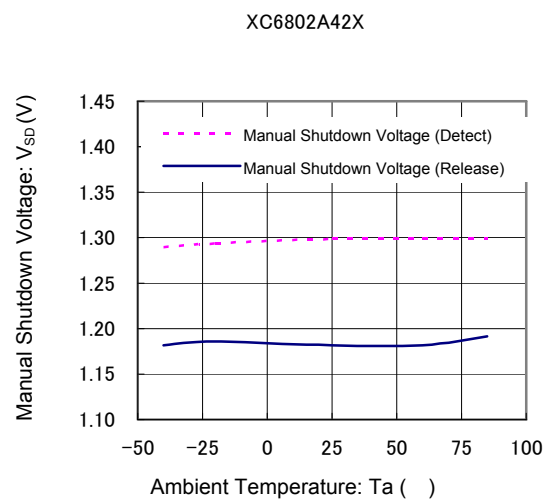
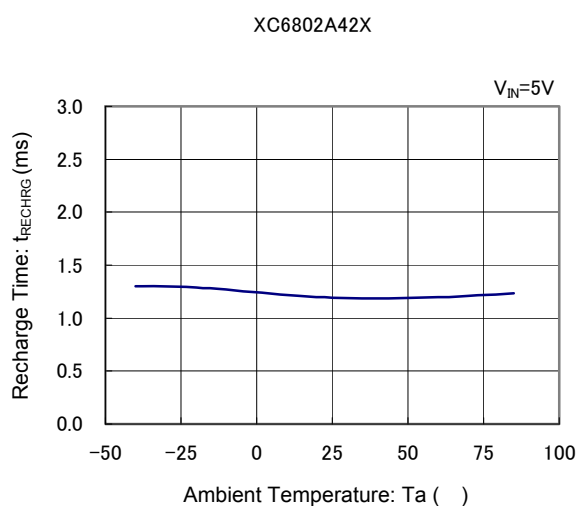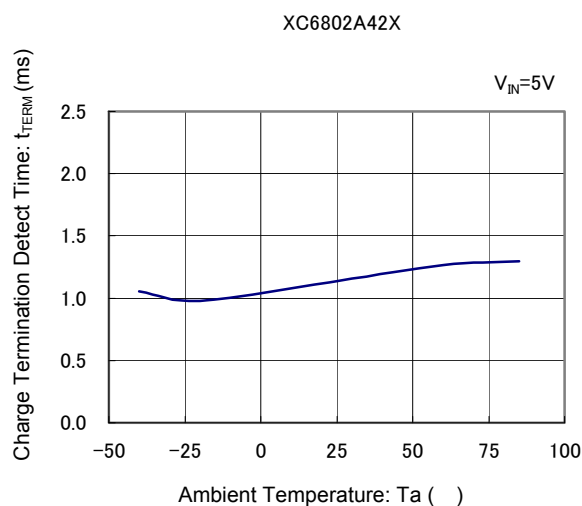# TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) UVLO Voltage vs. Ambient Temperature
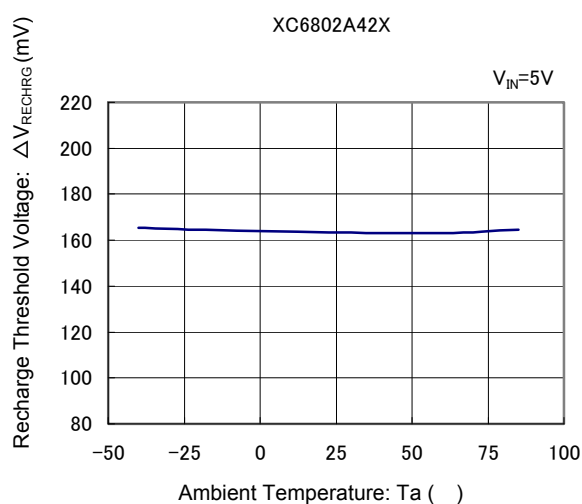
XC6802A42X
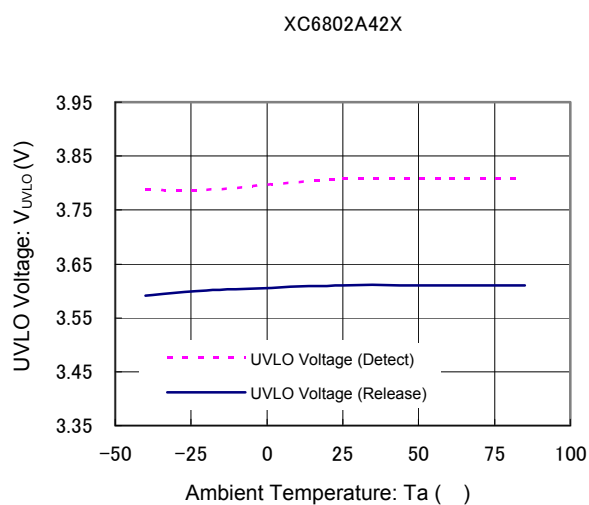
(10) $V_{IN} - V_{BAT}$ Shutdown Voltage vs. Ambient Temperature
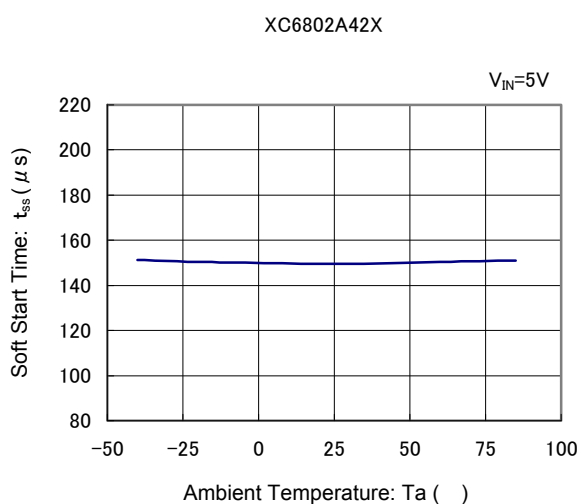
XC6802A42X
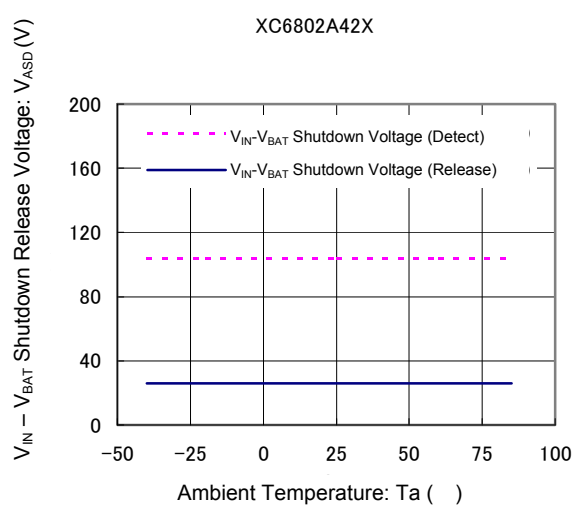
(11) Charge Termination Detect Time vs. Ambient Temperature

XC6802A42X

(12) Recharge Time vs. Ambient Temperature

XC6802A42X

(13) Recharge Threshold Voltage vs. Ambient Temperature
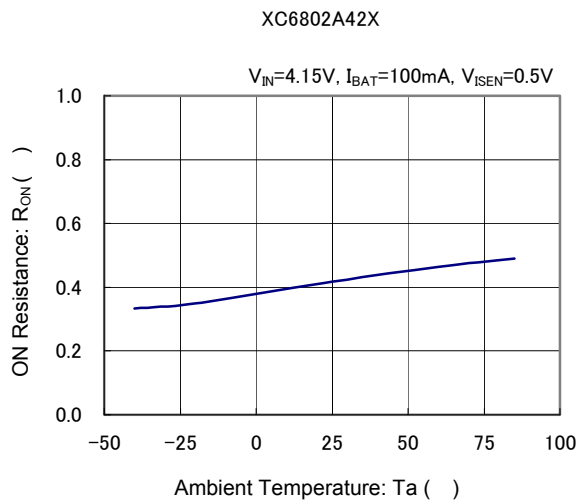
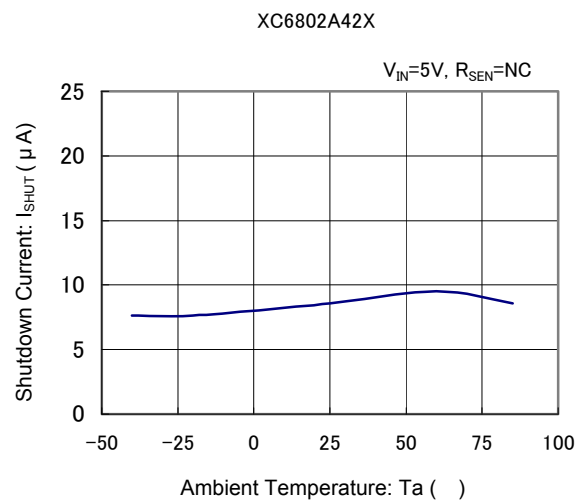XC6802A42X

(14) Soft Start Time vs. Ambient Temperature

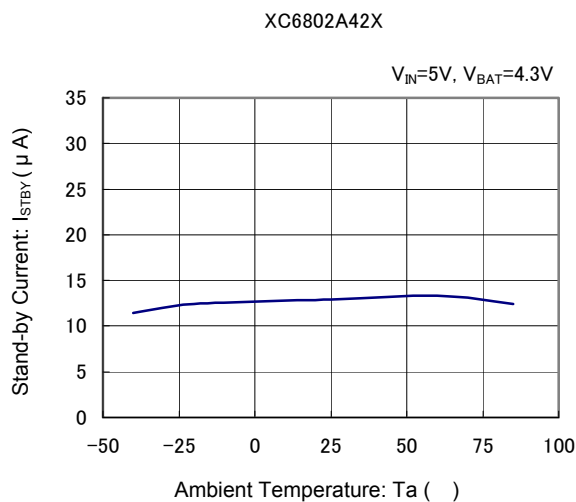XC6802A42X

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)
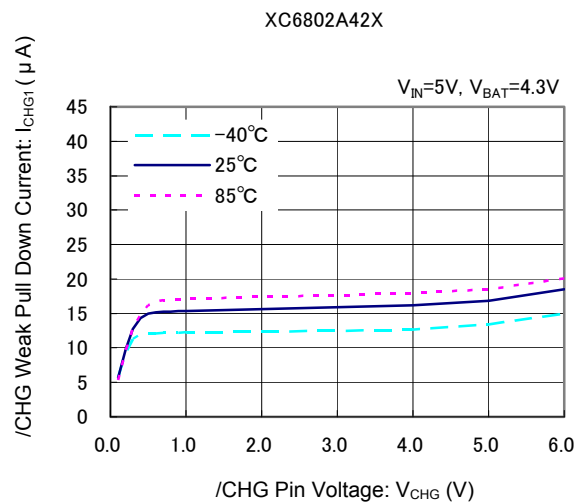
(15) ON Resistance vs. Ambient Temperature

XC6802A42X

V_{IN}=4.15V, I_{BAT}=100mA, V_{ISEN}=0.5V

(16) Shutdown Current vs. Ambient Temperature

XC6802A42X

V_{IN}=5V, R_{SEN}=NC

(17) Stand-by Current vs. Ambient Temperature

XC6802A42X

V_{IN}=5V, V_{BAT}=4.3V

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

XC6802A42X

V_{IN}=5V, V_{BAT}=4.3V

- −40℃
- 25℃
- 85℃

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

XC6802A42X

V_{IN}=5V, V_{BAT}=4.0V

- −40℃
- 25℃
- 85℃
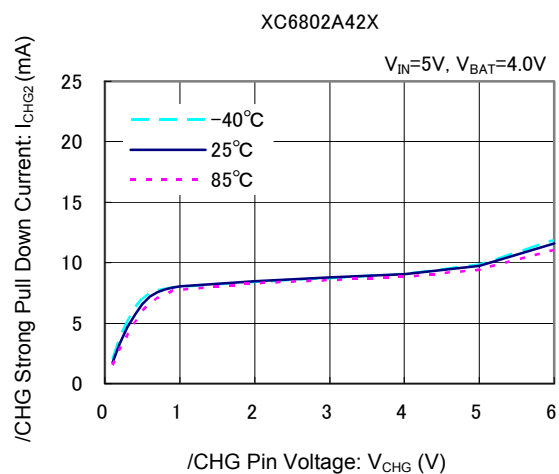
(20) /CHG Pin Output Low Voltage vs. Ambient Temperature

XC6802A42X

$I_{/CHG}$=5mA, V_{IN}=5V, V_{BAT}=2.5V
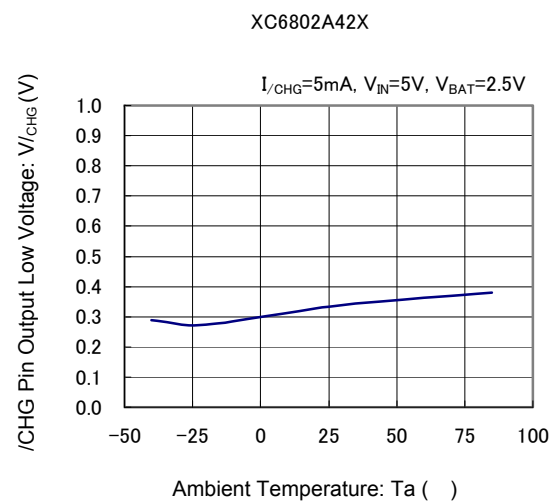
PACKAGING INFORMATION

SOT-25

SOT-89-5

(unit : mm)

(unit : mm)
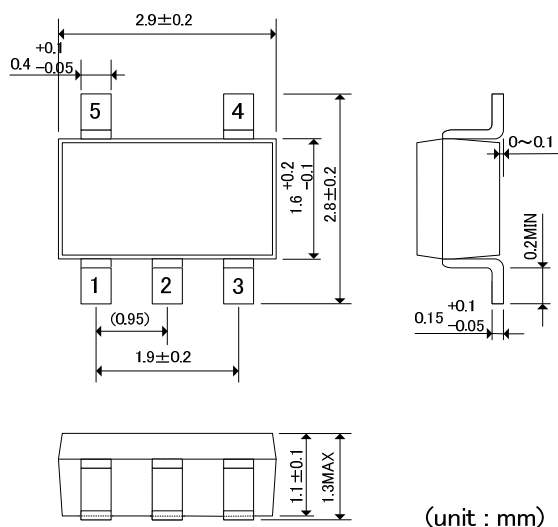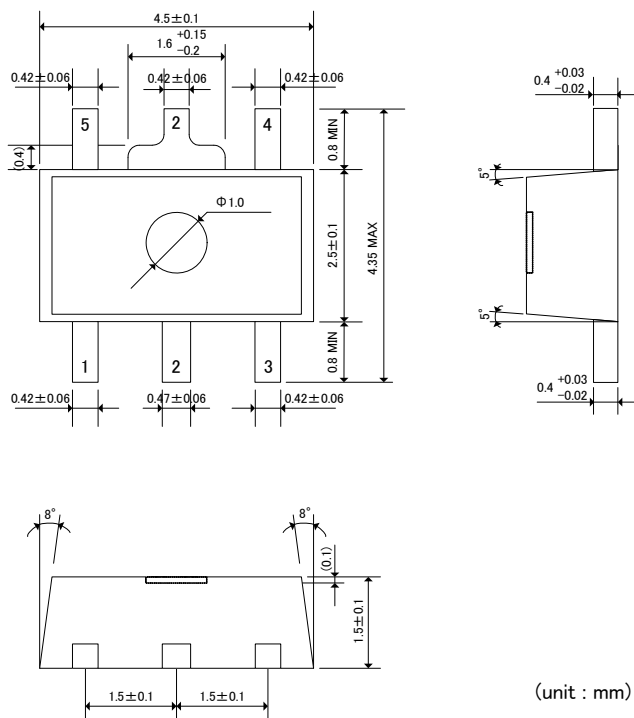
USP-6C
Package Dimensions
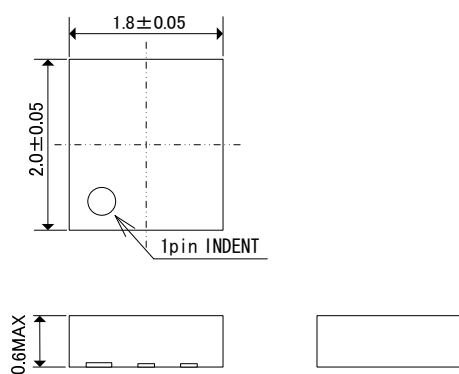
USP-6C   Reference Pattern Layout

1pin INDENT

(unit : mm)
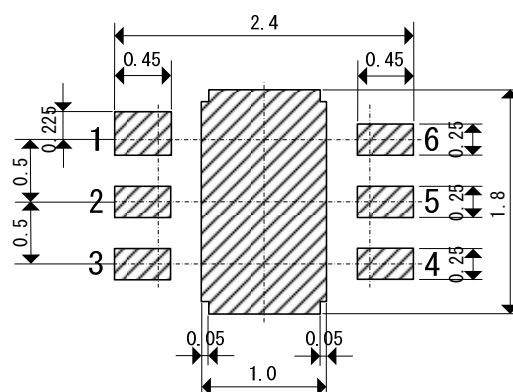
USP-6C   Reference Metal Mask Design
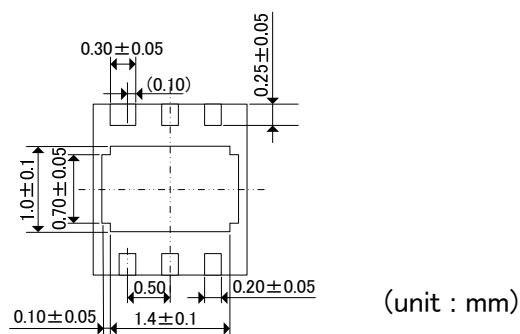
MARKING RULE

SOT25

SOT89−5

USP6C
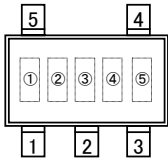
Represents product series

MARK	PRODUCT SERIES
N	XC6802******

Standard product, Represent the 7th digits

MARK	PRODUCT SERIES
A	XC6802A*****
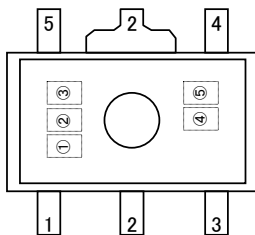
Custom product, the last 2 digits

MARK	SEQUENCE No.	PRODUCT SERIES
0	001	XC6802S001**

Standard product, Represents the 8th digits

MARK	PRODUCT SERIES
4	XC6802*4****

Custom product, the last 1 digits

MARK	SEQUENCE No.	PRODUCT SERIES
1	001	XC6802S001**
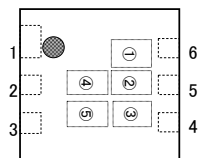
Represents production lot number
01 to 09, 0A to 0Z, 11 to 9Z, A1 to A9, AA to Z9, ZA to ZZ in order.
(G, I, J, O, Q, W excepted)
*No character inversion used.

PACKAGING INFORMATION (Continued)
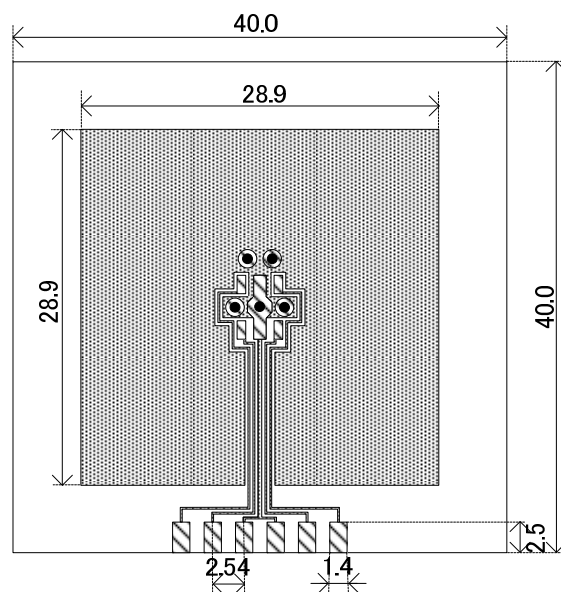
SOT-89-5 Power Dissipation

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^2 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 (Tj max = 125)

Ambient Temperature（℃）	Power Dissipation Pd（mW）	Thermal Resistance (℃/W)
25	1300	76.92
85	520	

Pd vs. Ta
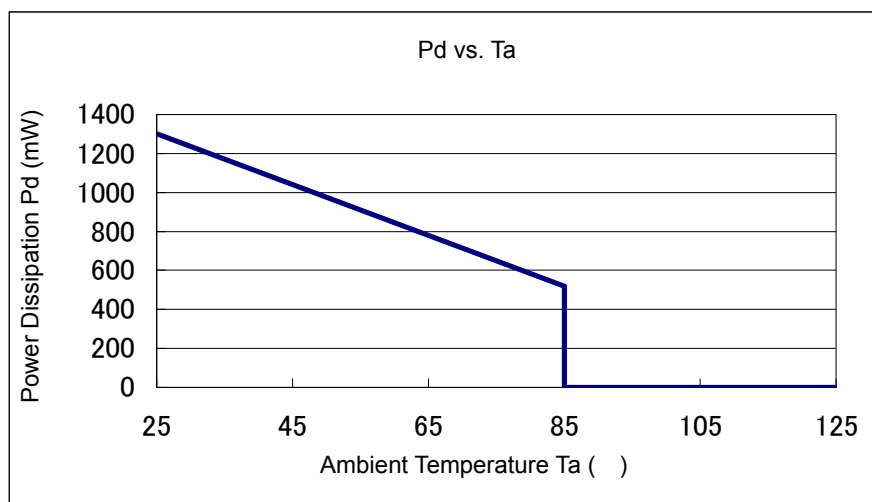
PACKAGING INFORMATION (Continued)

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^2 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.)
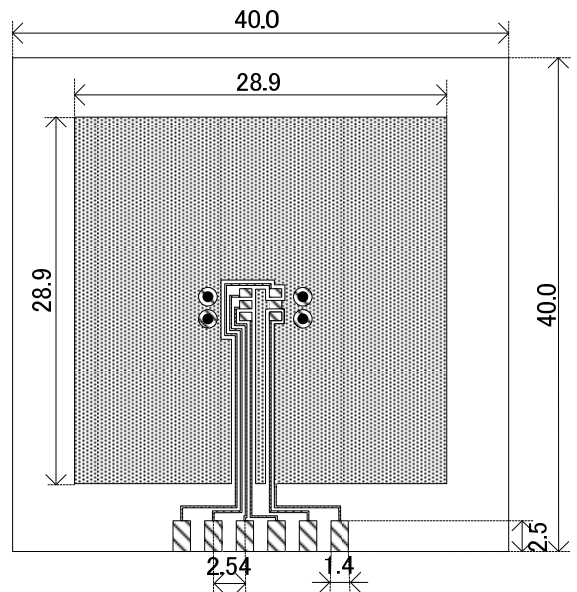   Material: Glass Epoxy (FR-4)
    Thickness: 1.6 mm
    Through-hole: 4 x 0.8 Diameter
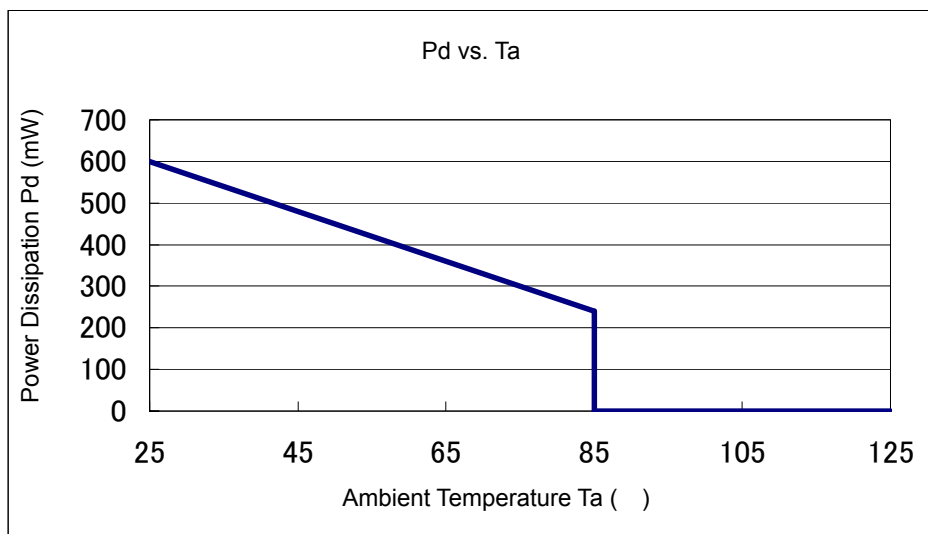
Evaluation Board (Unit: mm)

2. Power Dissipation vs. Operating temperature

Board Mount (Tj max = 125)

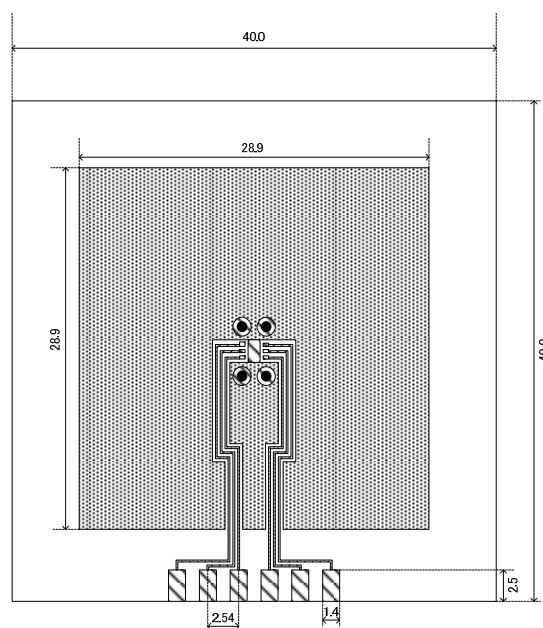| Ambient Temperature（℃）	Power Dissipation Pd（mW）	Thermal Resistance (℃/W)
25	600	166.67
85	240	

Pd vs. Ta

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^2 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

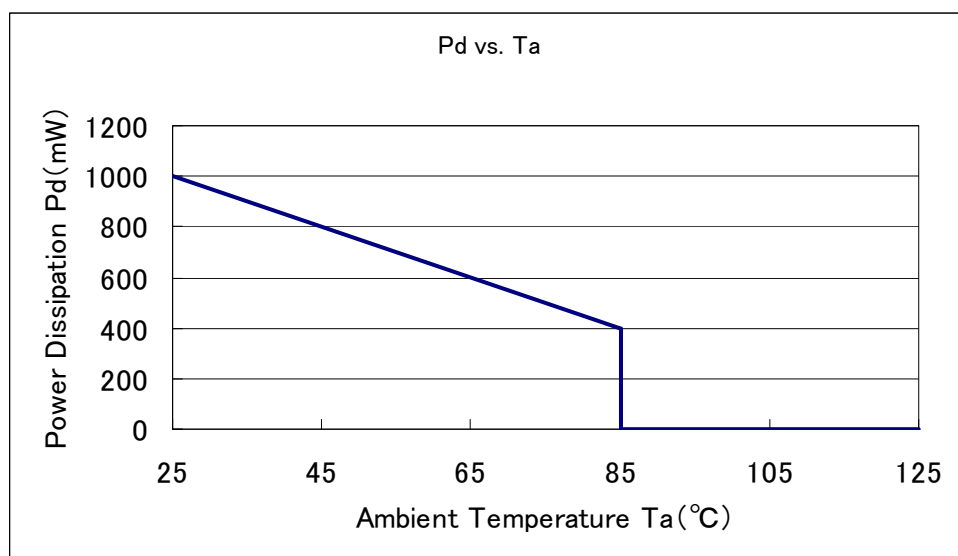Evaluation Board (Unit: mm)

2. Power Dissipation vs. Operating temperature

Board Mount (Tj max = 125)

Ambient Temperature(℃)	Power Dissipation Pd(mW)	Thermal Resistance (℃/W)
25	1000	100
85	400	

Pd vs. Ta

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