

Built-in Inrush Current Protection, 300mA High Speed LDO Voltage Regulator

GENERAL DESCRIPTION

The XC6223 series is a high speed LDO regulator that features high accurate, low noise, high ripple rejection, low dropout and low power consumption. The series consists of a voltage reference, an error amplifier, a driver transistor, a current limiter, a phase compensation circuit, a thermal shutdown circuit and an inrush current protection circuit.

The CE function enables the circuit to be in stand-by mode by inputting low level signal. In the stand-by mode, the series enables the electric charge at the output capacitor C_L to be discharged via the internal switch, and as a result the V_{OUT} pin quickly returns to the V_{SS} level. The output stabilization capacitor C_L is also compatible with low ESR ceramic capacitors.

The output voltage is selectable in 0.05V increments within the range of 1.2V to 4.0V which fixed by laser trimming technologies. The over current protection circuit and the thermal shutdown circuit are built-in. These two protection circuits will operate when the output current reaches current limit level or the junction temperature reaches temperature limit level.

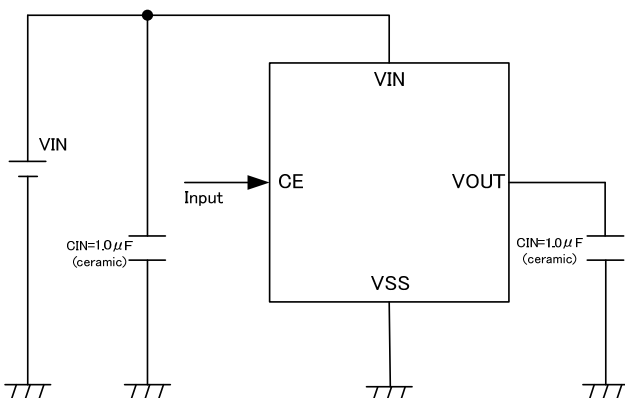
APPLICATIONS

- Digital still cameras
- Smart phones / Mobile phones
- Portable game consoles
- Modules (wireless, cameras, etc.)
- IC recorders
- Mobile devices / terminals
- Bluetooth
- Wireless LAN
- Digital TV tuners

FEATURES

| | |
|--------------------------------------|---|
| Maximum Output Current | : 300mA |
| Input Voltage Range | : 1.6~5.5V |
| Output Voltages | : 2.0~4.0V (Accuracy $\pm 1\%$) 1.2~1.95V (Accuracy $\pm 20mV$) 0.05V increments |
| Dropout Voltage | : 200mV@ $I_{OUT}=300mA$ ($V_{OUT}=3.0V$) |
| Low Power Consumption | : 100 μA |
| Stand-by Current | : 0.1 μA |
| High Ripple Rejection | : 80dB@f=1kHz |
| Protection Circuits | : Current Limit(400mA) Short Circuit Protection Over Heat Protection Inrush Current Protection |
| Low ESR Capacitors | : $C_{IN}=1.0\mu F$, $C_L=1.0\mu F$ |
| CE Function | : Active High C_L High Speed Discharge |
| Operating Ambient Temperature | : -40°C~+105°C |
| Packages | : USPQ-4B03 USP-4 SSOT-24 SOT-25 SOT-89-5 |
| Environmentally Friendly | : EU RoHS Compliant, Pb Free |

TYPICAL APPLICATION CIRCUIT



TYPICAL PERFORMANCE CHARACTERISTICS



PIN CONFIGURATION



USPQ-4B03
(BOTTOM VIEW)



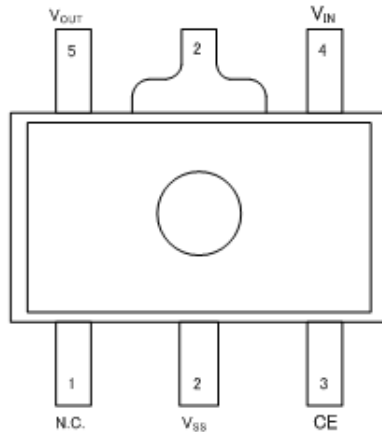
USP-4
(BOTTOM VIEW)



SSOT-24
(TOP VIEW)



SOT-25
(TOP VIEW)



SOT-89-5
(TOP VIEW)

*The dissipation pad for the USPQ-4B03, USP-4 packages should be solder-plated in reference 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 |
|------------|-------|---------|--------|----------|------------------|----------------|
| USPQ-4B03 | USP-4 | SSOT-24 | SOT-25 | SOT-89-5 | | |
| 4 | 4 | 4 | 1 | 4 | V _{IN} | Power Input |
| 1 | 1 | 3 | 5 | 5 | V _{OUT} | Output |
| 2 | 2 | 2 | 2 | 2 | V _{SS} | Ground |
| 3 | 3 | 1 | 3 | 3 | CE | ON/OFF Control |
| - | - | - | 4 | 1 | NC | No Connection |

LOGIC CONDITION FOR THE PIN

| PIN NAME | DESIGNATOR | CONDITION |
|----------|------------|------------------------------|
| CE | L | $0V \leq V_{CE} \leq 0.3V$ |
| | H | $1.0V \leq V_{CE} \leq 5.5V$ |
| | OPEN | CE=OPEN |

■ PIN FUNCTION ASSIGNMENT

| CE LOGIC CONDITION | IC OPERATION |
|--------------------|-------------------------|
| H | Operation ON |
| L | Operation OFF(Stand-by) |
| OPEN | * |

* Undefined state in XC6223 A/B/E/F/J/K/P/Q. On the other hand, Operation OFF states in XC6223C/D/G/H/M/N/R/T because that an internal pull-down resistor maintains the CE pin voltage to be low.

■ PRODUCT CLASSIFICATION

● Ordering Information

XC6223①②③④⑤⑥-⑦^(*)

| DESIGNATOR | ITEM | SYMBOL | DESCRIPTION |
|---------------------|-----------------------|--------------------|--|
| ① | Type of Regulator | A/J ^(*) | Without Inrush Current Protection, Without CE Pull-down, Without C _L discharge (Semi-Custom) |
| | | B/K ^(*) | Without Inrush Current Protection, Without CE Pull-down, With C _L discharge (Semi-Custom) |
| | | C/M ^(*) | Without Inrush Current Protection, With CE Pull-down ^(*) , Without C _L discharge (Semi-Custom) |
| | | D/N ^(*) | Without Inrush Current Protection, With CE Pull-down ^(*) , With C _L discharge |
| | | E/P ^(*) | With Inrush Current Protection, Without CE Pull-down, Without CL discharge (Semi-Custom) |
| | | F/Q ^(*) | With Inrush Current Protection, Without CE Pull-down, With C _L discharge (Semi-Custom) |
| | | G/R ^(*) | With Inrush Current Protection, With CE Pull-down ^(*) , Without C _L discharge (Semi-Custom) |
| | | H/T ^(*) | With Inrush Current Protection, With CE Pull-down ^(*) , With C _L discharge |
| ②③ | Output Voltage | 12~40 | ex.) 2.80V → ②=2, ③=8, ④=please see down below. |
| ④ | Output Accuracy | 1 | ±1% (V _{OUT} ≥ 2.0V) ±0.02V (V _{OUT} < 2.0V) In case of 2nd decimal place 0 (ex.2.80V → ④=1) |
| | | B | ±1% (V _{OUT} ≥ 2.0V) ±0.02V (V _{OUT} < 2.0V) In case of 2nd decimal place 5 (ex.2.85V → ④=B) |
| ⑤⑥-⑦ ^(*) | Packages (Order Unit) | 9R-G | USPQ-4B03 (5,000/Reel) |
| | | GR-G | USP-4 (3,000/Reel) |
| | | NR-G | SSOT-24 (3,000/Reel) |
| | | MR-G | SOT-25 (3,000/Reel) |
| | | PR-G | SOT-89-5 (1,000/Reel) |

^(*) The "-G" suffix denotes Halogen and Antimony free as well as being fully EU RoHS compliant.

⁽²⁾ With CE pin pull-down resistor.

⁽³⁾ Product types A/B/C/D/E/F/G/H are for pre-existing customers who were or are already using these types of products.

For customers who intend to adopt this product newly, please select from types J/K/M/N/P/Q/R/T which have been extended the operating temperature range (105°C compliance).

BLOCK DIAGRAMS



XC6223A/J series



XC6223B/K series



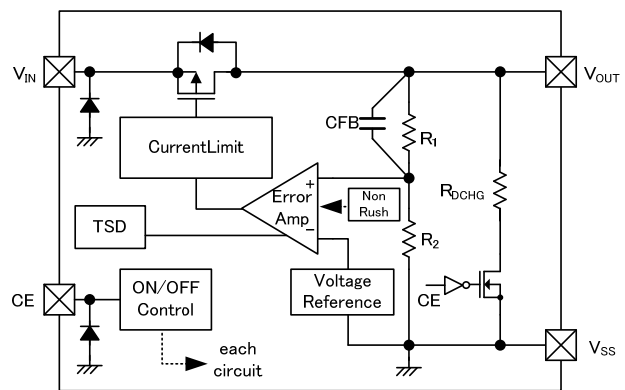
XC6223C/M series



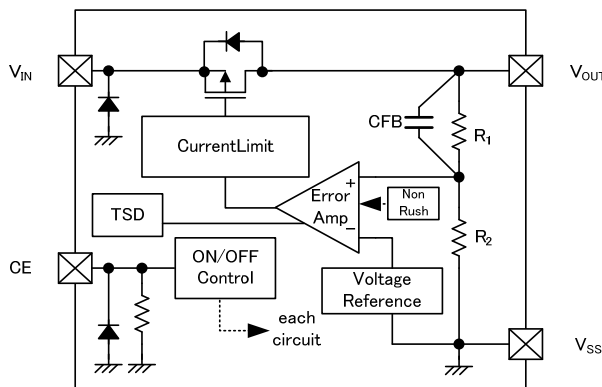
XC6223D/N series



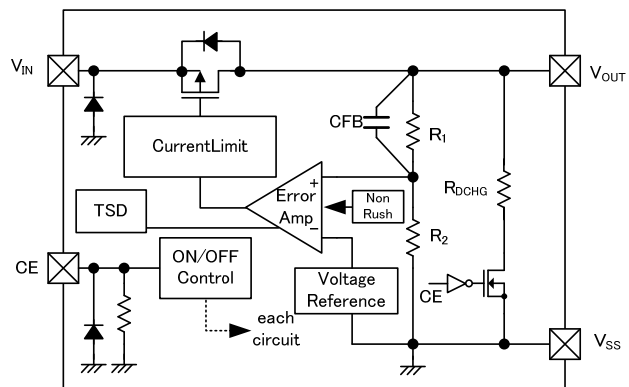
XC6223E/P series



XC6223F/Q series



XC6223G/R series



XC6223H/T series

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

■ ABSOLUTE MAXIMUM RATINGS

●XC6223A/B/C/D/E/F/G/H Series

Ta=25°C

| PARAMETER | | SYMBOL | RATINGS | UNITS |
|-------------------------------|-----------|------------------|---|-------|
| Input Voltage | | V _{IN} | V _{SS} -0.3~+7.0 | V |
| Output Current | | I _{OUT} | 500 ^(*1) | mA |
| Output Voltage | | V _{OUT} | V _{SS} -0.3~V _{IN} +0.3 | V |
| CE Input Voltage | | V _{CE} | V _{SS} -0.3~+7.0 | V |
| Power Dissipation | USPQ-4B03 | Pd | 100 | mW |
| | | | 550 (PCB mounted) ^(*2) | |
| | USP-4 | | 120 | |
| | | | 1000 (PCB mounted) ^(*2) | |
| | SSOT-24 | | 150 | |
| | | | 500 (PCB mounted) ^(*2) | |
| | SOT-25 | | 250 | |
| | | | 600 (PCB mounted) ^(*2) | |
| SOT-89-5 | 500 | | | |
| Operating Ambient Temperature | | Topr | -40~+85 | °C |
| Storage Temperature | | Tstg | -55~+125 | °C |

(*1) : $I_{OUT} \leq Pd / (V_{IN} - V_{OUT})$

(*2) : The power dissipation figure shown is PCB mounted. Please refer to page 29~33 for details.

●XC6223J/K/M/N/P/Q/R/T Series

Ta=25°C

| PARAMETER | | SYMBOL | RATINGS | UNITS |
|-------------------------------|-----------|------------------|---|-------|
| Input Voltage | | V _{IN} | V _{SS} -0.3~+7.0 | V |
| Output Current | | I _{OUT} | 500 ^(*1) | mA |
| Output Voltage | | V _{OUT} | V _{SS} -0.3~V _{IN} +0.3 | V |
| CE Input Voltage | | V _{CE} | V _{SS} -0.3~+7.0 | V |
| Power Dissipation | USPQ-4B03 | Pd | 100 | mW |
| | | | 550 (PCB mounted) ^(*2) | |
| | USP-4 | | 120 | |
| | | | 1000 (PCB mounted) ^(*2) | |
| | SSOT-24 | | 150 | |
| | | | 500 (PCB mounted) ^(*2) | |
| | SOT-25 | | 250 | |
| | | | 600 (PCB mounted) ^(*2) | |
| SOT-89-5 | 500 | | | |
| Operating Ambient Temperature | | Topr | -40~+105 | °C |
| Storage Temperature | | Tstg | -55~+125 | °C |

(*1) : $I_{OUT} \leq Pd / (V_{IN} - V_{OUT})$

(*2) : The power dissipation figure shown is PCB mounted. Please refer to page 29~33 for details.

ELECTRICAL CHARACTERISTICS

●XC6223A/B/C/D/E/F/G/H/J/K/M/N/P/Q/R/T Series

Ta=25°C

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUITS |
|---|---|---|------------------------------------|-----------------------------|------------------------------------|----------|----------|
| Output Voltage | V _{OUT(E)} (*1) | V _{OUT(T)} ≥ 2.0V, V _{CE} =V _{IN} , I _{OUT} =10mA | V _{OUT(T)} × 0.99 (*2) | V _{OUT(T)} (*2) | V _{OUT(T)} × 1.01 (*2) | V | ① |
| | | V _{OUT(T)} < 2.0V, V _{CE} =V _{IN} , I _{OUT} = 10mA(*3) | V _{OUT(T)} - 20mV (*2) | V _{OUT(T)} (*2) | V _{OUT(T)} + 20mV (*2) | V | |
| Maximum Output Current | I _{OUTMAX} | V _{CE} =V _{IN} | 300 | - | - | mA | ① |
| Load Regulation | ΔV _{OUT} | V _{CE} =V _{IN} , 0.1mA ≤ I _{OUT} ≤ 300mA | - | 25 | 45 | mV | ① |
| Dropout Voltage | V _{dif} (*4) | V _{CE} =V _{IN} , I _{OUT} =300mA | E-1 | | | mV | ① |
| Supply Current | I _{SS} | V _{CE} =V _{IN} | - | 100 | 220 | μA | ② |
| Stand-by Current | I _{STB} | V _{CE} =V _{SS} | - | 0.01 | 0.4 | μA | ② |
| Line Regulation | ΔV _{OUT} / (ΔV _{IN} · V _{OUT}) | V _{OUT(T)} +0.5V ≤ V _{IN} ≤ 5.5V V _{CE} =V _{IN} , I _{OUT} =50mA | - | 0.01 | 0.1 | %/V | ① |
| Input Voltage | V _{IN} | - | 1.6 | - | 5.5 | V | ① |
| Output Voltage Temperature Characteristics (A/B/C/D/E/F/G/H Type) | ΔV _{OUT} / (ΔTa · V _{OUT}) | V _{CE} =V _{IN} , I _{OUT} =10mA -40°C ≤ Ta ≤ 85°C | - | ±100 | - | ppm / °C | ① |
| Output Voltage Temperature Characteristics (J/K/M/N/P/Q/R/T Type) | ΔV _{OUT} / (ΔTa · V _{OUT}) | V _{CE} =V _{IN} , I _{OUT} =10mA -40°C ≤ Ta ≤ 105°C | - | ±100 | - | ppm / °C | ① |
| Power Supply Rejection Ratio | PSRR | V _{OUT(T)} < 2.5V V _{IN} =3.0V _{DC} +0.5V _{p-pAC} V _{CE} =V _{OUT(T)} +1.0V I _{OUT} =30mA, f=1kHz | - | 80 | - | dB | ③ |
| | | V _{OUT(T)} ≥ 2.5V V _{IN} ={V _{OUT(T)} +1.0} V _{DC} +0.5V _{p-pAC} V _{CE} =V _{OUT(T)} +1.0V I _{OUT} =30mA, f=1kHz | | | | | |
| Current Limit | I _{LIM} | V _{CE} =V _{IN} | 310 | 400 | - | mA | ① |
| Short Current | I _{SHORT} | V _{CE} =V _{IN} , V _{OUT} =V _{SS} | - | 50 | - | mA | ① |
| CE High Level Voltage | V _{CEH} | - | 1.0 | - | 5.5 | V | ④ |
| CE Low Level Voltage | V _{CEL} | - | - | - | 0.3 | V | ④ |
| CE High Level Current (A/B/E/F/J/K/P/Q Type) | I _{CEH} | V _{CE} =V _{IN} =5.5V | -0.1 | - | 0.1 | μA | ④ |
| CE High Level Current (C/D/G/H/M/N/R/T Type) | I _{CEH} | V _{CE} =V _{IN} =5.5V | 3.0 | 5.5 | 9.0 | μA | ④ |
| CE Low Level Current | I _{CEL} | V _{CE} =V _{SS} | -0.1 | - | 0.1 | μA | ④ |
| C. Discharge Resistance (Only B/D/F/H/K/N/Q/T Type) | R _{DCHG} | V _{IN} =5.5V, V _{OUT} =2.0V, V _{CE} =V _{SS} | - | 300 | - | Ω | ① |
| Inrush Current (Only E/F/G/H/P/Q/R/T Type) | I _{rush} | V _{IN} =V _{CE} =5.5V | - | 150 | - | mA | ⑤ |
| Thermal Shutdown Detect Temperature | T _{TSD} | Junction Temperature | - | 150 | - | °C | ① |
| Thermal Shutdown Release Temperature | T _{TSR} | Junction Temperature | - | 120 | - | °C | |
| Thermal Shutdown Hysteresis Width | T _{TSD} - T _{TSR} | Junction Temperature | - | 30 | - | °C | |

NOTE:

- *1: V_{OUT(E)}: Effective output voltage
(i.e. the output voltage when "V_{OUT(T)}+1.0V" is provided at the V_{IN} pin while maintaining a certain I_{OUT} value.)
- *2: V_{OUT(T)}: Nominal output voltage
- *3: The standard output voltage is specified in V_{OUT(T)} ± 20mV where V_{OUT(T)} < 2.0V.
- *4: V_{dif} = {V_{IN1}{*5} - V_{OUT1}{*6}} (V_{IN1} ≥ 1.6V)
- *5: V_{IN1} = The input voltage when V_{OUT1} appears as input voltage is gradually decreased.
- *6: V_{OUT1} = A voltage equal to 98% of the output voltage whenever an amply stabilized I_{OUT} {V_{OUT(T)}+1.0V} is input
- *7: Unless otherwise stated regarding input voltage conditions, V_{IN}=V_{OUT(T)}+1.0V.

■ ELECTRICAL CHARACTERISTICS (Continued)

● Voltage Chart 1

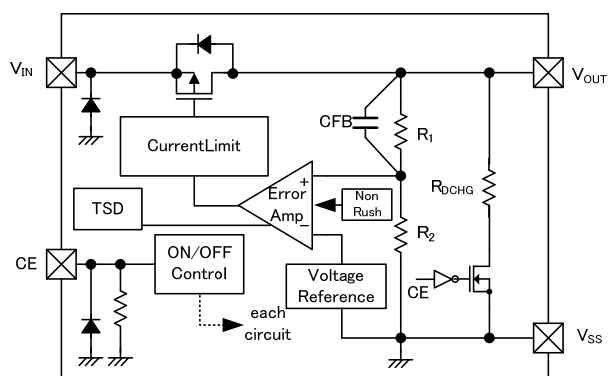
| SYMBOL PARAMETER NOMINAL OUTPUT VOLTAGE (V) | E-0 | | E-1 | |
|---|-----------------------|---------------------|-------------------------|------------------|
| | OUTPUT VOLTAGE (V) | | DROPOUT VOLTAGE (mV) | |
| | V _{OUT(T)} | V _{OUT(E)} | | V _{dif} |
| MIN | | MAX | TYP | MAX |
| 1.20 | 1.1800 | 1.2200 | 480 | 630 |
| 1.25 | 1.2300 | 1.2700 | | |
| 1.30 | 1.2800 | 1.3200 | 440 | 580 |
| 1.35 | 1.3300 | 1.3700 | | |
| 1.40 | 1.3800 | 1.4200 | 420 | 520 |
| 1.45 | 1.4300 | 1.4700 | | |
| 1.50 | 1.4800 | 1.5200 | | |
| 1.55 | 1.5300 | 1.5700 | | |
| 1.60 | 1.5800 | 1.6200 | 400 | 440 |
| 1.65 | 1.6300 | 1.6700 | | |
| 1.70 | 1.6800 | 1.7200 | | |
| 1.75 | 1.7300 | 1.7700 | | |
| 1.80 | 1.7800 | 1.8200 | 300 | 410 |
| 1.85 | 1.8300 | 1.8700 | | |
| 1.90 | 1.8800 | 1.9200 | | |
| 1.95 | 1.9300 | 1.9700 | | |
| 2.00 | 1.9800 | 2.0200 | 270 | 380 |
| 2.05 | 2.0295 | 2.0705 | | |
| 2.10 | 2.0790 | 2.1210 | | |
| 2.15 | 2.1285 | 2.1715 | | |
| 2.20 | 2.1780 | 2.2220 | | |
| 2.25 | 2.2275 | 2.2725 | | |
| 2.30 | 2.2770 | 2.3230 | | |
| 2.35 | 2.3265 | 2.3735 | | |
| 2.40 | 2.3760 | 2.4240 | 240 | 350 |
| 2.45 | 2.4255 | 2.4745 | | |
| 2.50 | 2.4750 | 2.5250 | | |
| 2.55 | 2.5245 | 2.5755 | | |
| 2.60 | 2.5740 | 2.6260 | | |
| 2.65 | 2.6235 | 2.6765 | | |
| 2.70 | 2.6730 | 2.7270 | | |
| 2.75 | 2.7225 | 2.7775 | | |

■ ELECTRICAL CHARACTERISTICS (Continued)

● Voltage Chart2

| SYMBOL | E-0 | | E-1 | |
|----------------------------|--------------------|--------|----------------------|------|
| PARAMETER | OUTPUT VOLTAGE (V) | | DROPOUT VOLTAGE (mV) | |
| NOMINAL OUTPUT VOLTAGE (V) | $V_{OUT(E)}$ | | V_{dif} | |
| $V_{OUT(T)}$ | MIN. | MAX. | TYP. | MAX. |
| 2.80 | 2.7720 | 2.8280 | 240 | 350 |
| 2.85 | 2.8215 | 2.8785 | | |
| 2.90 | 2.8710 | 2.9290 | | |
| 2.95 | 2.9205 | 2.9795 | | |
| 3.00 | 2.9700 | 3.0300 | 200 | 305 |
| 3.05 | 3.0195 | 3.0805 | | |
| 3.10 | 3.0690 | 3.1310 | | |
| 3.15 | 3.1185 | 3.1815 | | |
| 3.20 | 3.1680 | 3.2320 | | |
| 3.25 | 3.2175 | 3.2825 | | |
| 3.30 | 3.2670 | 3.3330 | | |
| 3.35 | 3.3165 | 3.3835 | | |
| 3.40 | 3.3660 | 3.4340 | | |
| 3.45 | 3.4155 | 3.4845 | | |
| 3.50 | 3.4650 | 3.5350 | | |
| 3.55 | 3.5145 | 3.5855 | | |
| 3.60 | 3.5640 | 3.6360 | | |
| 3.65 | 3.6135 | 3.6865 | | |
| 3.70 | 3.6630 | 3.7370 | | |
| 3.75 | 3.7125 | 3.7875 | | |
| 3.80 | 3.7620 | 3.8380 | | |
| 3.85 | 3.8115 | 3.8885 | | |
| 3.90 | 3.8610 | 3.9390 | | |
| 3.95 | 3.9105 | 3.9895 | | |
| 4.00 | 3.9600 | 4.0400 | | |

■ OPERATIONAL EXPLANATION



The voltage divided by resistors R1 & R2 is compared with the internal reference voltage by the error amplifier. The P-channel MOSFET which is connected to the Output pin (V_{OUT}) is then driven by the subsequent control signal. The output voltage at the Output pin (V_{OUT}) is controlled and stabilized by a system of negative feedback. The current limit circuit and short circuit protection operate in relation to the level of output current and heat dissipation. Further, the IC's internal circuitry can be shutdown via the CE pin (CE) signal.

<Low ESR Capacitor>

The XC6223 series needs an output capacitor C_L for phase compensation. In order to ensure the stable phase compensation, please place an output capacitor of 1.0 μ F or bigger at the V_{OUT} pin and V_{SS} pin as close as possible. For a stable power input, please connect an input capacitor (C_{IN}) of 1.0 μ F between the input pin (V_{IN}) and the ground pin (V_{SS}).

<Current Limiter, Short-Circuit Protection>

The protection circuit operates as a combination of an output current limiter and fold-back short circuit protection. When load current reaches the current limit level, the output voltage drops. As a result, the load current starts to reduce with showing fold-back curve. The output current finally falls at the level of 50mA when the output pin is short-circuited.

<CE Pin>

The IC's internal circuitry can be shutdown via the signal from the CE pin (CE). In shutdown mode, the XC6223B/D/F/H/K/N/Q/T series enables the electric charge at the output capacitor (C_L) to be discharged via the internal auto-discharge switch, and as a result the output pin (V_{OUT}) quickly returns to the ground pin (V_{SS}) level. When the CE pin (CE) is open, the output voltage becomes undefined state in the XC6223A/B/E/F/J/K/P/Q series because of a high active and no pull-down. On the other hand, the XC6223C/D/G/H/M/N/R/T series has a pull-down resistor at the CE pin (CE) inside, so that the CE pin (CE) input current flows.

<Thermal Shutdown>

When the junction temperature of the built-in driver transistor reaches the temperature limit, the thermal shutdown circuit operates and the driver transistor will be set to OFF. The IC resumes its operation when the thermal shutdown function is released and the IC's operation is automatically restored because the junction temperature drops to the level of the thermal shutdown release voltage.

<Inrush Current Protection>

The inrush current protection circuit is built in the XC6223 series.

When the IC starts to operate, the protection circuit limits the inrush current from input pin (V_{IN}) to output pin (V_{OUT}) to charge C_L capacitor. This function is built in the XC6223E/F/G/H/P/Q/R/T series.

■ NOTES ON USE

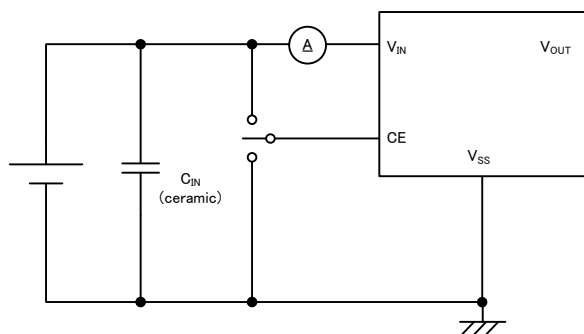
1. Where wiring impedance is high, operations may become unstable due to the noise and/or phase lag depending on output current. Please strengthen input pin (V_{IN}) and output pin (V_{OUT}) wiring in particular.
2. The input capacitor C_{IN} and the output capacitor C_L should be placed to the as close as possible with a shorter wiring.
3. The IC is controlled with constant current start-up. Start-up sequence control is requested to draw a load current after even nominal output voltage rising up the output voltage.
4. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.
5. Torex places an importance on improving our products and its reliability.
However, by any possibility, we would request user fail-safe design and post-aging treatment on system or equipment.

TEST CIRCUITS

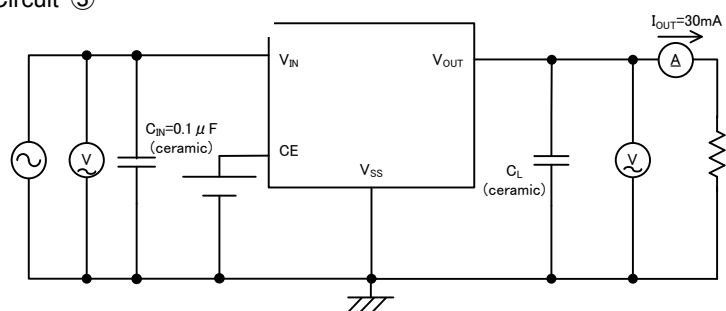
●Circuit ①



●Circuit ②



●Circuit ③



TEST CIRCUITS (Continued)

● Circuit ④

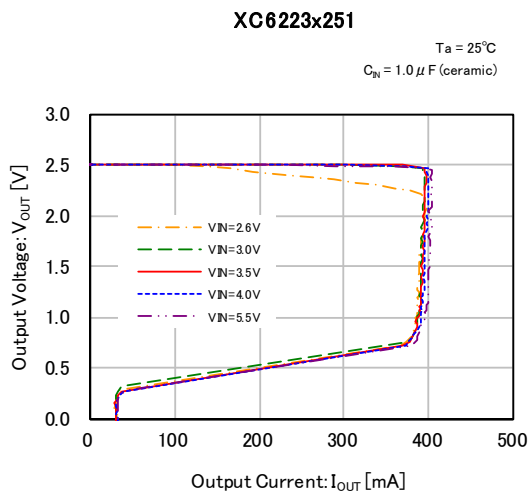
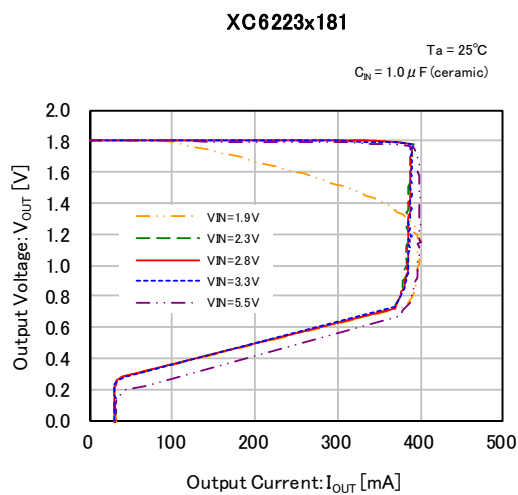


● Circuit ⑤



■ TYPICAL PERFORMANCE CHARACTERISTICS

(1) Output Voltage vs. Output Current

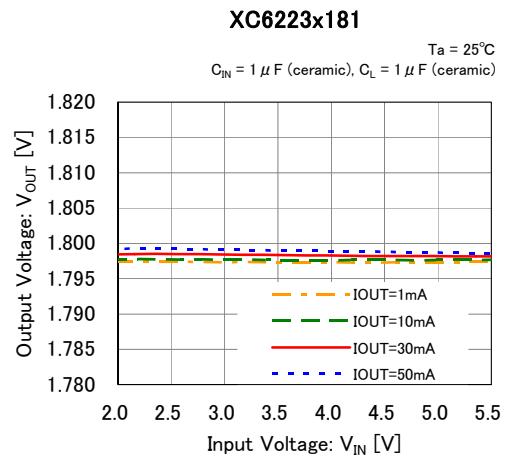
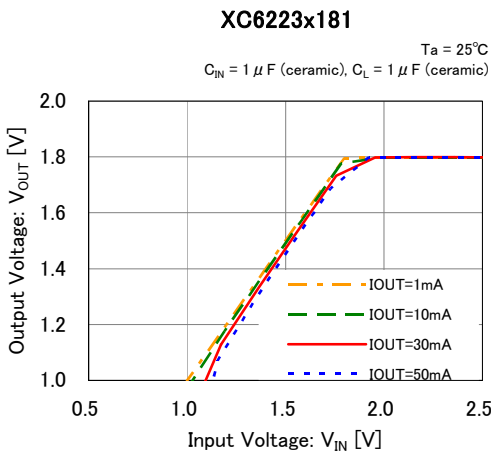
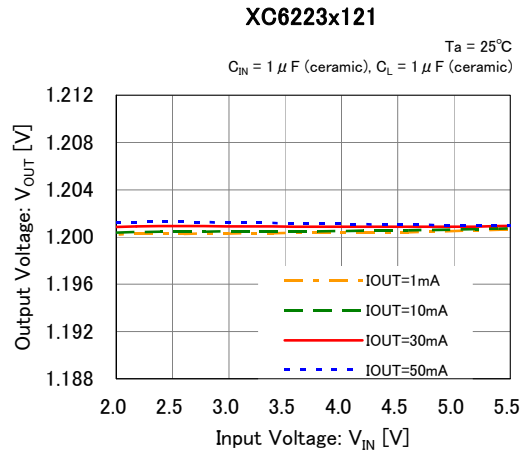
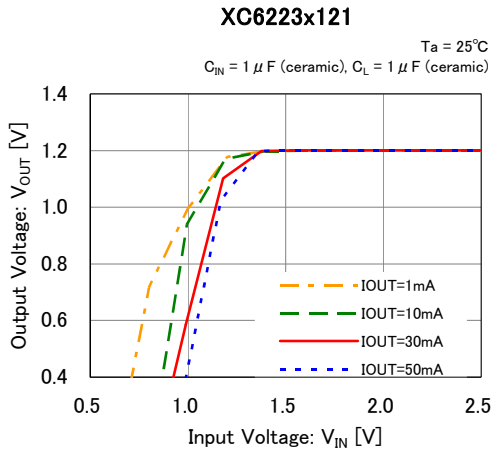


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(1) Output Voltage vs. Output Current (Continued)



(2) Output Voltage vs. Input Voltage



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(2) Output Voltage vs. Input Voltage (Continued)

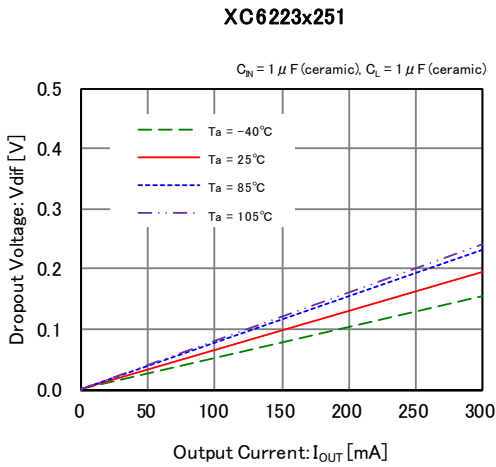


(3) Dropout Voltage vs. Output Current

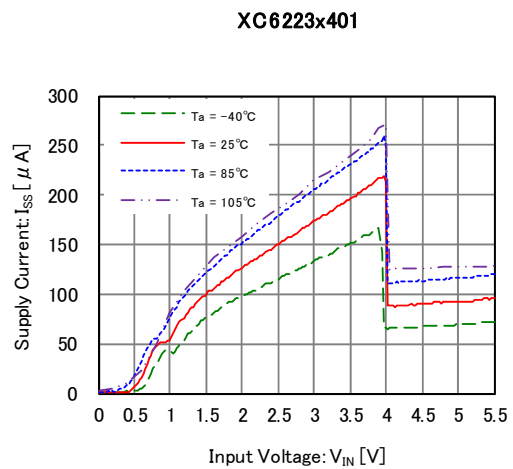
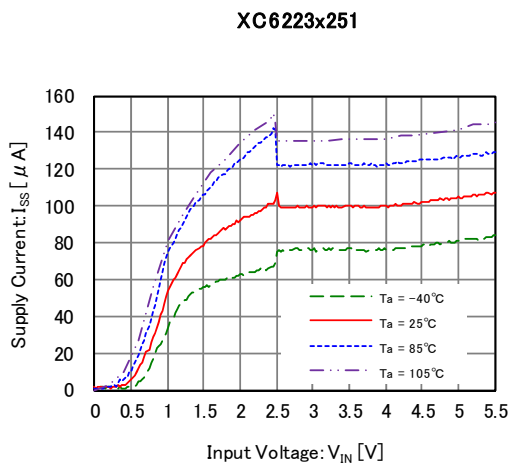
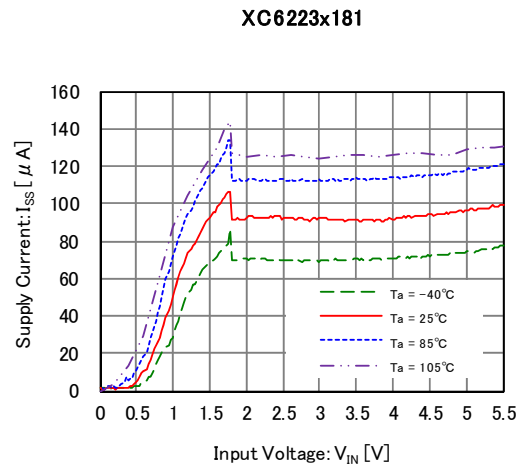


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(3) Dropout Voltage vs. Output Current (Continued)

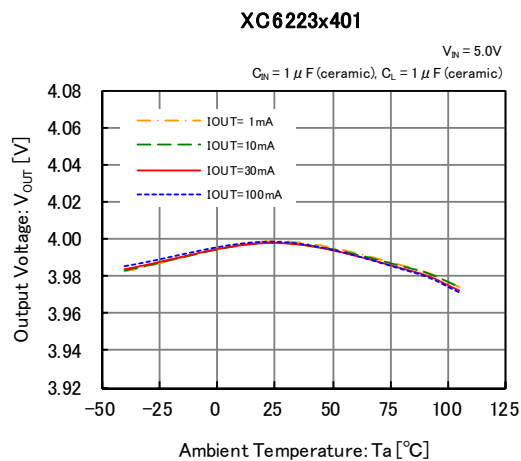
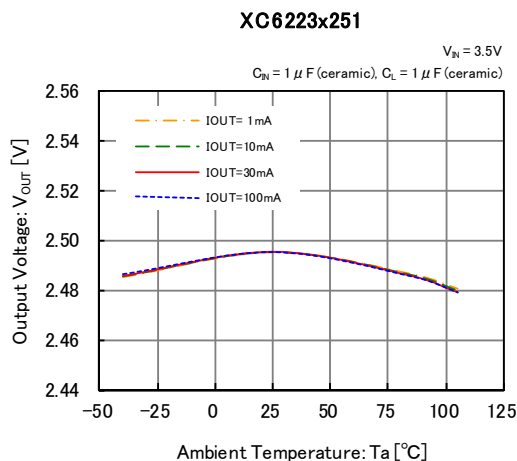
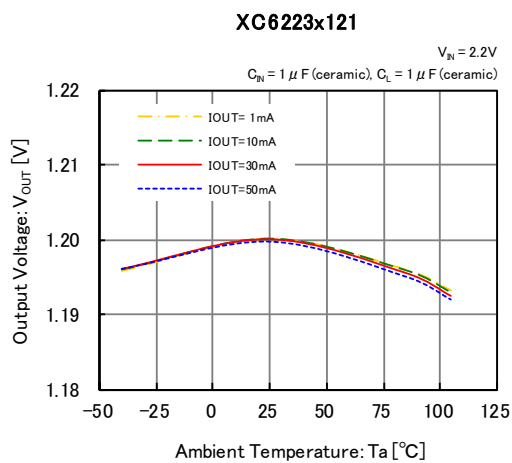


(4) Supply Current vs. Input Voltage

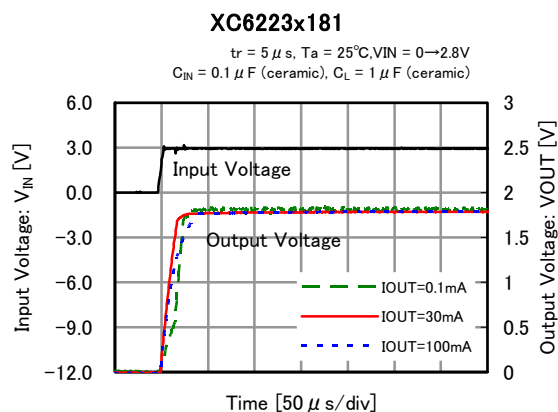
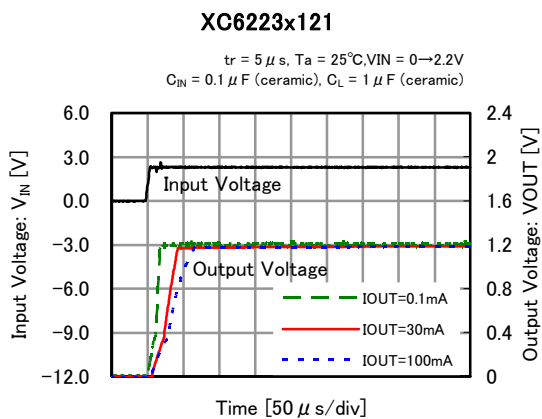


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(5) Output Voltage vs. Ambient Temperature



(6) Rising Response Time

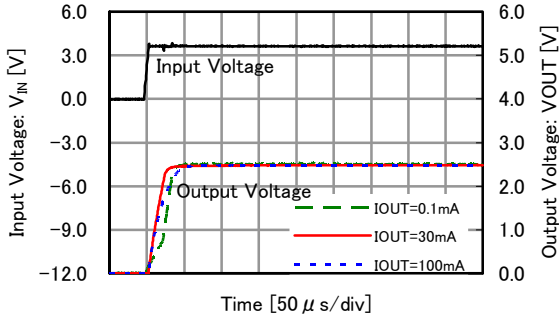


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(6) Rising Response Time (Continued)

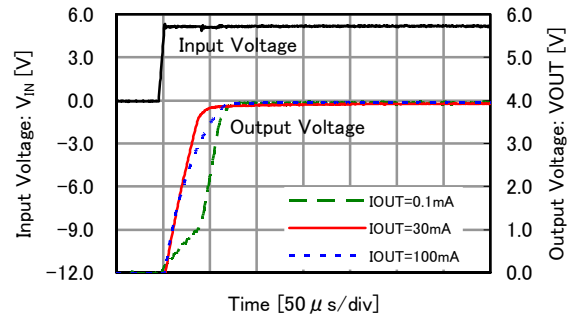
XC6223x251

$t_r = 5 \mu s$, $T_a = 25^\circ C$, $V_{IN} = 0 \rightarrow 3.5V$
 $C_{IN} = 0.1 \mu F$ (ceramic), $C_L = 1 \mu F$ (ceramic)



XC6223x401

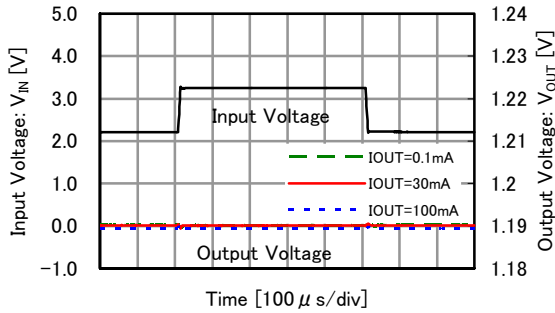
$t_r = 5 \mu s$, $T_a = 25^\circ C$, $V_{IN} = 0 \rightarrow 5.0V$
 $C_{IN} = 0.1 \mu F$ (ceramic), $C_L = 1 \mu F$ (ceramic)



(7) Input Transient Response

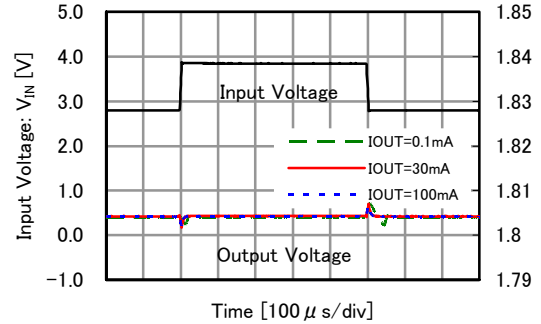
XC6223x121

$t_r = t_f = 5 \mu s$, $T_a = 25^\circ C$, $V_{IN} = 2.2V \leftrightarrow 3.2V$
 $C_{IN} = 0.1 \mu F$ (ceramic), $C_L = 1.0 \mu F$ (ceramic)



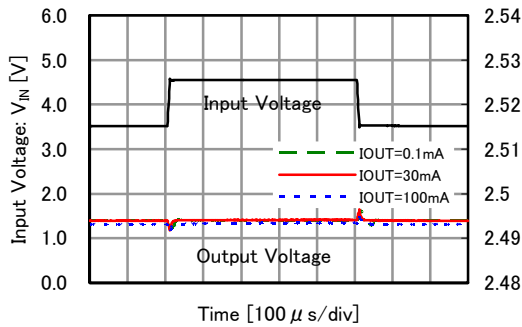
XC6223x181

$t_r = t_f = 5 \mu s$, $T_a = 25^\circ C$, $V_{IN} = 2.8V \leftrightarrow 3.8V$
 $C_{IN} = 0.1 \mu F$ (ceramic), $C_L = 1.0 \mu F$ (ceramic)



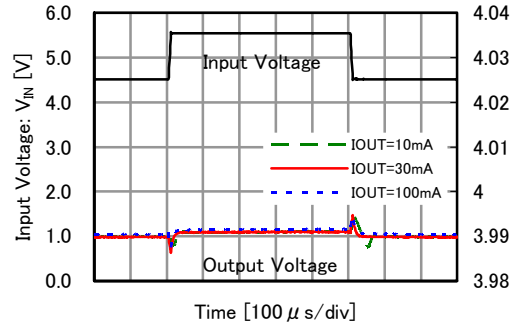
XC6223x251

$t_r = t_f = 5 \mu s$, $T_a = 25^\circ C$, $V_{IN} = 3.5V \leftrightarrow 4.5V$
 $C_{IN} = 0.1 \mu F$ (ceramic), $C_L = 1.0 \mu F$ (ceramic)



XC6223x401

$t_r = t_f = 5 \mu s$, $T_a = 25^\circ C$, $V_{IN} = 4.5V \leftrightarrow 5.5V$
 $C_{IN} = 0.1 \mu F$ (ceramic), $C_L = 1.0 \mu F$ (ceramic)



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(8) Load Transient Response ($t_r=t_f=0.5\mu s$)



TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(8) Load Transient Response ($t_r=t_f=0.5\mu s$) (Continued)

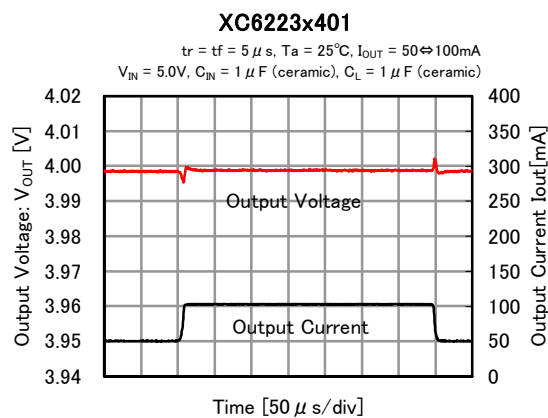
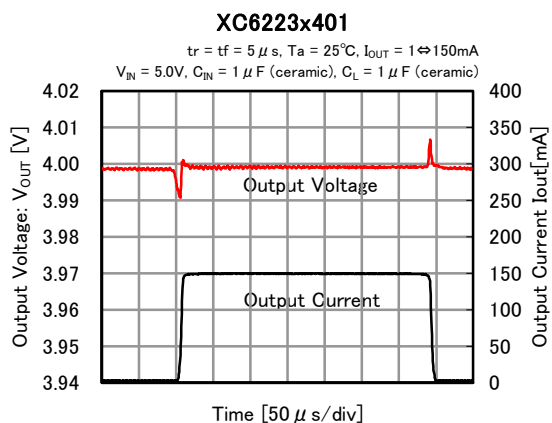
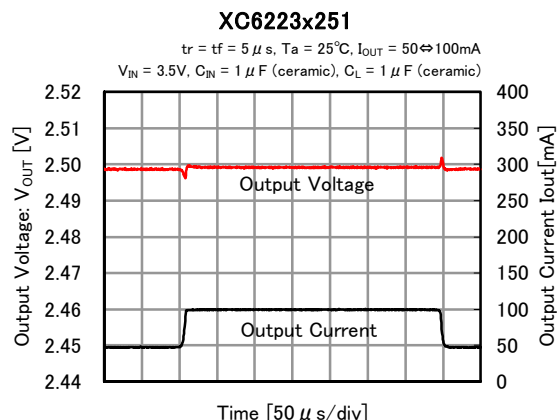
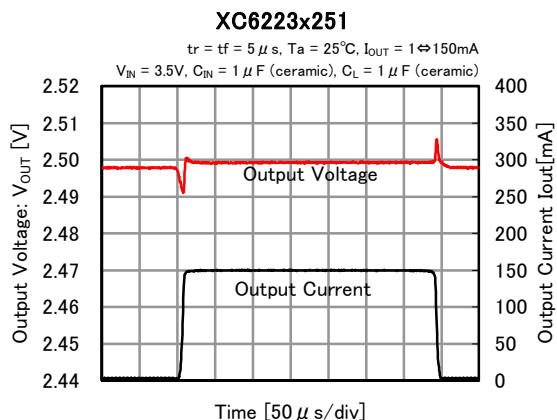


(8) Load Transient Response ($t_r=t_f=5\mu s$) (Continued)

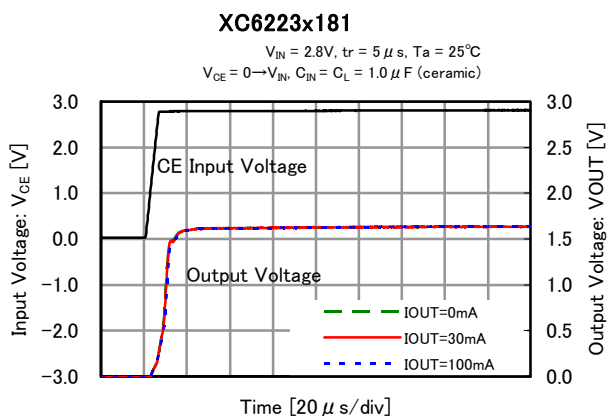
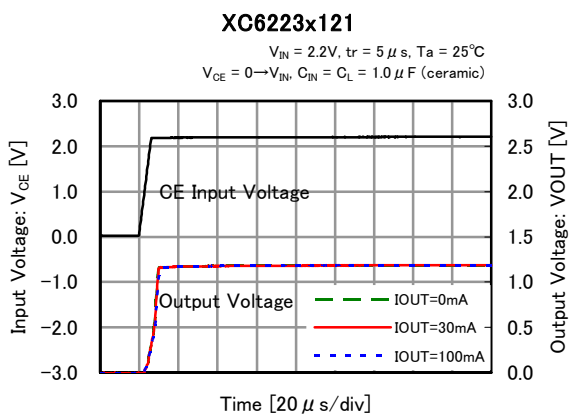


■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(8) Load Transient Response ($t_r=t_f=5\mu s$) (Continued)



(9) CE Rising Response Time (A,B,C,D J,K,M,N Type)

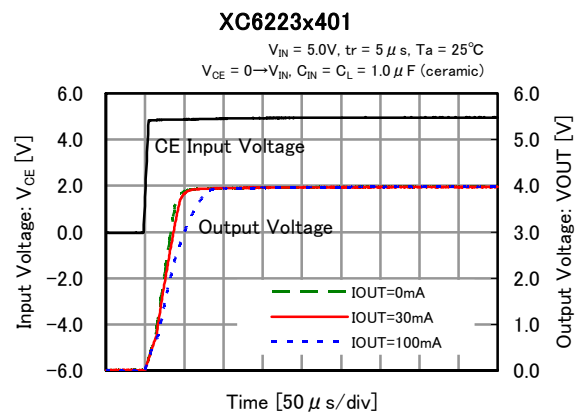
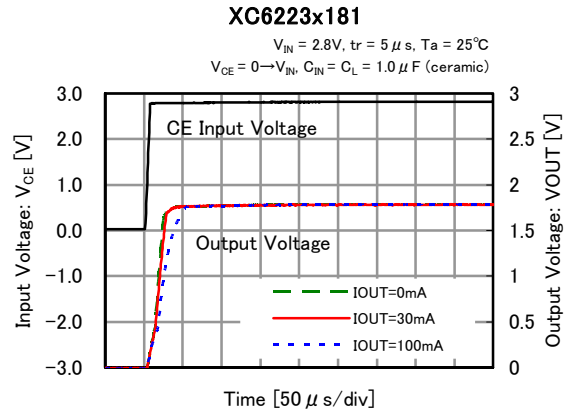


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) CE Rising Response Time (A,B,C,D,J,K,M,N Type) (Continued)

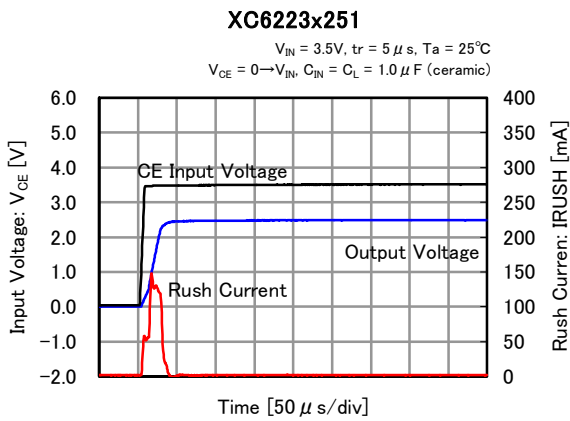
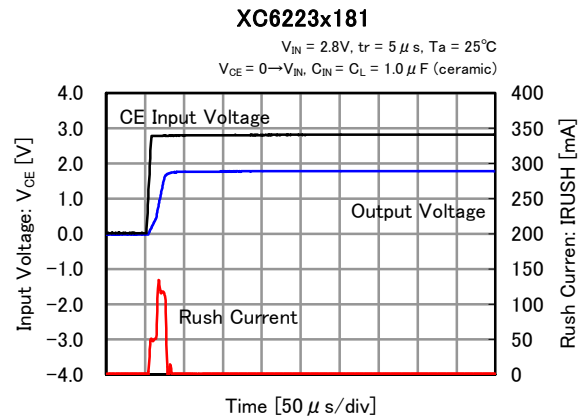
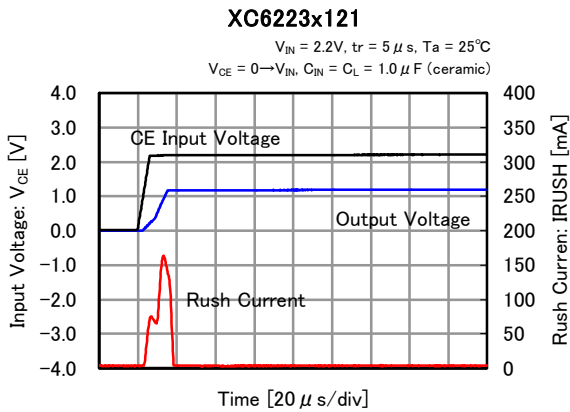


(9) CE Rising Response Time (E,F,G,H,P,Q,R,T Type) (Continued)



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(10) Inrush Current Response Time (E,F,G,H,P,Q,R,T Type)



TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(11) Ripple Rejection Rate

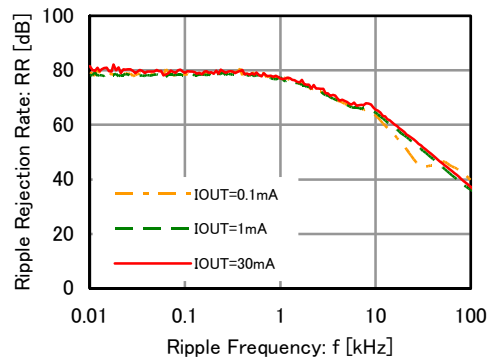
XC6223x121

$T_a = 25^\circ\text{C}$, $V_{IN} = 3.0\text{VDC} + 0.5\text{Vp-pAC}$
 $C_{IN} = 0.1 \mu\text{F}$ (ceramic), $C_L = 1 \mu\text{F}$ (ceramic)



XC6223x181

$T_a = 25^\circ\text{C}$, $V_{IN} = 3.0\text{VDC} + 0.5\text{Vp-pAC}$
 $C_{IN} = 0.1 \mu\text{F}$ (ceramic), $C_L = 1 \mu\text{F}$ (ceramic)



XC6223x251

$T_a = 25^\circ\text{C}$, $V_{IN} = 3.5\text{VDC} + 0.5\text{Vp-pAC}$
 $C_{IN} = 0.1 \mu\text{F}$ (ceramic), $C_L = 1 \mu\text{F}$ (ceramic)



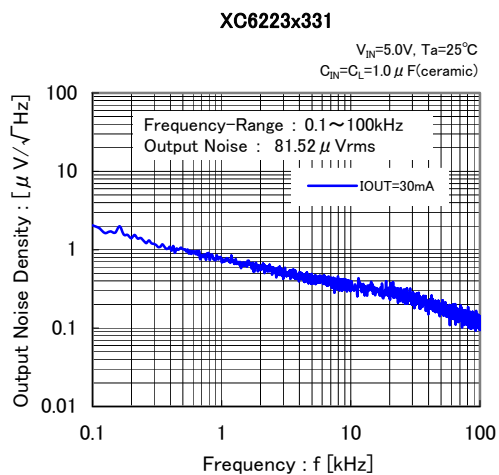
XC6223x331

$T_a = 25^\circ\text{C}$, $V_{IN} = 4.3\text{VDC} + 0.5\text{Vp-pAC}$
 $C_{IN} = 0.1 \mu\text{F}$ (ceramic), $C_L = 1 \mu\text{F}$ (ceramic)



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(12) Output Noise Density

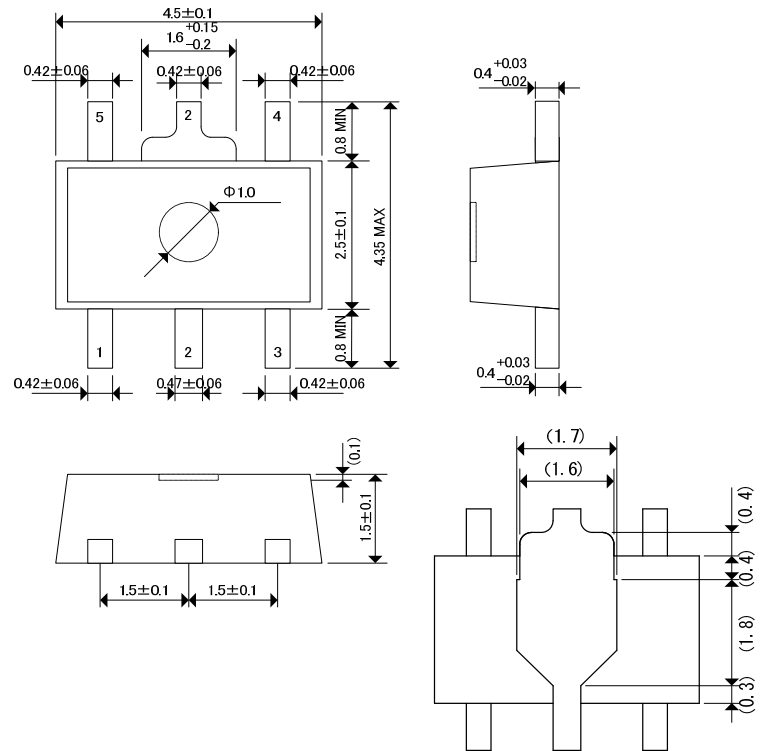


■ **PACKAGING INFORMATION (Continued)**

● SOT-25



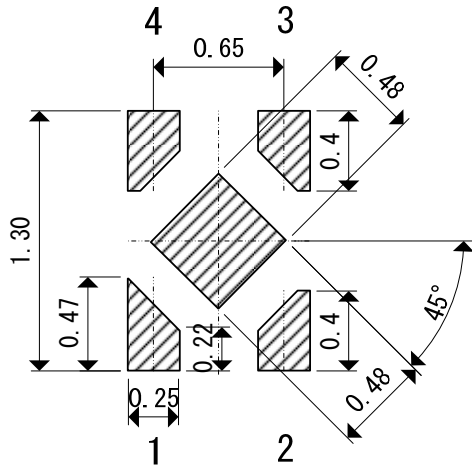
● SOT-89-5



PACKAGING INFORMATION (Continued)

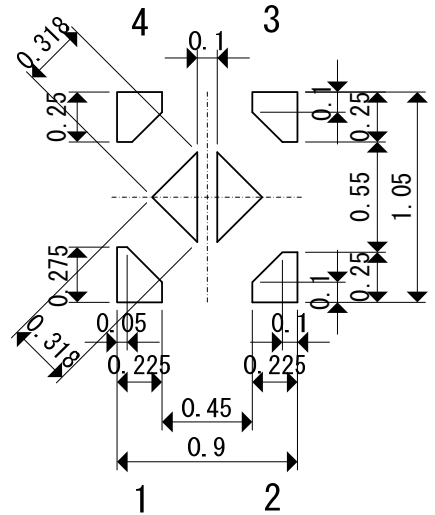
●USPQ-4B03 Reference Pattern Layout

(unit : mm)



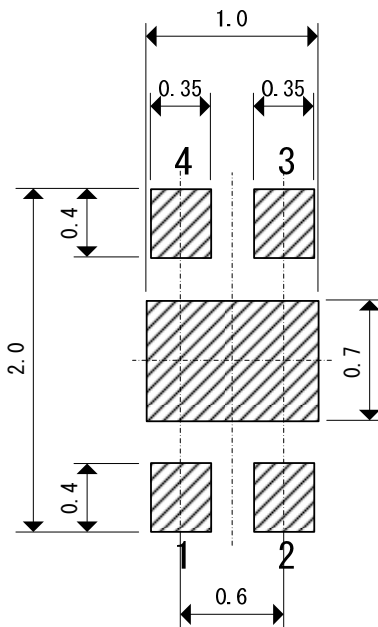
●USPQ-4B03 Reference Metal Mask Design

(unit : mm)



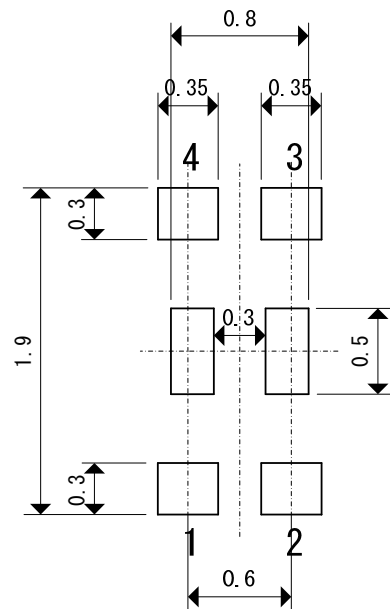
●USP-4 Reference Pattern Layout

(unit : mm)



●USP-4 Reference Metal Mask Design

(unit : mm)



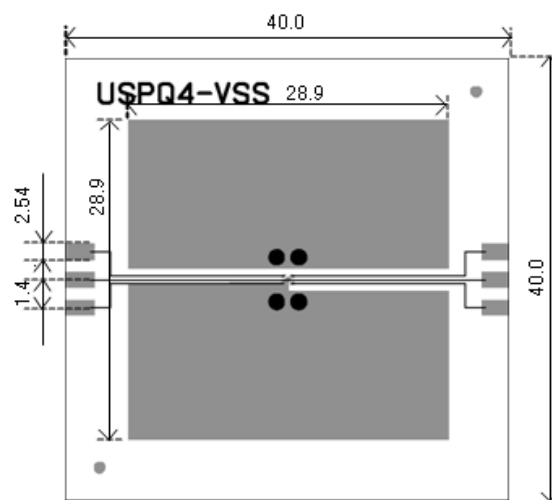
■ PACKAGING INFORMATION (Continued)

● USPQ-4B03 Power Dissipation

Power dissipation data for the USPQ-4B03 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 (1600mm²)
 Board Structure : 4 Copper Layers
 Each layer is connected to the package heat-sink and terminal pin No.1.
 Each layer has approximately 800mm² copper area.
 Material : Glass Epoxy (FR-4)
 Thickness : 1.6 mm
 Through-hole : 4 x 0.8 Diameter

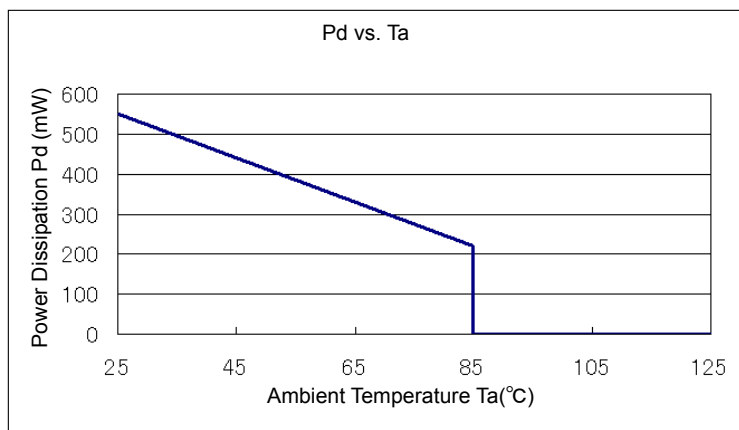


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient Temperature (85°C)

Board Mount (T_{jmax}=125°C)

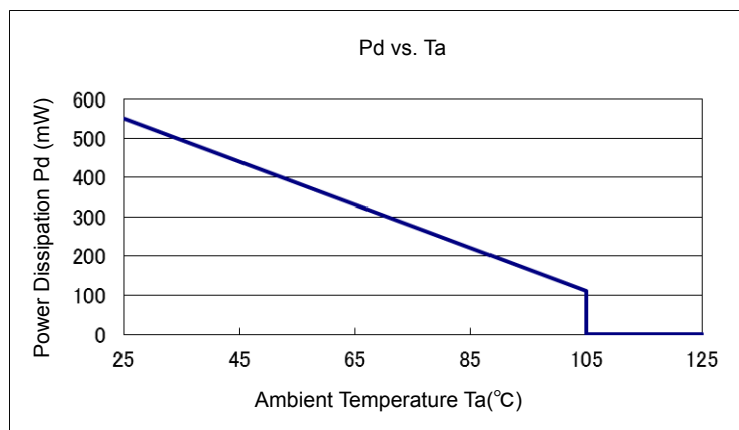
| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 550 | 181.82 |
| 85 | 220 | |



3. Power Dissipation vs. Ambient Temperature (105°C)

Board Mount (T_{jmax}=125°C)

| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 550 | 181.82 |
| 105 | 110 | |



PACKAGING INFORMATION (Continued)

● USP-4 Power Dissipation

Power dissipation data for the USP-4 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: 1.6 mm
- Through-hole: 4 x 0.8 Diameter

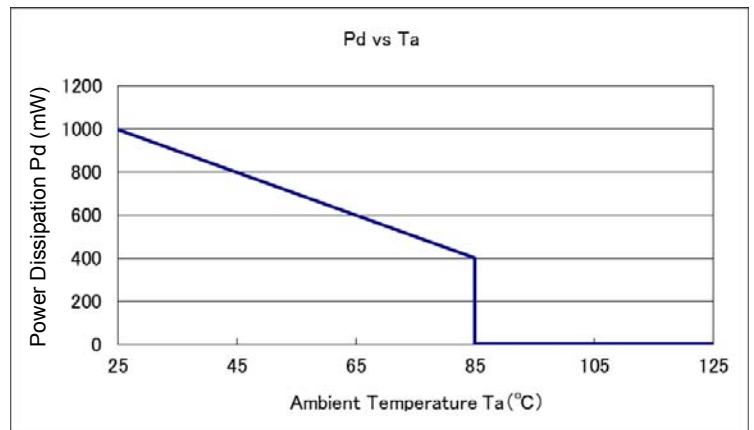


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient Temperature (85°C)

Board Mount (T_{jmax}=125°C)

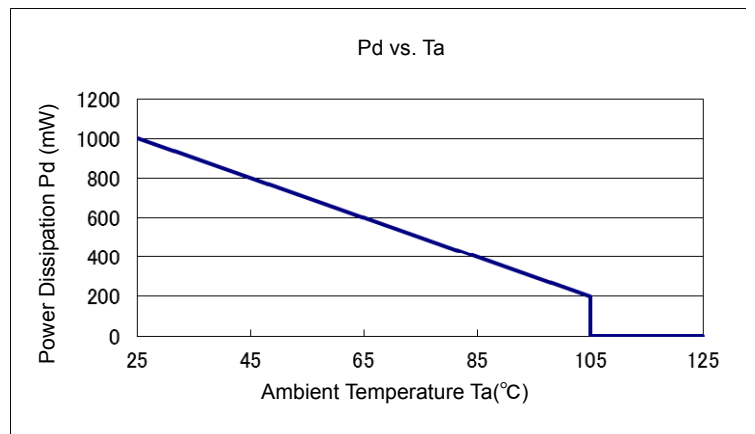
| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 1000 | 100.00 |
| 85 | 400 | |



3. Power Dissipation vs. Ambient Temperature (105°C)

Board Mount (T_{jmax}=125°C)

| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 1000 | 100.00 |
| 105 | 200 | |



■ PACKAGING INFORMATION (Continued)

● SSOT-24 Power Dissipation

Power dissipation data for the SSOT-24 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: 1.6 mm
- Through-hole: 4 x 0.8 Diameter

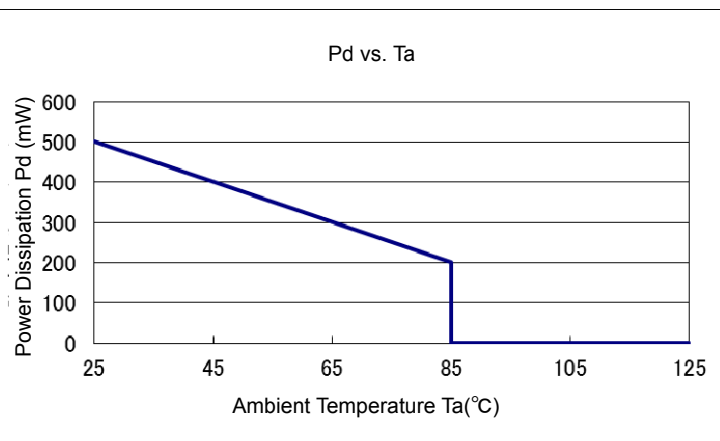


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient Temperature (85°C)

Board Mount (T_{jmax}=125°C)

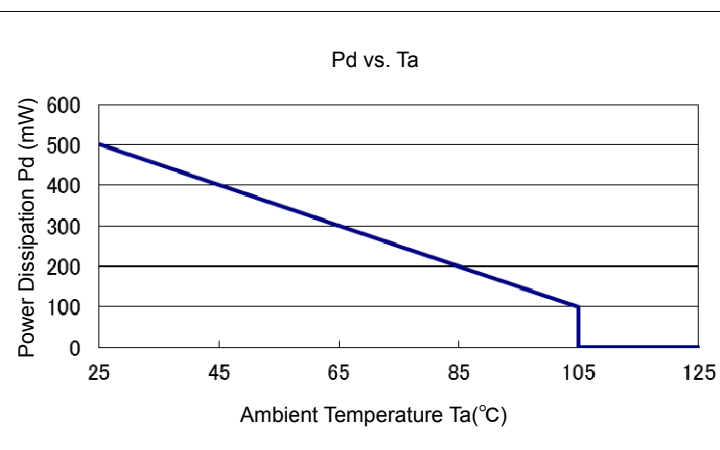
| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 500 | 200.00 |
| 85 | 200 | |



3. Power Dissipation vs. Ambient Temperature (105°C)

Board Mount (T_{jmax}=125°C)

| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 500 | 200.00 |
| 105 | 100 | |



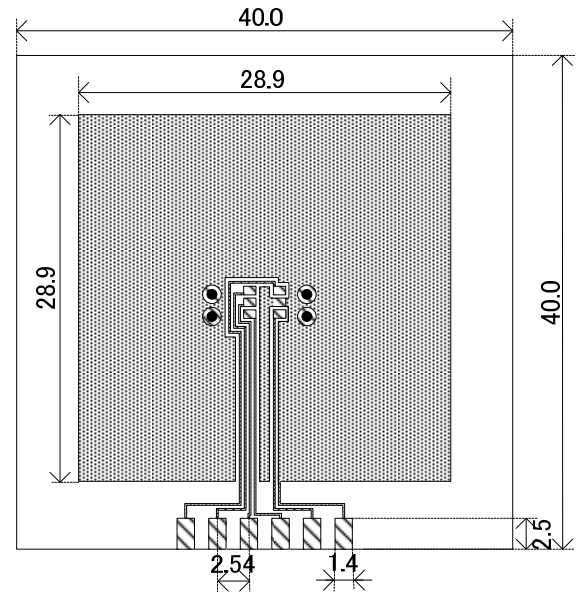
PACKAGING INFORMATION (Continued)

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: 1.6 mm
- Through-hole: 4 x 0.8 Diameter



Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient temperature (85°C)

Board Mount (Tjmax=125°C)

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



3. Power Dissipation vs. Ambient temperature (105°C)

Board Mount (Tjmax=125°C)

| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 600 | 166.67 |
| 105 | 120 | |



■ 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: 1.6 mm
- Through-hole: 5 x 0.8 Diameter



Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient temperature (85°C)

Board Mount (T_j max = 125°C)

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



3. Power Dissipation vs. Ambient temperature (105°C)

Board Mount (T_j max = 125°C)

| Ambient Temperature (°C) | Power Dissipation Pd (mW) | Thermal Resistance (°C/W) |
|--------------------------|---------------------------|---------------------------|
| 25 | 1300 | 76.92 |
| 105 | 260 | |



MARKING RULE

● USPQ-4B03

① represents type of regulator and output voltage range.

| MARK | | | PRODUCT SERIES |
|-----------------------------------|---------------|------------------------------------|----------------|
| OUTPUT VOLTAGE 0.1V INCREMENTS | | OUTPUT VOLTAGE 0.05V INCREMENTS | |
| VOLTAGE=1.2~3.9V | VOLTAGE =4.0V | VOLTAGE =1.25~3.95V | |
| 0 | H | 8 | XC6223A/J***** |
| 1 | | 9 | XC6223B/K***** |
| 2 | | A | XC6223C/M***** |
| 3 | | B | XC6223D/N***** |
| 4 | | C | XC6223E/P***** |
| 5 | | D | XC6223F/Q***** |
| 6 | | E | XC6223G/R***** |
| 7 | | F | XC6223H/T***** |



② represents output voltage.

VOLTAGE=1.2~3.95[V]

| MARK | OUTPUT VOLTAGE (V) | | MARK | OUTPUT VOLTAGE (V) | |
|------|--------------------|------|------|--------------------|------|
| 0 | - | - | F | 2.50 | 2.55 |
| 1 | - | - | H | 2.60 | 2.65 |
| 2 | 1.20 | 1.25 | K | 2.70 | 2.75 |
| 3 | 1.30 | 1.35 | L | 2.80 | 2.85 |
| 4 | 1.40 | 1.45 | M | 2.90 | 2.95 |
| 5 | 1.50 | 1.55 | N | 3.00 | 3.05 |
| 6 | 1.60 | 1.65 | P | 3.10 | 3.15 |
| 7 | 1.70 | 1.75 | R | 3.20 | 3.25 |
| 8 | 1.80 | 1.85 | S | 3.30 | 3.35 |
| 9 | 1.90 | 1.95 | T | 3.40 | 3.45 |
| A | 2.00 | 2.05 | U | 3.50 | 3.55 |
| B | 2.10 | 2.15 | V | 3.60 | 3.65 |
| C | 2.20 | 2.25 | X | 3.70 | 3.75 |
| D | 2.30 | 2.35 | Y | 3.80 | 3.85 |
| E | 2.40 | 2.45 | Z | 3.90 | 3.95 |

VOLTAGE=4.0[V]

| PRODUCT SERIES | MARK |
|----------------|------|
| XC6223A/J***** | 0 |
| XC6223B/K***** | 1 |
| XC6223C/M***** | 2 |
| XC6223D/N***** | 3 |
| XC6223E/P***** | 4 |
| XC6223F/Q***** | 5 |
| XC6223G/R***** | 6 |
| XC6223H/T***** | 7 |

③④ 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.

MARKING RULE (Continued)

●SSOT-24 (with bar)

① represents type of regulator and output voltage range.

| MARK | | | PRODUCT SERIES |
|-----------------------------------|-------------------|------------------------------------|----------------|
| OUTPUT VOLTAGE 0.1V INCREMENTS | | OUTPUT VOLTAGE 0.05V INCREMENTS | |
| VOLTAGE =1.2~2.9V | VOLTAGE =3.0~4.0V | VOLTAGE =1.25~3.95V | |
| B | 3 | 8 | XC6223A/J***** |
| C | 5 | 9 | XC6223B/K***** |
| D | 7 | S | XC6223C/M***** |
| E | A | T | XC6223D/N***** |
| K | F | U | XC6223E/P***** |
| L | H | V | XC6223F/Q***** |
| M | P | X | XC6223G/R***** |
| N | Z | Y | XC6223H/T***** |



SSOT-24(with bar)
(TOP VIEW)

② represents output voltage.

| MARK | OUTPUT VOLTAGE (V) | | | | MARK | OUTPUT VOLTAGE (V) | | | |
|------|--------------------|------|---|------|------|--------------------|------|---|------|
| 0 | - | - | - | - | F | 2.50 | 3.20 | - | 2.55 |
| 1 | - | - | - | - | H | 2.60 | 3.30 | - | 2.65 |
| 2 | 1.20 | - | - | 1.25 | K | 2.70 | 3.40 | - | 2.75 |
| 3 | 1.30 | - | - | 1.35 | L | 2.80 | 3.50 | - | 2.85 |
| 4 | 1.40 | - | - | 1.45 | M | 2.90 | 3.60 | - | 2.95 |
| 5 | 1.50 | - | - | 1.55 | N | - | - | - | 3.05 |
| 6 | 1.60 | - | - | 1.65 | P | - | 3.70 | - | 3.15 |
| 7 | 1.70 | - | - | 1.75 | R | - | 3.80 | - | 3.25 |
| 8 | 1.80 | - | - | 1.85 | S | - | 3.90 | - | 3.35 |
| 9 | 1.90 | - | - | 1.95 | T | - | 4.00 | - | 3.45 |
| A | 2.00 | - | - | 2.05 | U | - | - | - | 3.55 |
| B | 2.10 | - | - | 2.15 | V | - | - | - | 3.65 |
| C | 2.20 | - | - | 2.25 | X | - | - | - | 3.75 |
| D | 2.30 | 3.00 | - | 2.35 | Y | - | - | - | 3.85 |
| E | 2.40 | 3.10 | - | 2.45 | Z | - | - | - | 3.95 |

③④ 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.

MARKING RULE (Continued)

●SOT-25, SOT-89-5, USP-4

① represents product series

| MARK | PRODUCT SERIES |
|------|----------------|
| 9 | XC6223***** |

② represents type of regulator.

| MARK | | | PRODUCT SERIES |
|-----------------------------------|---------------|------------------------------------|----------------|
| OUTPUT VOLTAGE 0.1V INCREMENTS | | OUTPUT VOLTAGE 0.05V INCREMENTS | |
| VOLTAGE =1.2~3.9V | VOLTAGE =4.0V | VOLTAGE =1.25~3.95V | |
| C | D | E | XC6223A/J***** |
| F | H | K | XC6223B/K***** |
| L | M | N | XC6223C/M***** |
| P | R | S | XC6223D/N***** |
| T | U | V | XC6223E/P***** |
| X | Y | Z | XC6223F/Q***** |
| 0 | 1 | 2 | XC6223G/R***** |
| 3 | 4 | 5 | XC6223H/T***** |

③ represents output voltage.

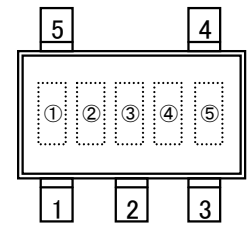
| MARK | OUTPUT VOLTAGE (V) | | | | MARK | OUTPUT VOLTAGE (V) | | | |
|------|--------------------|------|------|---|------|--------------------|---|------|---|
| | | | | | | | | | |
| 0 | - | 4.00 | - | - | F | 2.50 | - | 2.55 | - |
| 1 | - | - | - | - | H | 2.60 | - | 2.65 | - |
| 2 | 1.20 | - | 1.25 | - | K | 2.70 | - | 2.75 | - |
| 3 | 1.30 | - | 1.35 | - | L | 2.80 | - | 2.85 | - |
| 4 | 1.40 | - | 1.45 | - | M | 2.90 | - | 2.95 | - |
| 5 | 1.50 | - | 1.55 | - | N | 3.00 | - | 3.05 | - |
| 6 | 1.60 | - | 1.65 | - | P | 3.10 | - | 3.15 | - |
| 7 | 1.70 | - | 1.75 | - | R | 3.20 | - | 3.25 | - |
| 8 | 1.80 | - | 1.85 | - | S | 3.30 | - | 3.35 | - |
| 9 | 1.90 | - | 1.95 | - | T | 3.40 | - | 3.45 | - |
| A | 2.00 | - | 2.05 | - | U | 3.50 | - | 3.55 | - |
| B | 2.10 | - | 2.15 | - | V | 3.60 | - | 3.65 | - |
| C | 2.20 | - | 2.25 | - | X | 3.70 | - | 3.75 | - |
| D | 2.30 | - | 2.35 | - | Y | 3.80 | - | 3.85 | - |
| E | 2.40 | - | 2.45 | - | Z | 3.90 | - | 3.95 | - |

④⑤ represents production lot number.

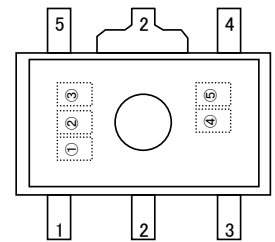
01 to 09, 0A to 0Z, 11 to 9Z, A1 to A9, AA to Z9, ZA to ZZ in order.

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

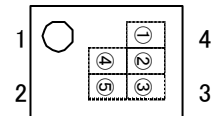
*No character inversion used.



SOT-25
(TOP VIEW)



SOT-89-5
(TOP VIEW)



USP-4
(TOP VIEW)