500mA 1 Cell Li-ion and Li-Po Battery Linear Charger IC with Constant-Current/Constant-Voltage

■GENERAL DESCRIPTION

The XC6801 series is a constant-current/constant-voltage linear charger IC for single cell Lithium-ion and Lithium polymer batteries. The XC6801 includes a reference voltage source, battery voltage monitor, driver transistor, constant-current/constant-voltage charge circuit, overheat protection circuit and 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 Lithium-ion and Lithium polymer battery charge is possible because approximately only 1/10 of the full charge current is supplied to the battery. As it is possible to select a highly accurate charge current of either 100mA (MAX.) for L level input to the L_{IM} pin or 500mA (MAX.) for H level, the series is ideal for applications where the charge is from USB. The series' charge status output pin, /CHG pin, is capable of checking the IC's charging state via connection to an external LED.

■APPLICATIONS

- USB charge 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	: 100mA (MAX.) @ L_{IM} pin=L
(externally set)	500mA (MAX.) @ L_{IM} pin=H
Charge Termination Voltage	: 4.2V ±0.7%
Trickle Charge Voltage	: 2.9V ±3%
Supply Current (Stand-by)	: 12 μ A (TYP.)
Operating Ambient Temperature	: - 40℃~ + 85℃
Packages	: SOT-89-5, SOT-25, USP-6C

Constant-current/constant-voltage operation with thermal shutdown

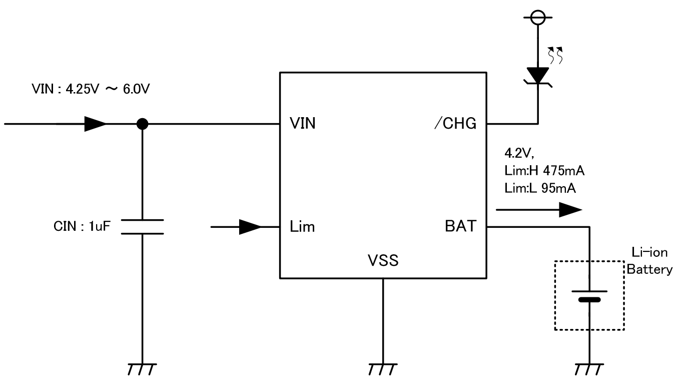
Automatic recharge

Charge status output pin

Soft-start function (Inrush limit current)

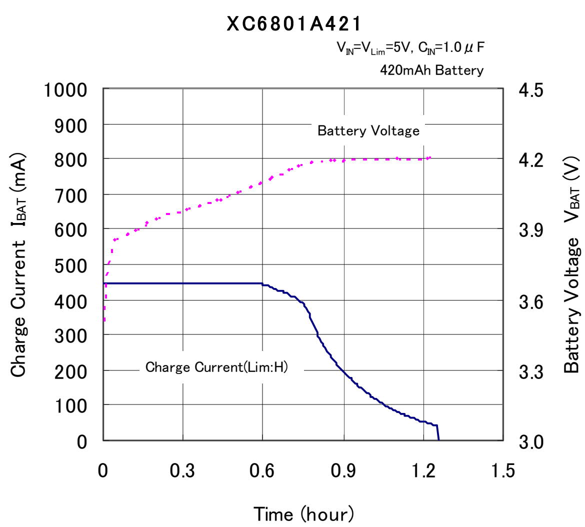
Environmentally Friendly : EU RoHS Compliant, Pb Free

■TYPICAL APPLICATION CIRCUIT

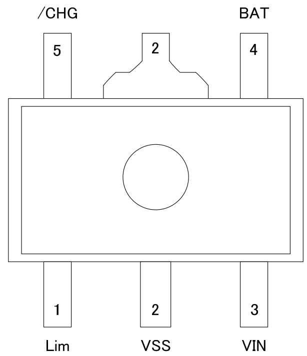


■TYPICAL PERFORMANCE CHARACTERISTICS

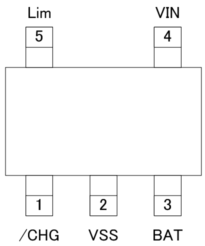
●Battery Charge Cycle



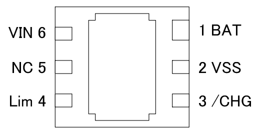
■PIN CONFIGURATION



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	FUNCTIONS
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 Pin
4	3	6	V_{IN}	Input Voltage Pin
5	1	4	L_{IM}	Changing Current Switch
-	-	5	NC	No Connection

■ FUNCTIONS

XC6801A421

PIN NAME	CONDITIONS		IC OPERATION
L_{IM}	L	$0V \leqq V_{LIM} \leqq 0.4V$	Charging Battery Current 1 (CC Mode)
	H	$1V \leqq V_{LIM} \leqq 6V$	Charging Battery Current 2 (CC Mode)

*If L_{IM} pin is left open, battery current is unstable. L_{IM} pin level should be fixed “High” or “Low”.

■ PRODUCT CLASSIFICATION

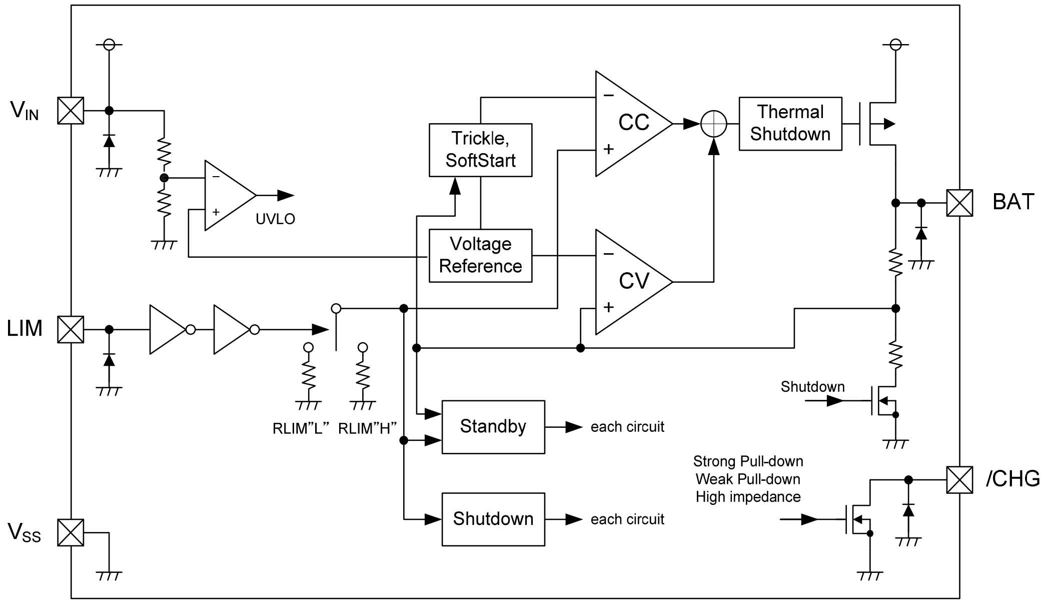
●Ordering Information

XC6801A42①②③-④

DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
①	Setting Charge Current	1	L_{IM}”L”=95mA, L_{IM}”H”=475mA
②③-④ [*1]	Packages (Order Unit)	PR-G	SOT-89-5 (1,000pcs/Reel)
		MR-G	SOT-25 (3,000pcs/Reel)
		ER-G	USP-6C (3,000pcs/Reel)

[*1] The “-G” suffix denotes Halogen and Antimony free as well as being fully EU RoHS compliant.

■BLOCK DIAGRAM



* Diodes inside the circuits are ESD protection diodes and parasitic diodes.

■ABSOLUTE MAXIMUM RATINGS

Ta=25℃

PARAMETER		SYMBOL	RATINGS	UNIT
VIN Pin Voltage		VIN	-0.3 ～ +6.5	V
LIM Pin Voltage		VLIM	-0.3 ～ +6.5	V
BAT Pin Voltage		VBAT	-0.3 ～ +6.5	V
/CHG Pin Voltage		V/CHG	-0.3 ～ +6.5	V
BAT Pin Current		IBAT	900(*1)	mA
Power Dissipation	SOT-25	Pd	250	mW
			600（PCB mounted）(*2)	
	SOT-89-5		500	
			1300（PCB mounted）(*2)	
	USP-6C		120	
			1000（PCB mounted）(*2)	
Operating Ambient Temperature		Topr	- 40 ~ + 85	℃
Storage Temperature		Tstg	- 55 ~ + 125	℃

All voltages are described based on the V_{SS} pin.
(*1) Please use within the range of $I_{BAT} \leqq Pd/(V_{IN}-V_{BAT})$.
(*2) The power dissipation figure shown is PCB mounted.
Please see the power dissipation page for the mounting condition.

■ELECTRICAL CHARACTERISTICS

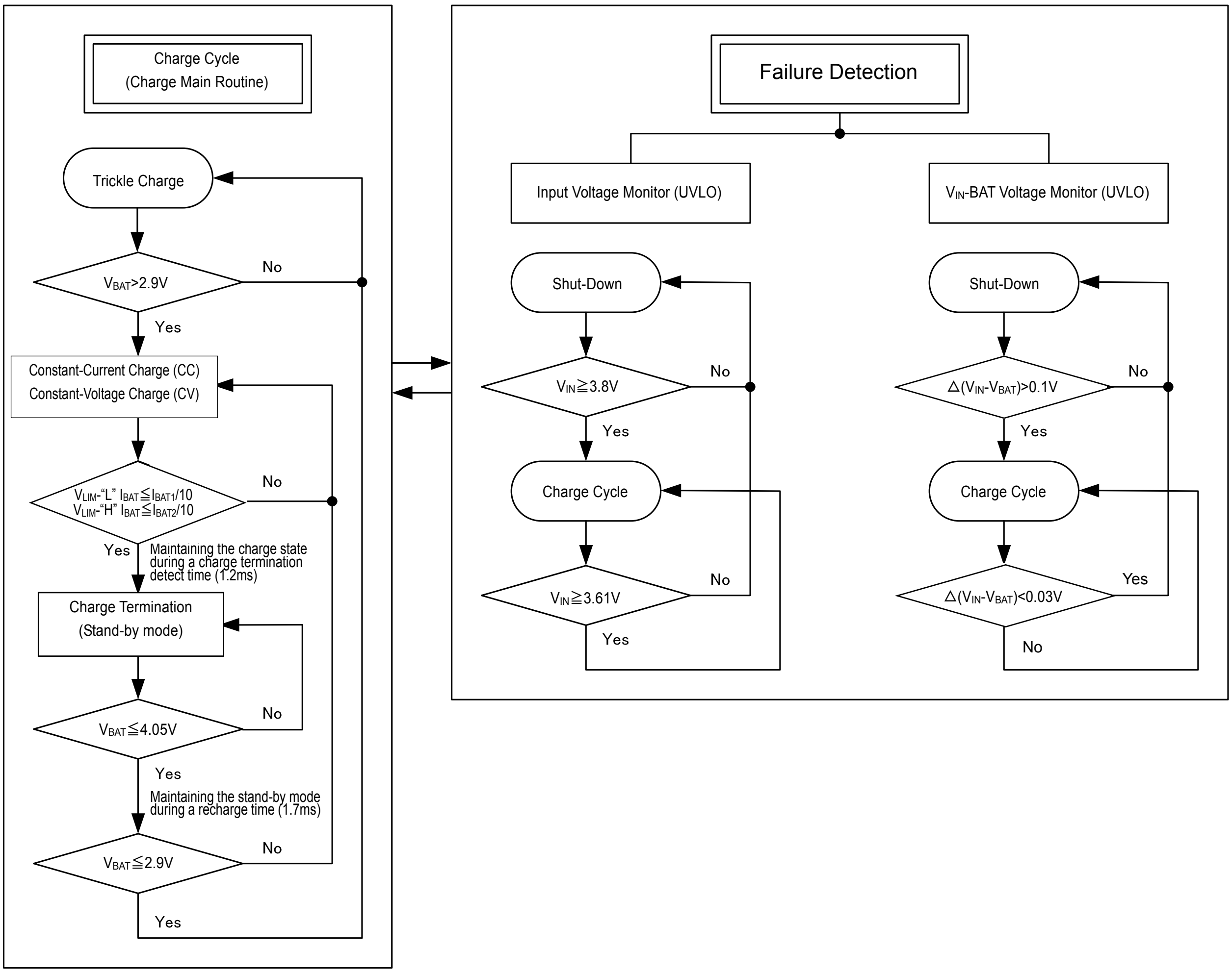
XC6801A421

Ta=25℃

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT	CIRCUIT
Input Voltage	V_{IN}		4.25	-	6.00	V	－
Supply Current	I_{SS}	Charge mode（V_{LIM}=H or V_{LIM}=L）	-	12	30	μA	③
Stand-by Current	I_{STBY}	Stand-by mode	-	12	30	μA	③
Shut-down Current	I_{SHUT}	Shut-down mode (V_{IN}<V_{BAT} or V_{IN}<V_{UVLO})	-	8	18	μA	③
Float Voltage 1	V_{FLOAT1}	Ta=25℃, I_{BAT}=40mA	×0.993	4.2	×1.007	V	②
Float Voltage 2 (*1)	V_{FLOAT2}	0℃≦Ta≦50℃, I_{BAT}=40mA	×0.99	4.2	×1.01	V	－
Battery Current 1	I_{BAT1}	V_{BAT}=3.8V, V_{LIM}=L, CC mode	88	95	100	mA	③
Battery Current 2	I_{BAT2}	V_{BAT}=3.8V, V_{LIM}=H, CC mode	440	475	500	mA	③
Battery Current 3	I_{BAT3}	Stand-by mode, V_{BAT}=4.2V	-	-	2.5	μA	③
Battery Current 4	I_{BAT4}	Shut-down mode	-	-	2.0	μA	③
Battery Current 5	I_{BAT5}	Stop mode, V_{IN}=0V	-	-	2.0	μA	③
Trickle Charge Current 1	I_{TRIKL1}	V_{BAT}<V_{TRIKL}（V_{LIM}=L ）	7.5	9.5	12.0	mA	③
Trickle Charge Current 2	I_{TRIKL2}	V_{BAT}<V_{TRIKL}（V_{LIM}=H ）	37.5	47.5	60.0	mA	③
Trickle Voltage	V_{TRIKL}	V_{LIM}=L, V_{BAT} Rising	2.813	2.9	2.987	V	③
Trickle Voltage Hysteresis Width	V_{TRIKL_HYS}	V_{LIM}=L	58	90	116	mV	③
UVLO Voltage	V_{UVLO}	V_{IN} : L → H	3.686	3.8	3.914	V	⑥
UVLO Hysteresis Width	V_{UVLO_HYS}	-	150	190	280	mV	－
V_{IN}-V_{BAT} Shut-down Voltage	V_{ASD}	V_{IN} : L → H	70	100	140	mV	③
V_{IN}-V_{BAT} Shut-down Voltage Hysteresis Width	V_{ASD_HYS}	-	50	70	90	mV	－
C/10 Charge Termination Current Threshold	I_{TERM}	V_{LIM}=L	0.07	0.1	0.13	mA/mA	②
		V_{LIM}=H	0.07	0.1	0.13	mA/mA	②
/CHG Pin Weak Pull-Down Current	$I_{/CHG1}$	V_{BAT}=4.3V, $V_{/CHG}$=5V	8	20	35	μA	③
/CHG Pin Strong Pull-Down Current	$I_{/CHG2}$	V_{BAT}=4.0V, $V_{/CHG}$=1V	4	10	18	mA	③
/CHG Pin Output Low Voltage	$V_{/CHG}$	$I_{/CHG}$=5mA	-	0.35	0.60	V	④
Recharge Battery Threshold Voltage	ΔV_{RECHRG}	V_{FLOAT1}-V_{RECHRG} (*2)	100	150	200	mV	③
ON Resistance	R_{ON}	-	300	450	800	mΩ	①
Soft-Start Time	t_{SS}	I_{BAT}= 0 → I_{BAT2}(V_{LIM}=H)	120	150	180	μs	⑤
Recharge Battery Time	t_{RECHRG}	V_{BAT} : H → L	0.4	1.7	3.2	ms	⑥
Battery Termination Detect Time	t_{TERM}	I_{BAT} falling (Less than I_{TERM})	0.3	1.2	2.4	ms	⑥
L_{IM} Pin "H" Level Voltage	V_{LIM_H}		1			V	③
L_{IM} Pin "L" Level Voltage	V_{LIM_L}				0.4	V	③
L_{IM} Pin "H" Level Current	I_{LIM_H}		-0.1		0.1	μA	①
L_{IM} Pin "L" Level Current	I_{LIM_L}		-0.1		0.1	μA	①
Thermal Shut-Down Detect Temperature	T_{TSD}	Junction temperature		120		℃	－
Thermal Shut-Down Release Temperature	T_{TSR}	Junction temperature		100		℃	－

Unless otherwise stated, V_{IN}=5.0V.
(*1) The figures under the condition of 0°C≦T_a≦50°C are guaranteed by design calculation.
(*2) V_{RECHRG} is a voltage to start recharging while reducing V_{BAT} in stand-by mode from the full charge.

■OPERATIONAL DESCRIPTION



<Charge Cycle>
If the BAT pin trickle voltage is less than 2.9V(TYP.), the charger enters trickle charge mode. In this mode, a safe battery charge is possible because approximately only 1/10 of the charge current is supplied to the battery. When the BAT pin voltage rises above trickle voltage, 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 from 475mA（TYP.）or 95mA（TYP.）by the L_{IM} pin.

L_{IM} "H" level input：475mA（TYP.）
L_{IM} "L" level input：95mA（TYP.）

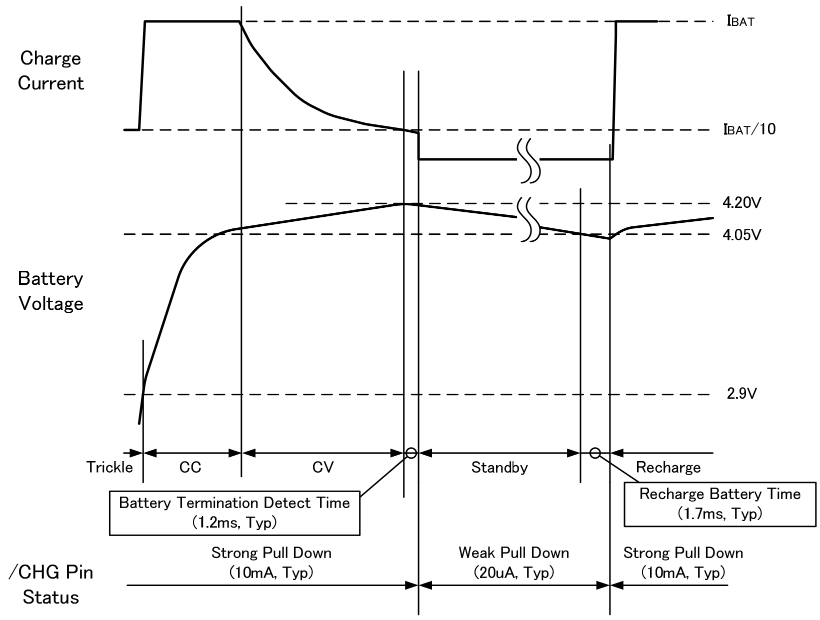
<Charge Termination>
The battery charge is terminated when the charge current decreases to 1/10 of the full charging level after the battery pin voltage reaches a float voltage. An internal comparator monitors the I_{SEN} pin voltage to detect the charge termination. When the comparator sees that the I_{SEN} pin voltage is less than 1.2ms (charge termination detect time), the IC enters stand-by mode. A driver transistor turns off during the stand-by mode.

<Automatic Recharge>
In stand-by mode battery voltage falls. When the voltage level at the battery pin drops to recharge battery threshold voltage 4.05V(TYP.) or less, the charge cycle automatically re-start after a delay of 1.7ms. 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: $I_{/CHG}$=20 μA (TYP.) in a stand-by mode,
- ●High impedance: in shutdown mode.



<Connection of Shorted BAT Pin>
Even if the BAT pin is shorted to V_{SS}, a trickle charge mode operates in order to protect 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 above the UVLO voltage. Moreover, in order to protect the battery charger, the UVLO circuit keeps the charger in shut-down mode when the 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 shut-down mode, the driver transistor turns off but a failure detection circuit operates, and supply current is reduced to 8 μA.

<Soft-Start Function>
To protect against inrush current from the input to the battery, soft-start time is optimized and internally set (150 μs, TYP.).

<Backflow Prevention Between the BAT Pin and the V_{IN} Pin>
A backflow prevention circuit protects against current flowing from the BAT pin to the V_{IN} pin even if the BAT pin voltage is higher than the V_{IN} pin voltage.

■NOTES ON USE

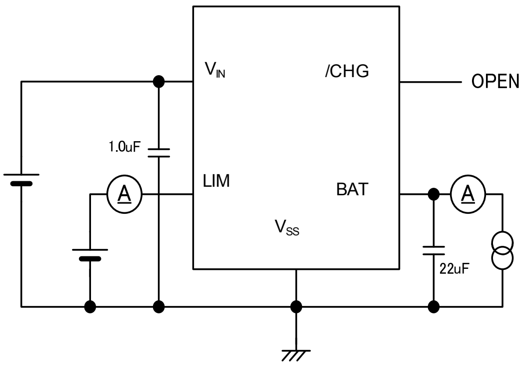
1. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.

2. Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current. Please wire the C_{IN} as close to the IC as possible.

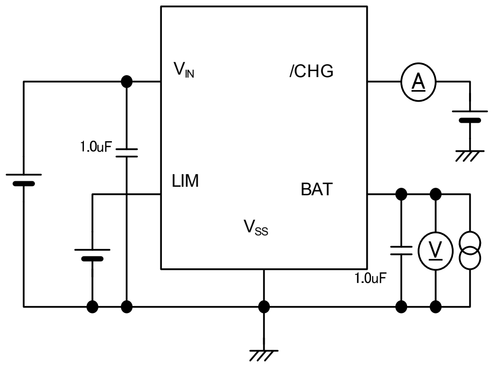
3. Torex places an importance on improving our products and their reliability.
   We request that users incorporate fail-safe designs and post-aging protection treatment when using Torex products in their systems.

■TEST CIRCUITS

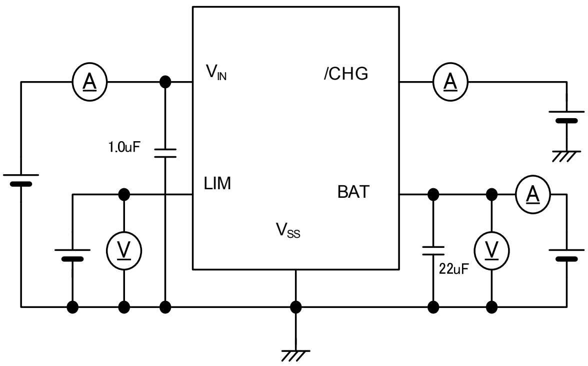
CIRCUIT①
ON Resistance, L_{IM} Pin "H" level current,
L_{IM} Pin "L" level current,



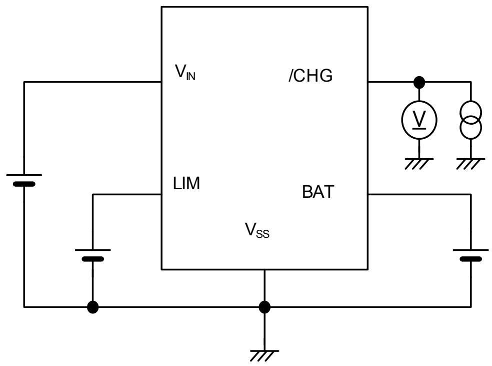
CIRCUIT②
C/10 Charge Termination Current Threshold,
Battery Termination Voltage1



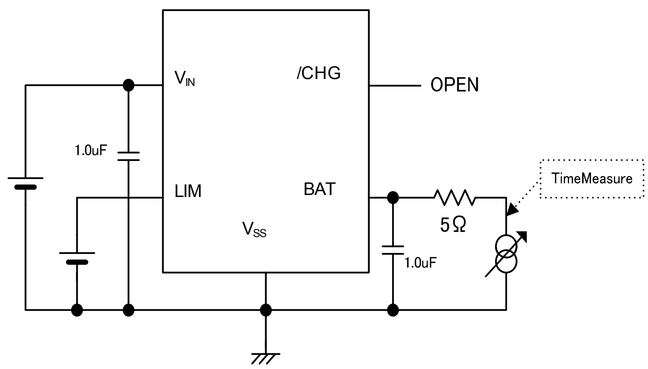
CIRCUIT③
Trickle Charge Current1~2, Battery Current1~5,
L_{IM} Pin "H" level Voltage, L_{IM} Pin "L" level Voltage,
Trickle Charge Voltage, Recharge Battery Threshold Voltage,
V_{IN}-V_{BAT} Shut-down Voltage, /CHG Pin Weak_Pull_down Current,
/CHG Pin Strong_Pull_down Current, Supply Current,
Stand-by Current, Shut-down Current



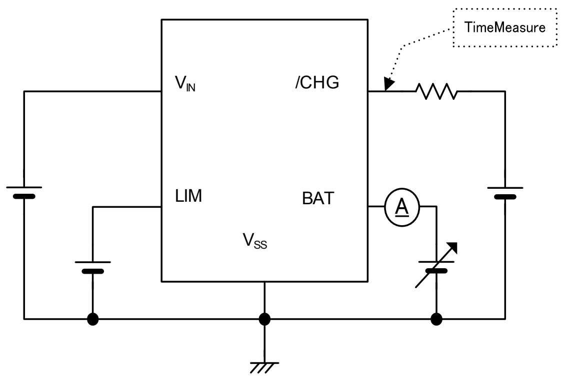
CIRCUIT④
/CHG Pin Output Low Voltage



CIRCUIT⑤
Soft-Start Time

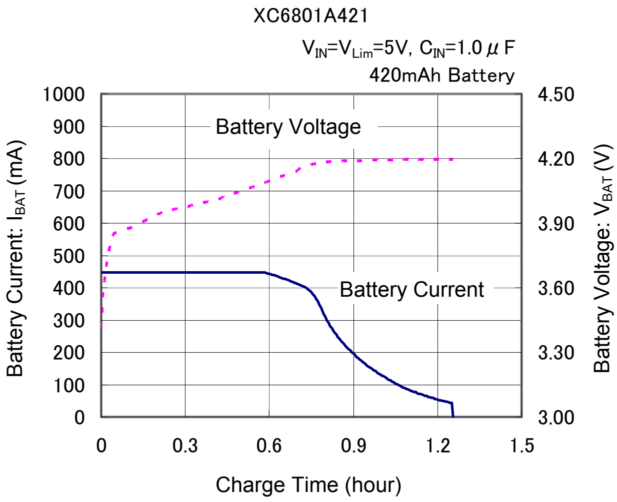


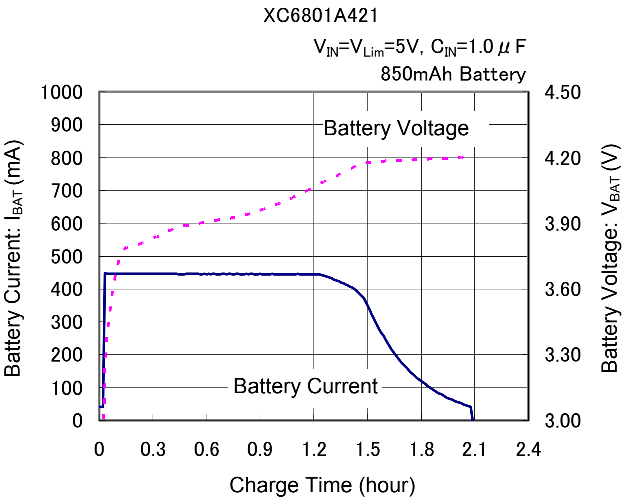
CIRCUIT⑥
Recharge Time at Charge Termination Detect, UVLO Voltage



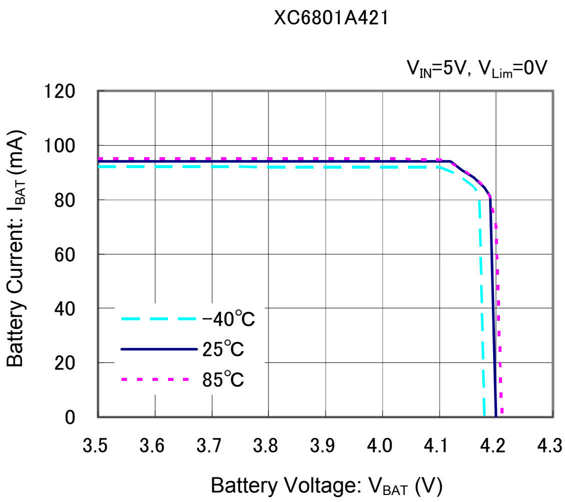
■TYPICAL PERFORMANCE CHARACTERISITCS

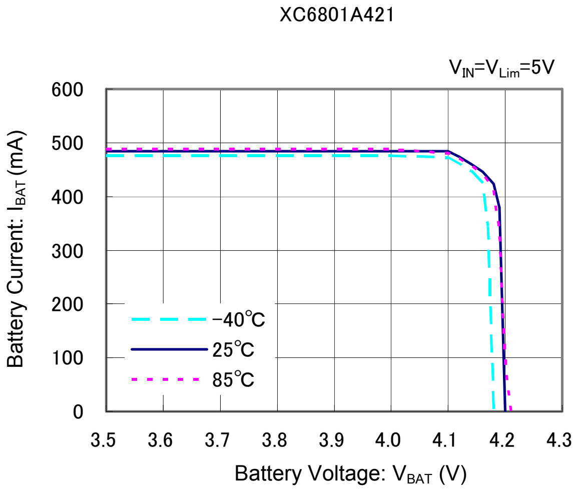
(1) Charge Cycle

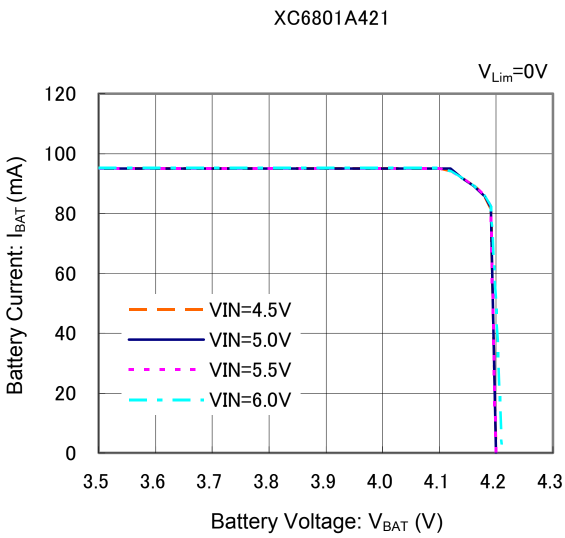


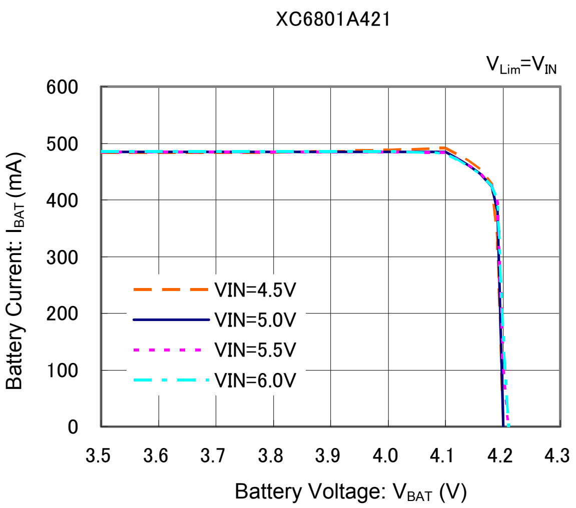


(2) Battery Current vs. Battery Voltage



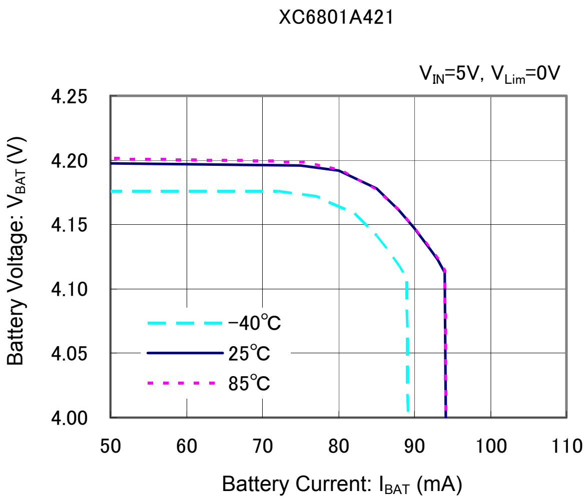


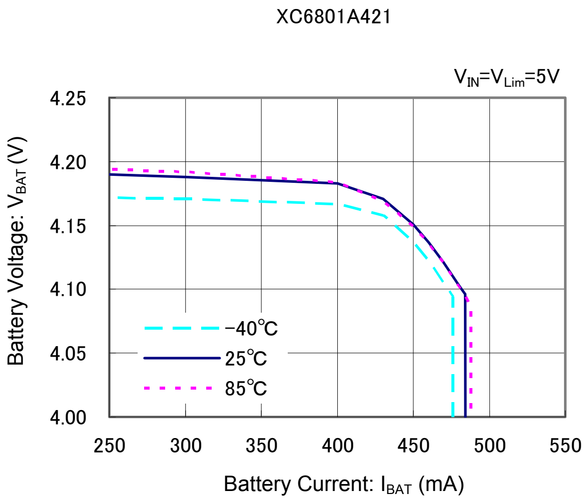


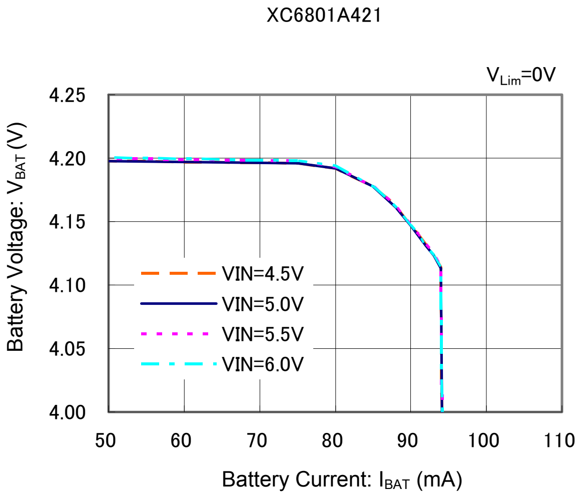


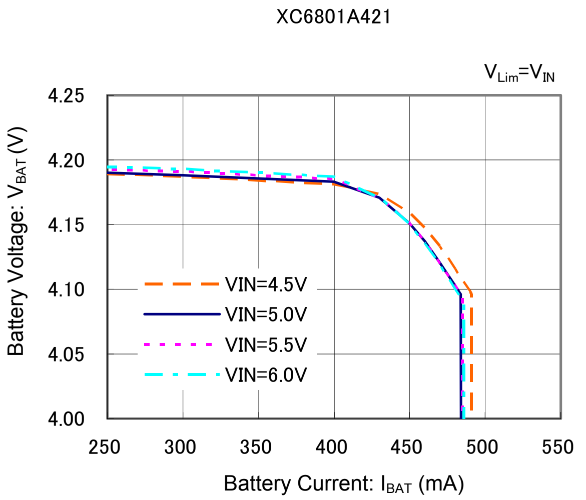
■TYPICAL PERFORMACNE CHARACTORISTICS (Continued)

(3) Battery Voltage vs. Battery Current

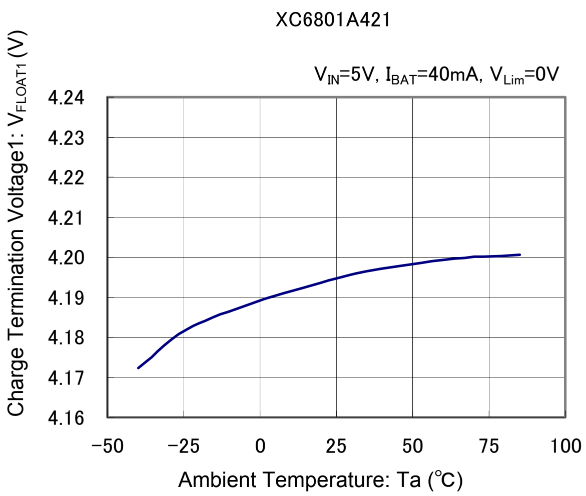


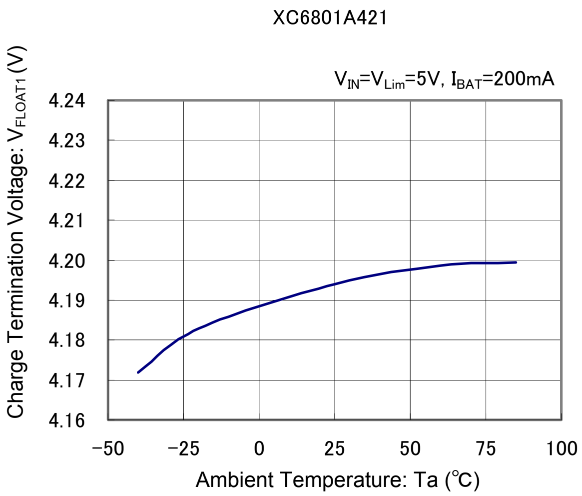






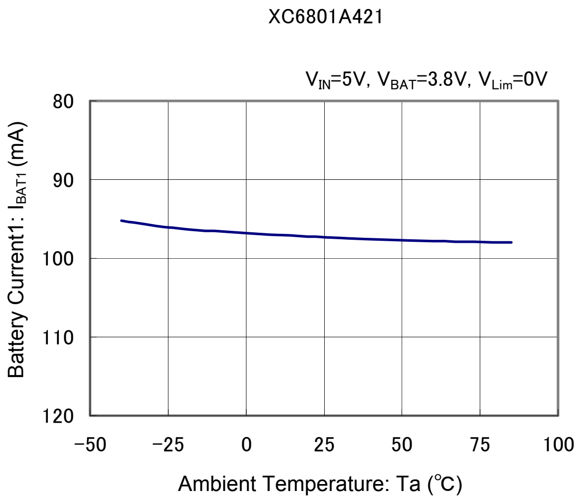
(4) Charge Termination Voltage vs. Ambient Temperature

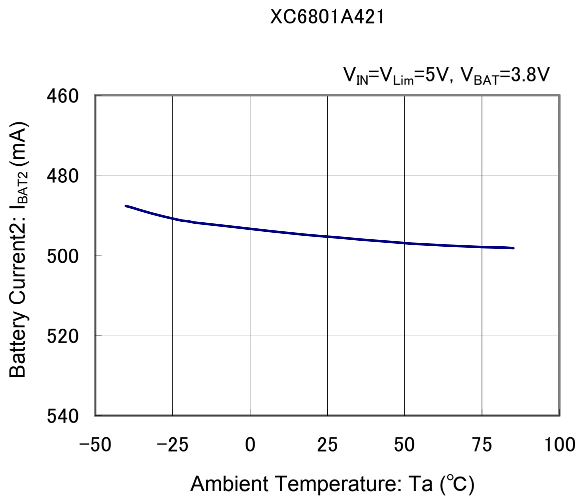




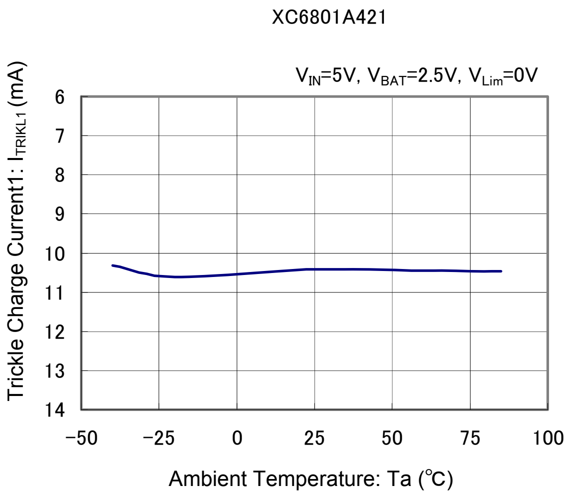
■TYPICAL PERFORMANCE CHARACTORISITCS (Continued)

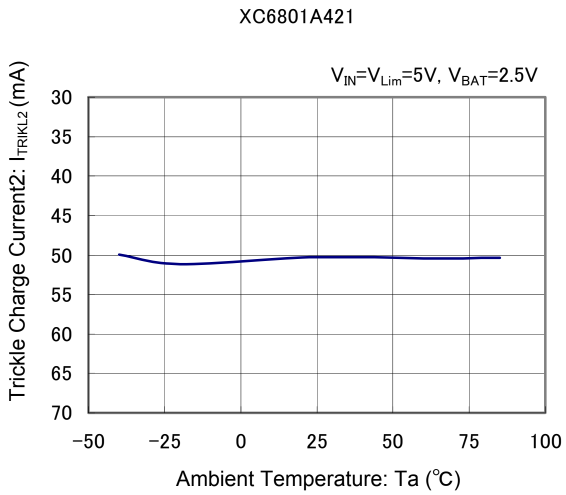
(5) Battery Current vs. Ambient Temperature



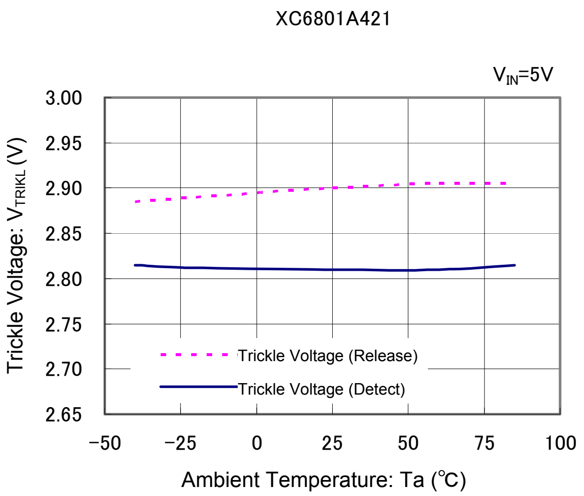


(6) Trickle Charge Current vs. Ambient Temperature

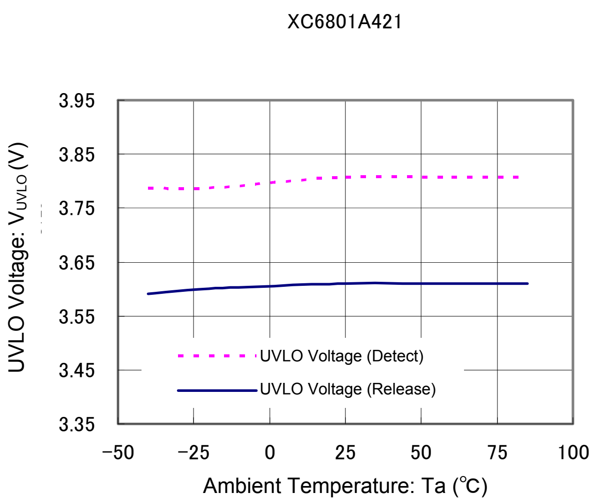




(7) Trickle Voltage vs. Ambient Temperature

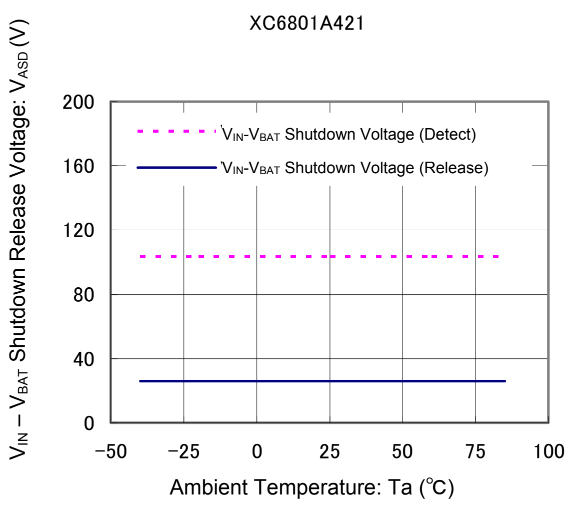


(8) UVLO Voltage vs. Ambient Temperature

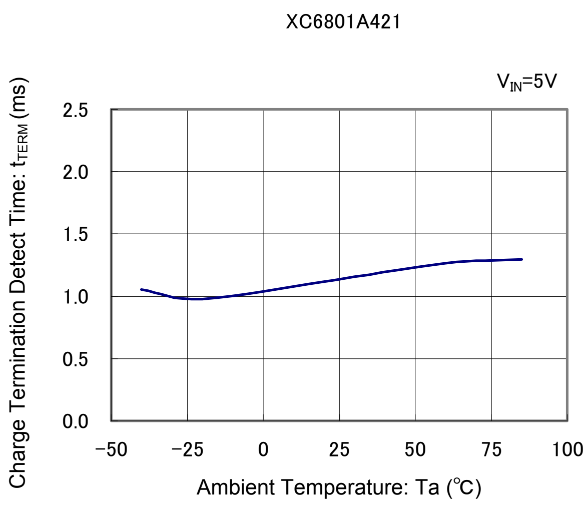


■TYPICAL PERFORMANCE CHARACTORISTICS (Continued)

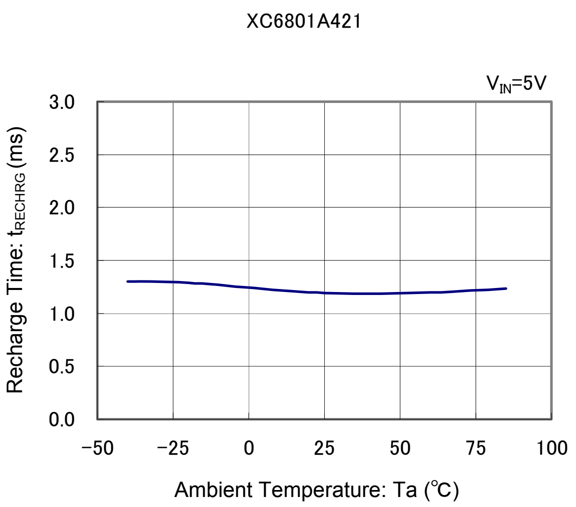
(9) V_{IN} – V_{BAT} Shutdown Voltage vs. Ambient Temperature



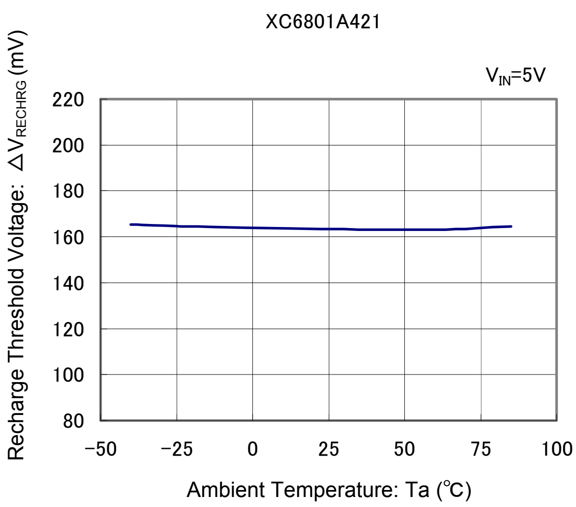
(10) Charge Termination Detect Time vs. Ambient Temperature



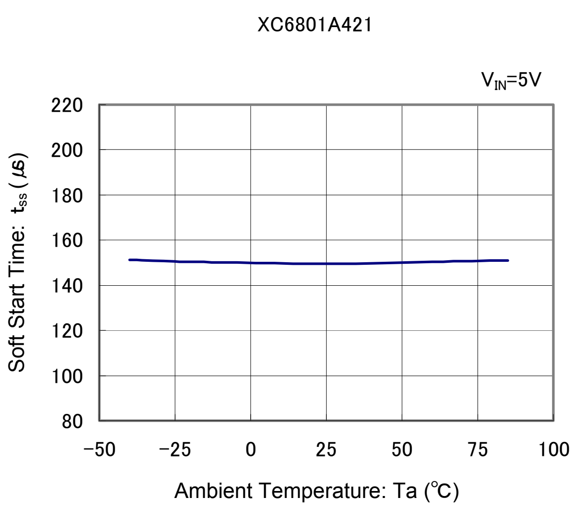
(11) Recharge Time vs. Ambient Temperature



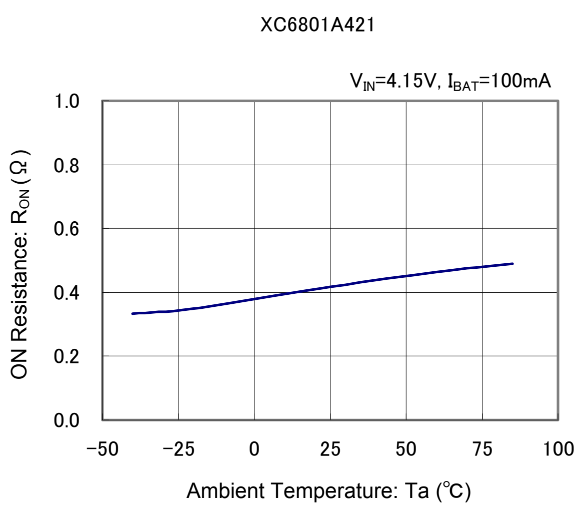
(12) Recharge Threshold Voltage vs. Ambient Temperature



(13) Soft Start Time vs. Ambient Temperature

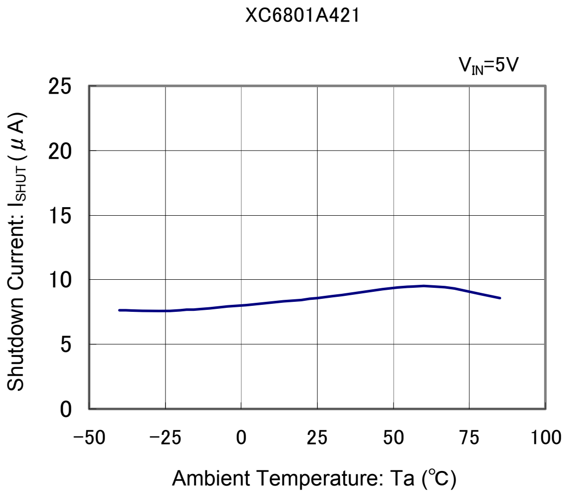


(14) ON Resistance vs. Ambient Temperature

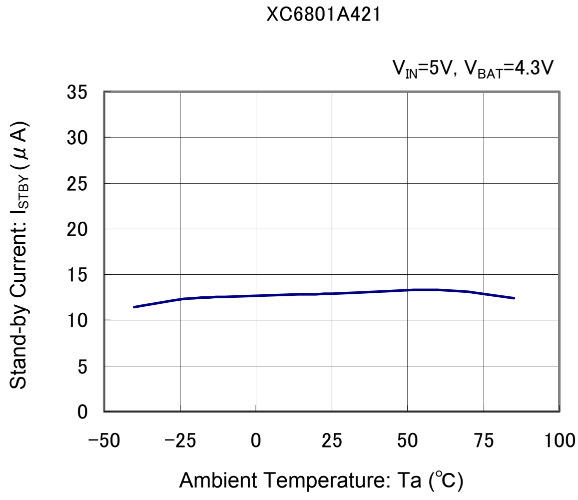


■TYPICAL PERFORMANCE CHARACTORISTCS (Continued)

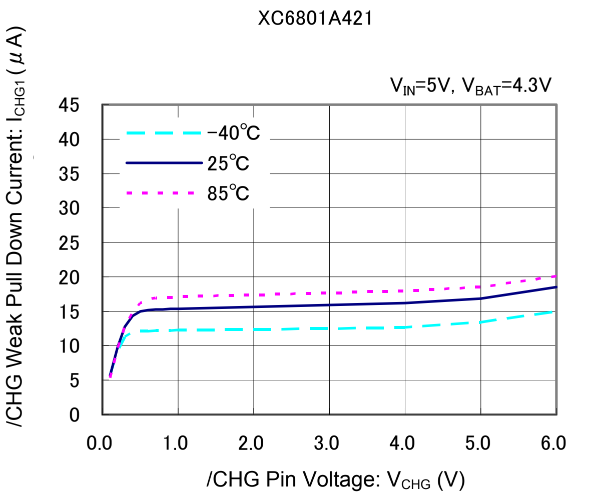
(15) Shutdown Current vs. Ambient Temperature



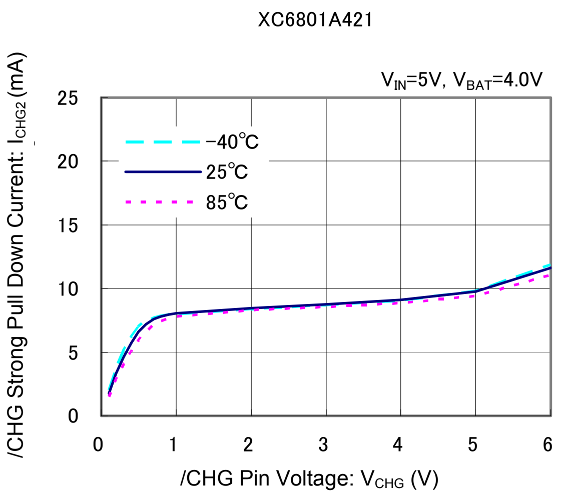
(16) Stand-by Current vs. Ambient Temperature



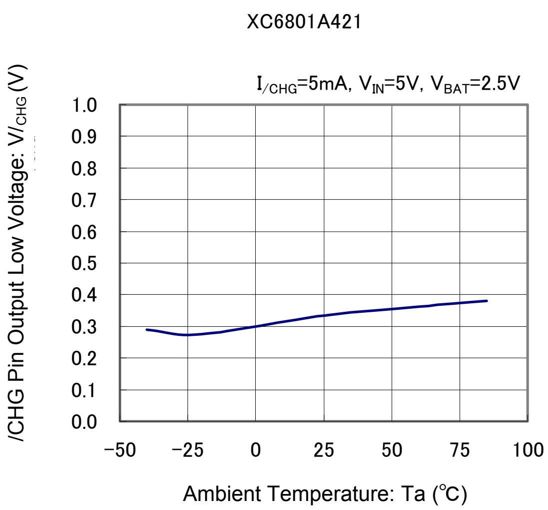
(17) /CHG Weak Pull Down Current vs. /CHG Pin Voltage



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

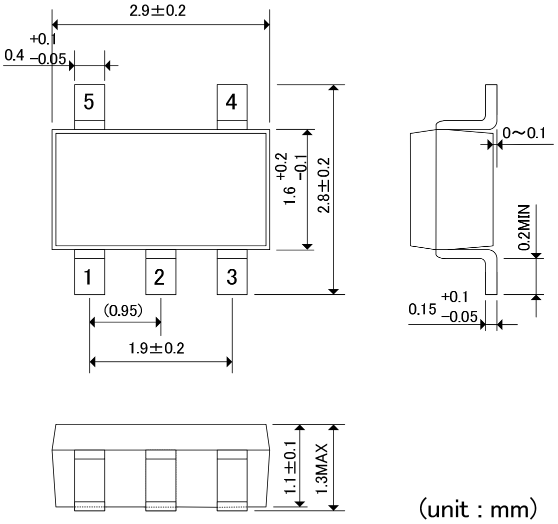


(19) /CHG Pin Output Low Voltage vs. Ambient Temperature



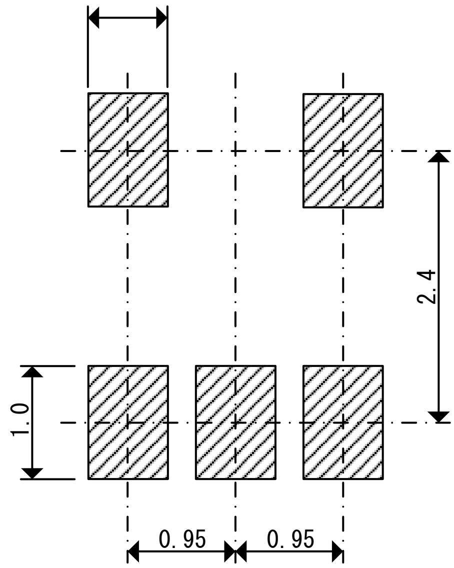
■PACKAGING INFORMATION

●SOT-25

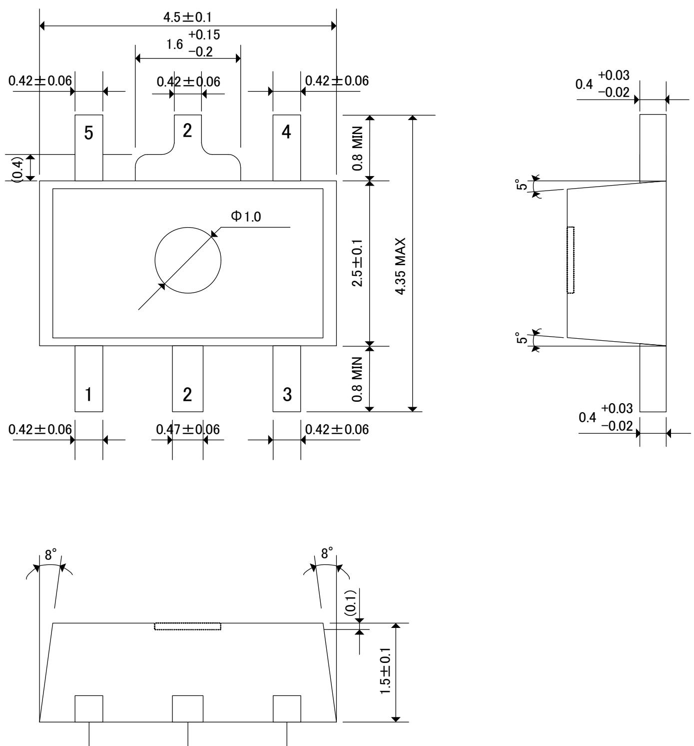


(unit : mm)

●SOT-25 Reference Pattern Layout

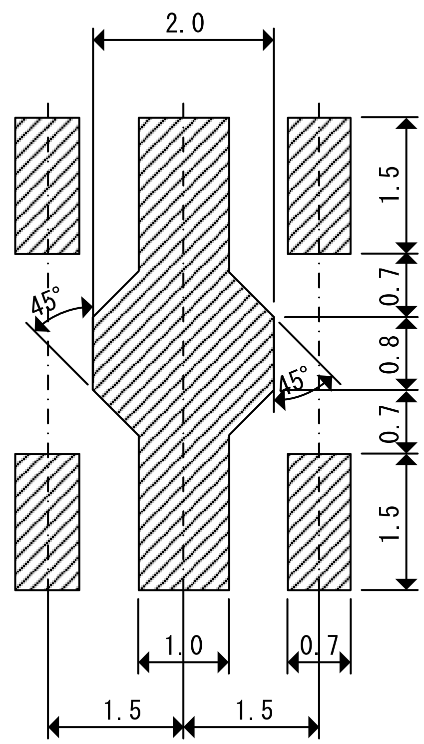


●SOT-89-5



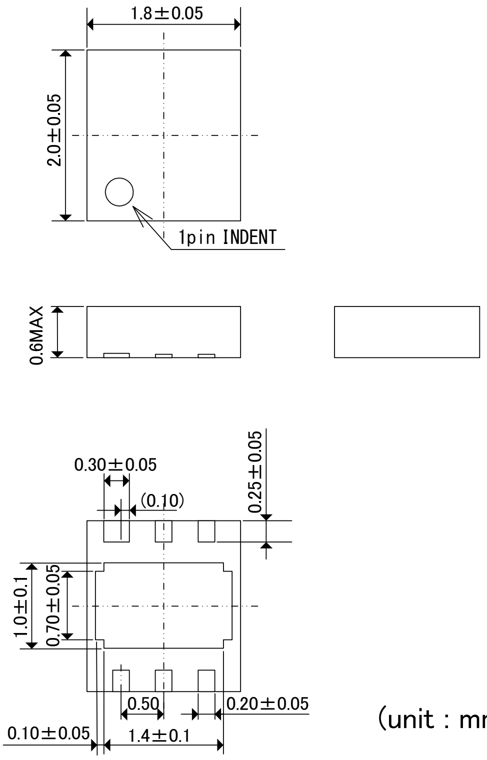
(unit : mm)

●SOT-89-5 Reference Pattern Layout



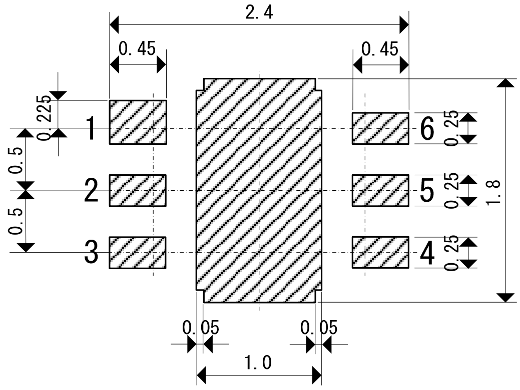
■PACKAGING INFORMATION (Continued)

●USP-6C

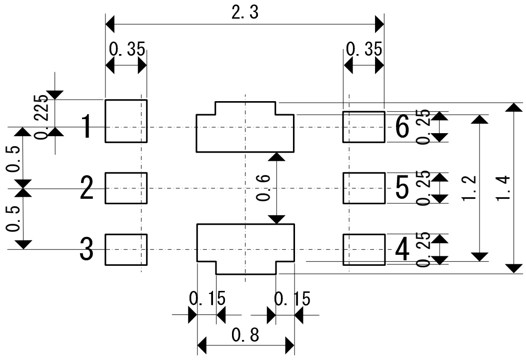


(unit : mm)

●USP-6C Reference Pattern Layout



●USP-6C Reference Metal Mask Design



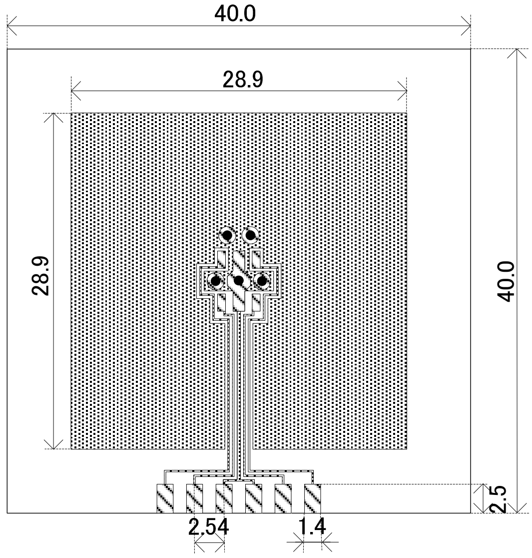
■PACKAGING INFORMATION (Continued)

● 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 the reference data taken in the following condition.

1. Measurement Condition

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 : 1.6mm
Through-hole : 5 x 0.8 Diameter

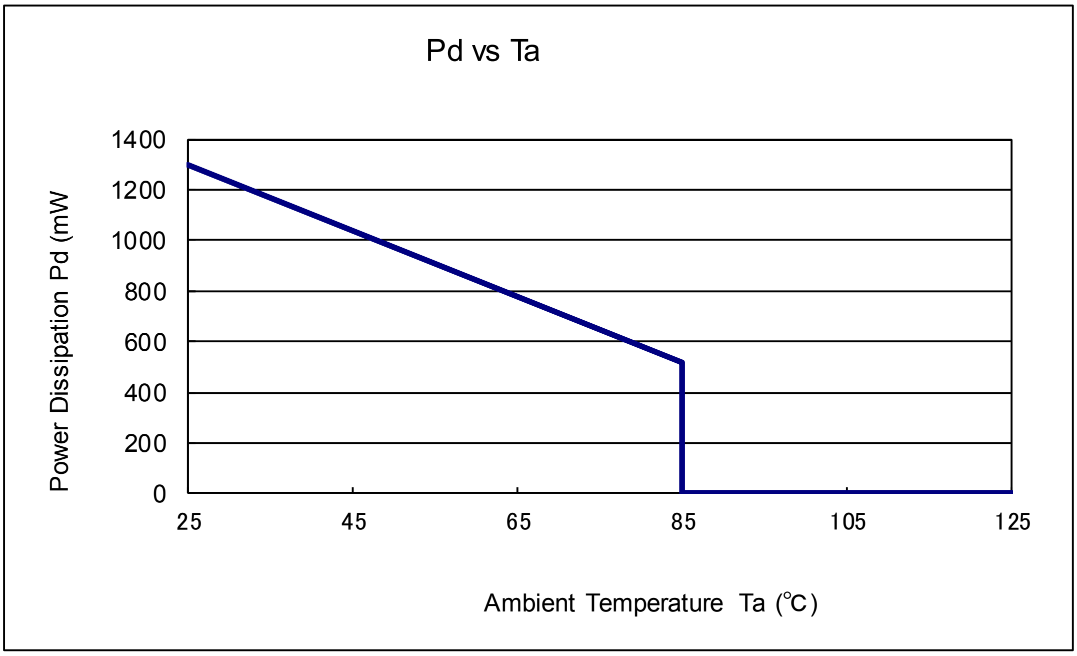


Evaluation Boxレイアウト（単位：mm）

2.Power Dissipation vs. Ambient Temperature

Board Mount (Tj max = 125℃)

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



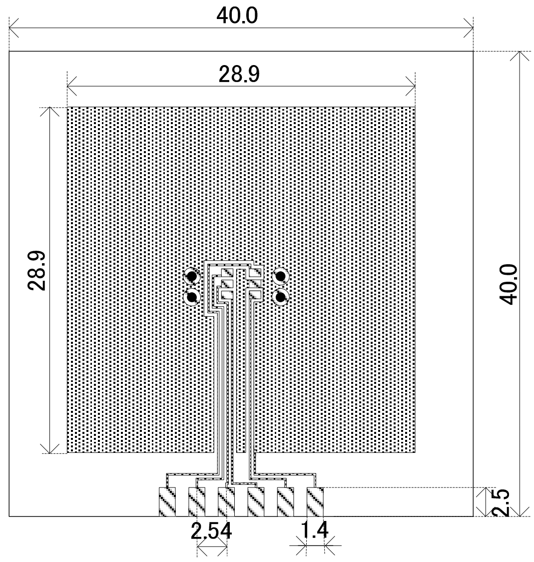
■PACKAGING INFORMATION (Continued)

● 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 the reference data taken in the following condition.

1. Measurement Condition

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: 1.6mm
Through-hole: 4 x 0.8 Diameter

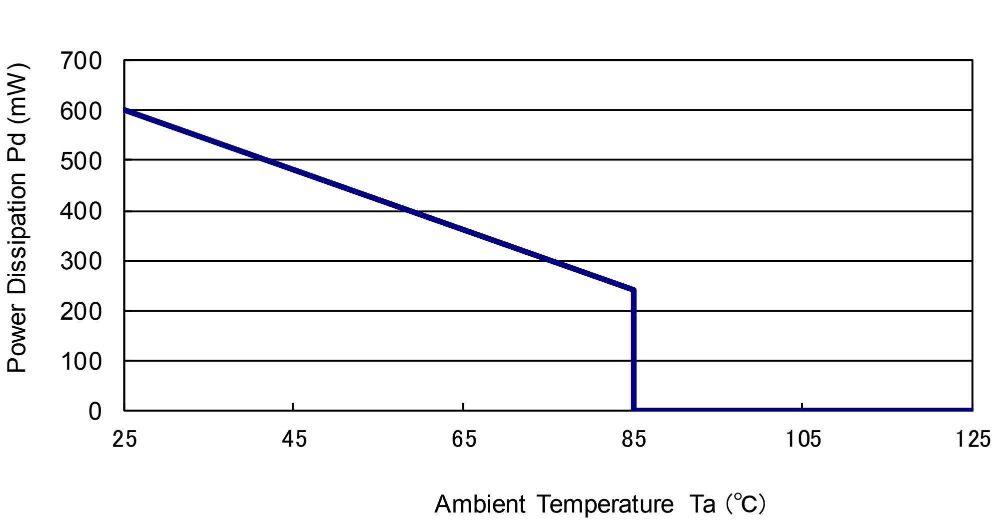


Evaluation Board (Unit: mm)

2.Power Dissipation vs. Ambient Temperature

Board Mount (Tj max = 125℃)

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



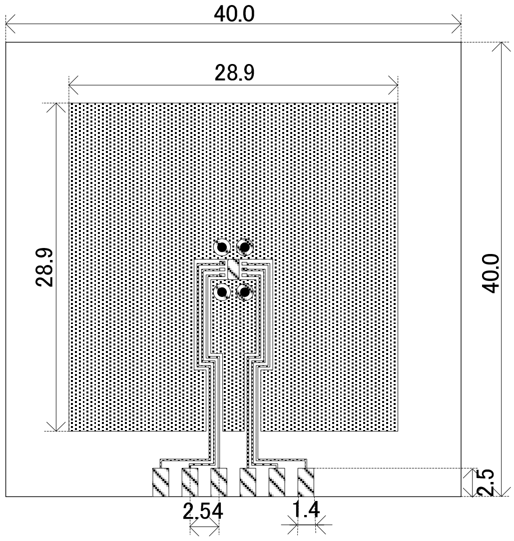
■PACKAGING INFORMATION (Continued)

● 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 the reference data taken in the following condition.

1. Measurement Condition

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 :	1.6mm
Through-hole :	4 x 0.8 Diameter

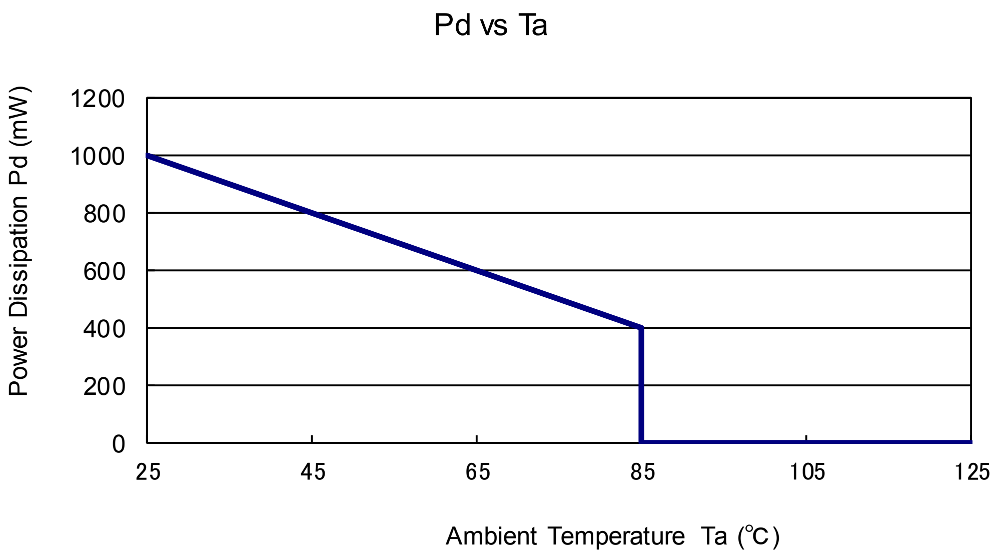


Evaluation Board (Unit : mm)

2.Power Dissipation vs. Ambient Temperature

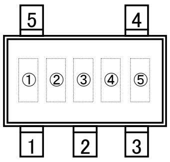
Board Mount (Tj max = 125℃)

Ambient Temperature (℃)	Power Dissipation Pd (mW)	Thermal Resistance (℃/W)
25	1000	100.00
85	400	

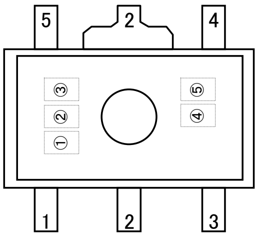


■MARKING RULE

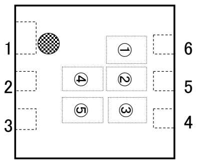
SOT-25



SOT-89-5



USP-6C



① represents product series

MARK	PRODUCT SERIES
4	XC6801******-G

② represents the 7th digits

MARK	PRODUCT SERIES
A	XC6801A*****-G

③ represents the 8th digits

MARK	PRODUCT SERIES
4	XC6801*4****-G

④⑤ represents production lot number

01~09, 0A~0Z, 11･･･9Z, A1･･･A9, AA ･･･Z9, ZA･･･ZZ in order.

(G, I, J, O, Q, W excepted)

*No character inversion used.

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