

## 28V Operation Voltage Regulator with Voltage Detector

### ■ GENERAL DESCRIPTION

The XC6408 series is a positive voltage regulator IC manufactured using CMOS process with 28V operation voltage. The series consists of a voltage reference, an error amplifier, a current limiter, a thermal shutdown circuit and a phase compensation circuit plus a driver transistor. The output voltage and the detect voltage are user selectable in 0.1V increments. 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. The XC6408D series monitors its output voltage and provides reset signal if its output voltage falls below the pre-set voltage. This reset time (release delay time) can be set by an external capacitor. The XC6408E series monitors an external power supply and enables the output to be turned off and the IC becomes a stand-by mode.

### ■ APPLICATIONS

- Note book computers, PDAs
- Car audio, Car navigation systems
- Home appliances
- Audio visuals, Digital cameras, Video cameras
- Cordless phones, Wireless communication

### ■ FEATURES

|                          |   |
|--------------------------|---|
| Max Output Current       | : 150mA ( $V_{IN}=V_{ROUT}+3.0V$ )                          |
| Dropout Voltage          | : 175mV @ $I_{OUT}=20mA$ ( $V_{ROUT}=12V$ )                 |
| Input Voltage Range      | : 2.0V~28.0V  |
| Output Voltage Range     | : 2.0V~18.0V (0.1V increments)                              |
| Detect Voltage Range     | : 2.0V~16.0V (0.1V increments)                              |
| High Accuracy(Regulator) | : $\pm 2\%$   |
| (Detector)               | $\pm 2.5\%$   |
| Low Power Consumption    | : XC6408D 9.5 $\mu A$ (TYP.) ( $V_{ROUT}=12V, V_{DF}=11V$ ) |
|                          | : XC6408E 8 $\mu A$ (TYP.) ( $V_{ROUT}=12V, V_{DF}=11V$ )   |
| Operating Temperature    | : $-40^{\circ}C \sim +85^{\circ}C$                          |
| Packages                 | : SOT-89-5, SOT-25, USP-6C                                  |
| Environmentally Friendly | : EU RoHS Compliant, Pb Free                                |

### ■ TYPICAL APPLICATION CIRCUITS



XC6408D Series



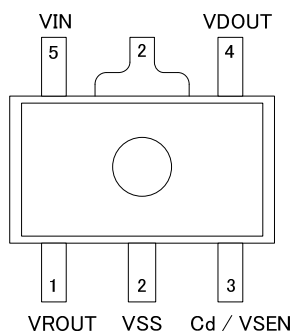
XC6408E Series

### ■ TYPICAL PERFORMANCE CHARACTERISTICS

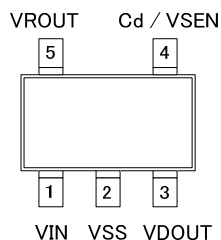
- Supply Current vs. Input Voltage



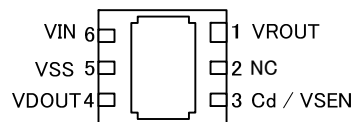
## PIN CONFIGURATION



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 reference mount pattern and metal masking to enhance mounting strength and heat release. If the pad needs to be connected to other pins, it should be connected to the V<sub>SS</sub> (No. 5) pin.

## PIN ASSIGNMENT

| PIN NUMBER |        |        | PIN NAME          | FUNCTIONS                 |
|------------|--------|--------|-------------------|---------------------------|
| SOT-89-5   | SOT-25 | USP-6C |                   |                           |
| 1          | 5      | 1      | V <sub>ROUT</sub> | VR Output                 |
| 2          | 2      | 5      | V <sub>SS</sub>   | Ground                    |
| 3          | 4      | 3      | V <sub>SEN</sub>  | Sense(E series)           |
|            |        |        | Cd                | Delay Capacitor(D series) |
| 4          | 3      | 4      | V <sub>DOUT</sub> | VD Output                 |
| 5          | 1      | 6      | V <sub>IN</sub>   | Power Input               |
| -          | -      | 2      | NC                | No connection             |

## ■ PRODUCT CLASSIFICATION

### ● Selection Guide

XC6408D Series :  $V_{ROUT}$  pin voltage detection, release delay capacitor

XC6408E Series :  $V_{SEN}$  pin for external voltage detection, auto power ON/OFF function

### ● Ordering Information

XC6408D①②③④⑤-⑥ <sup>(\*)</sup>

| DESIGNATOR | ITEM                               | SYMBOL | DESCRIPTION   |
|------------|------------------------------------|--------|---|
| ①          | $V_{DOUT}$<br>Output Configuration | N      | Open Drain  |
| ②③         | Output Voltage<br>Detect Voltage   | -      | Sequential number relating to output voltage and detect voltage (refer to the chart below)<br>$V_{ROUT}$ Output Voltage Range: 2.0V~18.0V<br>$V_{DF}$ Detect Voltage Range: 2.0V~16.0V<br>Output voltage and detect voltage can be set in 0.1V increments |
| ④⑤-⑥       | Packages<br>(Order Unit)           | ER-G   | USP-6C (3,000/Reel)   |
|            |                                    | MR-G   | SOT-25 (3,000/Reel)   |
|            |                                    | PR-G   | SOT-89-5 (1,000/Reel)   |

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

DESIGNATOR②③ (No. 01~20 is standard voltage)

| ②③ | $V_{ROUT}$ | $V_{DF}$ | ②③ | $V_{ROUT}$ | $V_{DF}$ |
|----|------------|----------|----|------------|----------|
| 01 | 2.50       | 2.10     | 11 | —          | —        |
| 02 | 3.00       | 2.50     | 12 | —          | —        |
| 03 | 3.30       | 2.70     | 13 | —          | —        |
| 04 | 3.30       | 2.80     | 14 | —          | —        |
| 05 | 5.00       | 4.10     | 15 | —          | —        |
| 06 | 5.00       | 4.20     | 16 | —          | —        |
| 07 | 8.00       | 6.80     | 17 | —          | —        |
| 08 | 9.00       | 5.00     | 18 | —          | —        |
| 09 | 9.00       | 7.50     | 19 | —          | —        |
| 10 | 12.00      | 10.00    | 20 | —          | —        |

For other voltage, please contact your local Torex sales office or representative.

## ■ PRODUCT CLASSIFICATION

### ● Ordering Information

XC6408E①②③④⑤-⑥ (\*1)

| DESIGNATOR | ITEM                                      | SYMBOL | DESCRIPTION   |
|------------|---|--------|---|
| ①          | V <sub>DOUT</sub><br>Output Configuration | N      | Open Drain  |
| ②③         | Output Voltage<br>Detect Voltage          | -      | Sequential number relating to output voltage and detect voltage (refer to the chart below)<br>V <sub>ROUT</sub> Output Voltage Range: 2.0V~18.0V<br>V <sub>DF</sub> Detect Voltage Range: 2.0V~16.0V<br>Output voltage and detect voltage can be set in 0.1V increments |
| ④⑤-⑥       | Packages<br>(Order Unit)                  | ER-G   | USP-6C (3,000/Reel)   |
|            |   | MR-G   | SOT-25 (3,000/Reel)   |
|            |   | PR-G   | SOT-89-5 (1,000/Reel)   |

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

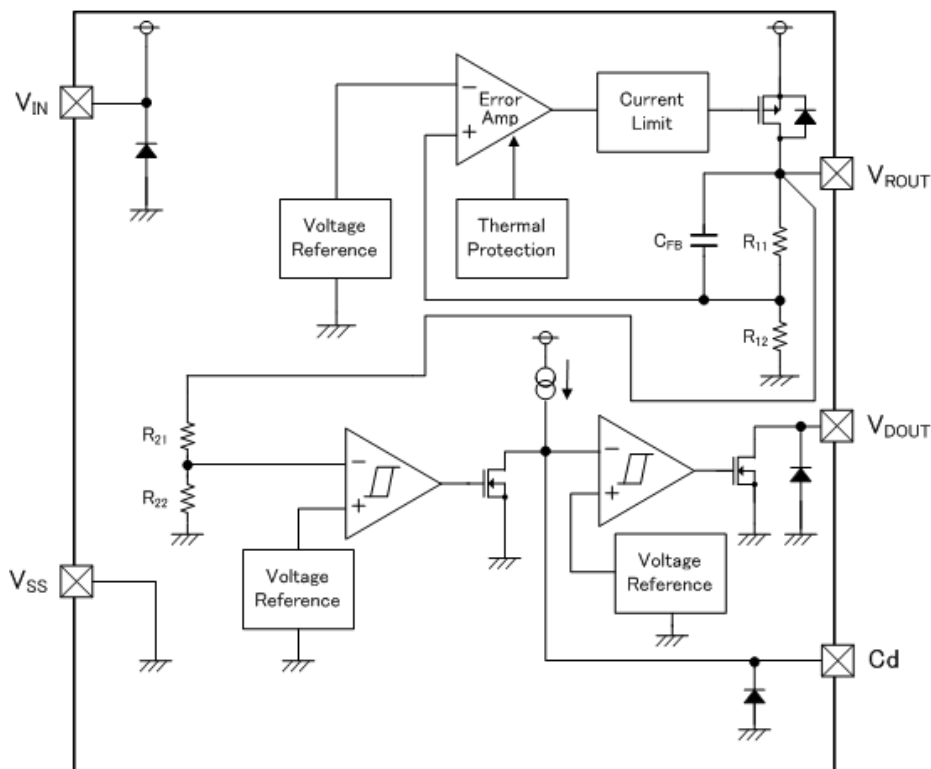
DESIGNATOR②③ (No. 01~20 is standard voltage)

| ②③ | V <sub>ROUT</sub> | V <sub>DF</sub> | ②③ | V <sub>ROUT</sub> | V <sub>DF</sub> |
|----|-------------------|-----------------|----|-------------------|-----------------|
| 01 | 2.50              | 2.10            | 11 | 2.50              | 2.70            |
| 02 | 3.00              | 2.50            | 12 | 2.50              | 2.80            |
| 03 | 3.30              | 2.70            | 13 | 3.00              | 4.10            |
| 04 | 3.30              | 2.80            | 14 | 3.00              | 4.20            |
| 05 | 5.00              | 4.10            | 15 | 3.30              | 4.10            |
| 06 | 5.00              | 4.20            | 16 | 3.30              | 4.20            |
| 07 | 8.00              | 6.80            | 17 | 5.00              | 5.60            |
| 08 | 9.00              | 5.00            | 18 | 5.00              | 6.80            |
| 09 | 9.00              | 7.50            | 19 | 9.00              | 10.00           |
| 10 | 12.00             | 10.00           | 20 | 12.00             | 15.00           |

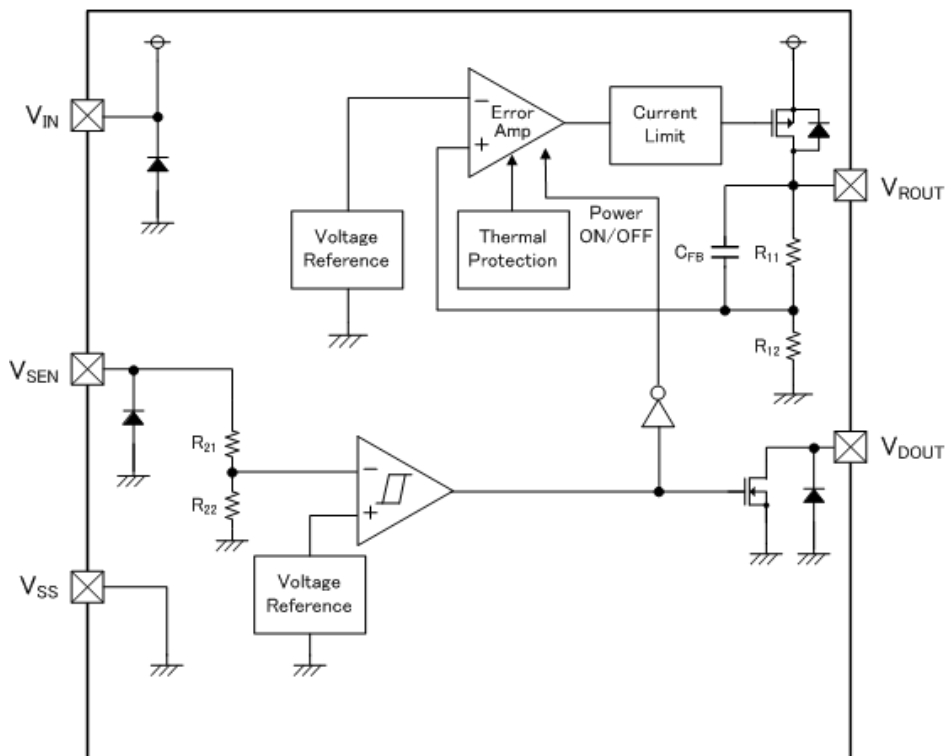
For other voltage, please contact your local Torex sales office or representative.

■ **BLOCK DIAGRAMS**

XC6408 D Type



XC6408 E Type



\*Diodes inside the circuit are an ESD protection diode and a parasitic diode.

## ABSOLUTE MAXIMUM RATINGS

### ●XC6408D Series

| PARAMETER                          |        | SYMBOL     | RATINGS                            | UNITS |
|------------------------------------|--------|------------|------------------------------------|-------|
| Input Voltage                      |        | $V_{IN}$   | $V_{SS}-0.3\sim+30$                | V     |
| Delay Capacitor Voltage            |        | $V_{Cd}$   | $V_{SS}-0.3\sim V_{IN}+0.3$        | V     |
| Delay Capacitor Current            |        | $I_{Cd}$   | 5.0                                | mA    |
| $V_{ROUT}$ Output Current          |        | $I_{ROUT}$ | 210 <sup>(*)1</sup>                | mA    |
| $V_{DOUT}$ Output Current          |        | $I_{DOUT}$ | 20                                 | mA    |
| $V_{ROUT}$ Output Voltage          |        | $V_{ROUT}$ | $V_{SS}-0.3\sim V_{IN}+0.3$        | V     |
| $V_{DOUT}$ Output Voltage          |        | $V_{DOUT}$ | $V_{SS}-0.3\sim+30$                | V     |
| Power Dissipation                  | USP-6C | Pd         | 120                                | mW    |
|                                    |        |            | 1000 (PCB mounted) <sup>(*)2</sup> |       |
|                                    | SOT-25 |            | 250                                |       |
|                                    |        |            | 600 (PCB mounted) <sup>(*)2</sup>  |       |
|                                    |        |            | SOT-89-5                           |       |
| 1300 (PCB mounted) <sup>(*)2</sup> |        |            |                                    |       |
| Operating Temperature Range        |        | $T_{opr}$  | -40~+85                            | °C    |
| Storage Temperature Range          |        | $T_{stg}$  | -55~+125                           | °C    |

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

\*2: The power dissipation figure shown is PCB mounted. Please refer to page 30~32 for details.

### ●XC6408E

| PARAMETER                          |        | SYMBOL     | RATINGS                            | UNITS |
|------------------------------------|--------|------------|------------------------------------|-------|
| Input Voltage                      |        | $V_{IN}$   | $V_{SS}-0.3\sim+30$                | V     |
| Sense Voltage                      |        | $V_{SEN}$  | $V_{SS}-0.3\sim+30$                | V     |
| $V_{ROUT}$ Output Current          |        | $I_{ROUT}$ | 210 <sup>(*)1</sup>                | mA    |
| $V_{DOUT}$ Output Current          |        | $I_{DOUT}$ | 20                                 | mA    |
| $V_{ROUT}$ Output Voltage          |        | $V_{ROUT}$ | $V_{SS}-0.3\sim V_{IN}+0.3$        | V     |
| $V_{DOUT}$ Output Voltage          |        | $V_{DOUT}$ | $V_{SS}-0.3\sim+30$                | V     |
| Power Dissipation                  | USP-6C | Pd         | 120                                | mW    |
|                                    |        |            | 1000 (PCB mounted) <sup>(*)2</sup> |       |
|                                    | SOT-25 |            | 250                                |       |
|                                    |        |            | 600 (PCB mounted) <sup>(*)2</sup>  |       |
|                                    |        |            | SOT-89-5                           |       |
| 1300 (PCB mounted) <sup>(*)2</sup> |        |            |                                    |       |
| Operating Temperature Range        |        | $T_{opr}$  | -40~+85                            | °C    |
| Storage Temperature Range          |        | $T_{stg}$  | -55~+125                           | °C    |

\*1:  $Pd > (V_{IN} - V_{ROUT}) \times I_{ROUT}$

\*2: The power dissipation figure shown is PCB mounted. Please refer to page 30~32 for details.

## ELECTRICAL CHARACTERISTICS

●XC6408D Series

Ta=25°C

| PARAMETER                                  | SYMBOL   | CONDITIONS   | MIN.  | TYP.   | MAX.  | UNITS  | CIRCUIT |   |
|--|--|--|---|--|---|--|---------|---|
| Supply Current                             | I <sub>SS</sub>  | 2.0V ≤ V <sub>ROUT(T)</sub> ≤ 5.0V <sup>(*)1</sup>               | 1.5   | 9.6  | 20.5  | μA   | ②       |   |
|  |  | 5.1V ≤ V <sub>ROUT(T)</sub> ≤ 12.0V <sup>(*)1</sup>              | 2.3   | 10   | 25.3  |  |         |   |
|  |  | 12.1V ≤ V <sub>ROUT(T)</sub> ≤ 18.0V <sup>(*)1</sup>             | 2.5   | 14.3   | 28.1  |  |         |   |
| Regulator Block                            | VR Output Voltage  | V <sub>ROUT(E)</sub> <sup>(*)2</sup>                             | I <sub>OUT</sub> = 20mA   | V <sub>ROUT(T)</sub> × 0.98<br>(E-1) <sup>(*)1</sup> | V <sub>ROUT(T)</sub><br>(E-1) <sup>(*)1</sup> | V <sub>ROUT(T)</sub> × 1.02<br>(E-1) <sup>(*)1</sup> | V       | ① |
|  | VR Maximum Output Current  | I <sub>ROUTMAX</sub>   | V <sub>IN</sub> = V <sub>ROUT(T)</sub> + 3.0V,<br>(V <sub>ROUT(T)</sub> ≥ 3.0V) <sup>(*)1</sup> | 150  | -   | -  | mA      | ① |
|  |  |  | V <sub>IN</sub> = V <sub>ROUT(T)</sub> + 3.0V,<br>(V <sub>ROUT(T)</sub> < 3.0V) <sup>(*)1</sup> | 100  | -   | -  |         |   |
|  | Load Regulation  | ΔV <sub>ROUT</sub>   | 1mA ≤ I <sub>ROUT</sub> ≤ 50mA<br>(2.0V ≤ V <sub>ROUT(T)</sub> ≤ 5.0V) <sup>(*)1</sup>          | -  | 25  | 50   | mV      | ① |
|  |  |  | 1mA ≤ I <sub>ROUT</sub> ≤ 50mA<br>(5.0V < V <sub>ROUT(T)</sub> ≤ 12.0V) <sup>(*)1</sup>         | -  | 60  | 120  |         |   |
|  |  |  | 1mA ≤ I <sub>ROUT</sub> ≤ 50mA<br>(12.0V < V <sub>ROUT(T)</sub> ≤ 18.0V) <sup>(*)1</sup>        | -  | 90  | 160  |         |   |
|  | Dropout Voltage1 <sup>(*)3</sup>                                 | V <sub>dif1</sub> <sup>(*)3</sup>                                | I <sub>ROUT</sub> = 20mA,   | -  | E-4   |  | mV      | ① |
|  | Dropout Voltage2 <sup>(*)3</sup>                                 | V <sub>dif2</sub> <sup>(*)3</sup>                                | I <sub>ROUT</sub> = 100mA   | -  | E-5   |  | mV      | ① |
|  | Line Regulation1   | ΔV <sub>ROUT</sub> /<br>(ΔV <sub>IN</sub> · V <sub>ROUT</sub> )  | V <sub>ROUT(T)</sub> + 2.0V ≤ V <sub>IN</sub> ≤ 28V <sup>(*)1</sup><br>I <sub>ROUT</sub> = 5mA  | 0.01   | 0.05  | 0.10   | %/V     | ① |
|  | Line Regulation2   | ΔV <sub>ROUT</sub> /<br>(ΔV <sub>IN</sub> · V <sub>ROUT</sub> )  | V <sub>ROUT(T)</sub> + 2.0V ≤ V <sub>IN</sub> ≤ 28V <sup>(*)1</sup><br>I <sub>ROUT</sub> = 13mA | 0.03   | 0.15  | 0.30   | %/V     | ① |
| Input Voltage                              | V <sub>IN</sub>  |  | 2.0   | -  | 28.0  | V  | -       |   |
| Output Voltage Temperature Characteristics | ΔV <sub>ROUT</sub> /<br>(ΔT <sub>opr</sub> · V <sub>ROUT</sub> ) | I <sub>ROUT</sub> = 20mA,<br>-40°C ≤ T <sub>opr</sub> ≤ 85°C     | -   | ± 100  | -   | ppm/°C   | ①       |   |
| Short Current                              | I <sub>RSHORT</sub>  | V <sub>SEN</sub> = V <sub>DF(T)</sub> + 2V <sup>(*)1</sup>       | -   | 30   | -   | mA   | ①       |   |
| Detector Block                             | VD Detect Voltage  | V <sub>DF(E)</sub> <sup>(*)2</sup>                               |   | V <sub>DF(T)</sub> × 0.975<br>(E-2) <sup>(*)1</sup>  | V <sub>DF(T)</sub><br>(E-2) <sup>(*)1</sup>   | V <sub>DF(T)</sub> × 1.025<br>(E-2) <sup>(*)1</sup>  | V       | ③ |
|  | Hysteresis Width   | V <sub>HYS</sub>   |   | E-3  |   | V  | ③       |   |
|  | Output Current   | I <sub>DOUT</sub>  | V <sub>IN</sub> = 3.0V,<br>C <sub>d</sub> = 0V, V <sub>DS</sub> = 0.5V                          | 0.3  | 0.5   | -  | mA      | ④ |
|  | Output Leakage Current   | I <sub>DLEAK</sub>   | V <sub>IN</sub> = 28V, C <sub>d</sub> = 0V, V <sub>DS</sub> = 28V                               | -  | -   | 0.1  | μA      | ④ |
|  | Detect Voltage Temperature Characteristics                       | ΔV <sub>DOUT</sub> /<br>(ΔT <sub>opr</sub> · V <sub>DOUT</sub> ) | -40°C ≤ T <sub>opr</sub> ≤ 85°C   | -  | ± 100   | -  | ppm/°C  | ③ |
|  | Release Delay Time   | t <sub>DR</sub>  | Cap = 1000pF  | 3.4  | 6.0   | 15.6   | ms      | ⑤ |
| Thermal Shutdown Detect Temperature        | T <sub>TSD</sub>   | Junction Temperature   | -   | 150  | -   | °C   | ①       |   |
| Thermal Shutdown Release Temperature       | T <sub>TSR</sub>   | Junction Temperature   | -   | 125  | -   | °C   | ①       |   |
| Hysteresis Width                           | T <sub>TSR</sub> - T <sub>TSD</sub>                              | Junction Temperature   | -   | 25   | -   | °C   | -       |   |

\*1: V<sub>ROUT(T)</sub>: Nominal output voltage, V<sub>DF(T)</sub>: Nominal detect voltage

\*2: V<sub>ROUT(E)</sub>: Effective output voltage, V<sub>DF(E)</sub>: Effective detect voltage

\*3: V<sub>dif</sub> = {V<sub>IN1</sub><sup>(\*)5</sup> - V<sub>ROUT1</sub><sup>(\*)4</sup>}

\*4: V<sub>ROUT1</sub>: In case of V<sub>ROUT(T)</sub> < 3.0V, the V<sub>OUT1</sub> is equal to 98% of the I<sub>ROUT(T)</sub> when a stabilized input voltage is applied in V<sub>ROUT(T)</sub> + 3.0V.  
In case of V<sub>ROUT(T)</sub> ≥ 3.0V, the V<sub>OUT1</sub> is equal to 98% of the I<sub>ROUT(T)</sub> when a stabilized input voltage is applied in V<sub>ROUT(T)</sub> + 2.0V.

\*5: V<sub>IN1</sub>: The input voltage when V<sub>ROUT1</sub> appears as input voltage is gradually decreased.

\*6: Unless otherwise stated, V<sub>IN</sub> = V<sub>ROUT(T)</sub> + 2.0V

## ELECTRICAL CHARACTERISTICS (Continued)

●XC6408E Series

Ta=25°C

| PARAMETER                            | SYMBOL                                     | CONDITIONS  | MIN.  | TYP.   | MAX.                                   | UNITS  | CIRCUIT |   |
|--------------------------------------|--|---|---|--|--|--|---------|---|
| Supply Current                       | I <sub>SS</sub>                            | $V_{SEN}=V_{DF(T)}+2.0V$<br>( $2.0V \leq V_{ROUT(T)} \leq 5.0V$ ) <sup>(*)1</sup>   | 1.5   | 6.5  | 17.6                                   | μA   | ②       |   |
|                                      |  | $V_{SEN}=V_{DF(T)}+2.0V$<br>( $5.1V \leq V_{ROUT(T)} \leq 12.0V$ ) <sup>(*)1</sup>  | 2.1   | 8  | 17.6                                   |  |         |   |
|                                      |  | $V_{SEN}=V_{DF(T)}+2.0V$<br>( $12.1V \leq V_{ROUT(T)} \leq 18.0V$ ) <sup>(*)1</sup> | 2.2   | 8.5  | 17.6                                   |  |         |   |
| VD Supply Current                    | I <sub>DSS</sub>                           | $V_{SEN}=V_{SS}$  | -   | 1.5  | 3.9                                    | μA   | ②       |   |
| Regulator Block                      | VR Output Voltage                          | $V_{ROUT(E)}$ <sup>(*)2</sup>   | $V_{SEN}=V_{DF(T)}+2.0V$<br>$I_{ROUT}=20mA$   | $V_{ROUT(T)} \times 0.98$<br>(E-1) <sup>(*)1</sup> | $V_{ROUT(T)}$<br>(E-1) <sup>(*)1</sup> | $V_{ROUT(T)} \times 1.02$<br>(E-1) <sup>(*)1</sup> | V       | ① |
|                                      | VR Maximum Output Current                  | I <sub>ROUTMAX</sub>  | $V_{IN}=V_{ROUT(T)}+3.0V$<br>$V_{SEN}=V_{DF(T)}+2.0V$<br>( $V_{ROUT(T)} \geq 3.0V$ )                              | 150  | -                                      | -  | mA      | ① |
|                                      |  |   | $V_{IN}=V_{ROUT(T)}+3.0V$<br>$V_{SEN}=V_{DF(T)}+2.0V$<br>( $V_{ROUT(T)} < 3.0V$ ) <sup>(*)1</sup>                 | 100  | -                                      | -  |         |   |
|                                      | Load Regulation                            | ΔV <sub>ROUT</sub>  | $V_{SEN}=V_{DF(T)}+2.0V$<br>$1mA \leq I_{ROUT} \leq 50mA$<br>( $2.0 \leq V_{ROUT(T)} \leq 5.0V$ ) <sup>(*)1</sup> | -  | 25                                     | 50   | mV      | ① |
|                                      |  |   | $V_{SEN}=V_{DF(T)}+2.0V$<br>$1mA \leq I_{ROUT} \leq 50mA$<br>( $5.0 < V_{ROUT(T)} \leq 12.0V$ ) <sup>(*)1</sup>   | -  | 60                                     | 120  |         |   |
|                                      |  |   | $V_{SEN}=V_{DF(T)}+2.0V$<br>$1mA \leq I_{ROUT} \leq 50mA$<br>( $12.0 < V_{ROUT(T)} \leq 18.0V$ ) <sup>(*)1</sup>  | -  | 90                                     | 160  |         |   |
|                                      | Dropout Voltage1 <sup>(*)3</sup>           | V <sub>dif1</sub> <sup>(*)3</sup>   | $I_{ROUT}=20mA$   | -  | (E-4)                                  |  | mV      | ① |
|                                      | Dropout Voltage2 <sup>(*)3</sup>           | V <sub>dif2</sub> <sup>(*)3</sup>   | $I_{ROUT}=100mA$  | -  | (E-5)                                  |  | mV      | ① |
|                                      | Line Regulation1                           | $\frac{\Delta V_{ROUT}}{(\Delta V_{IN} \cdot V_{ROUT})}$                            | $V_{SEN}=V_{DF(T)}+2.0V$<br>$V_{ROUT(T)}+2.0V \leq V_{IN} \leq 28V$ <sup>(*)1</sup><br>$I_{ROUT}=5mA$             | 0.01   | 0.05                                   | 0.10   | %/V     | ① |
|                                      | Line Regulation2                           | $\frac{\Delta V_{ROUT}}{(\Delta V_{IN} \cdot V_{ROUT})}$                            | $V_{SEN}=V_{DF(T)}+2.0V$<br>$V_{ROUT(T)}+2.0V \leq V_{IN} \leq 28V$ <sup>(*)1</sup><br>$I_{ROUT}=13mA$            | 0.03   | 0.15                                   | 0.30   | %/V     | ① |
|                                      | Input Voltage                              | V <sub>IN</sub>   |   | 2.0  | -                                      | 28.0   | V       | - |
|                                      | Output Voltage Temperature Characteristics | $\frac{\Delta V_{ROUT}}{(\Delta T_{opr} \cdot V_{ROUT})}$                           | $V_{SEN}=V_{DF(T)}+2.0V$ <sup>(*)1</sup><br>$I_{ROUT}=20mA$<br>$-40^\circ C \leq T_{opr} \leq 85^\circ C$         | -  | ±100                                   | -  | ppm/°C  | ① |
| Short Current                        | I <sub>RSHORT</sub>                        | $V_{SEN}=V_{DF(T)}+2.0V$ <sup>(*)1</sup>  | -   | 30   | -                                      | mA   | ①       |   |
| Detector Block                       | VD Detect Voltage                          | $V_{DF(E)}$ <sup>(*)2</sup>   |   | $V_{DF(T)} \times 0.975$<br>(E-2) <sup>(*)1</sup>  | $V_{DF(T)}$<br>(E-2) <sup>(*)1</sup>   | $V_{DF(T)} \times 1.025$<br>(E-2) <sup>(*)1</sup>  | V       | ③ |
|                                      | Hysteresis Width                           | V <sub>HYS</sub>  |   | (E-3)  |  | V  | ③       |   |
|                                      | Output Current                             | I <sub>DOUT</sub>   | $V_{IN}=3.0V, V_{SEN}=V_{DF(T)}-0.4V$ <sup>(*)1</sup><br>$V_{DS}=0.5V$  | 0.3  | 0.5                                    | -  | mA      | ④ |
|                                      | Output Leakage Current                     | I <sub>DLEAK</sub>  | $V_{IN}=28V, V_{SEN}=0V, V_{DS}=28V$  | -  | -                                      | 0.1  | μA      | ④ |
|                                      | Detect Voltage Temperature Characteristics | $\frac{\Delta V_{DOUT}}{(\Delta T_{opr} \cdot V_{DOUT})}$                           | $-40^\circ C \leq T_{opr} \leq 85^\circ C$  | -  | ±100                                   | -  | ppm/°C  | ③ |
|                                      | SENSE Input Current                        | I <sub>SENSE</sub>  | $V_{SEN}=V_{DF(T)}+2.0V$ <sup>(*)1</sup>  | (E-6)  |  | μA   | ⑥       |   |
| Thermal Shutdown Detect Temperature  | T <sub>TSD</sub>                           | Junction Temperature  | -   | 150  | -                                      | °C   | ①       |   |
| Thermal Shutdown Release Temperature | T <sub>TSR</sub>                           | Junction Temperature  | -   | 125  | -                                      | °C   | ①       |   |
| Hysteresis Width                     | T <sub>TSR</sub> - T <sub>TSD</sub>        | Junction Temperature  | -   | 25   | -                                      | °C   | -       |   |

\*1: V<sub>ROUT(T)</sub>: Nominal output voltage, V<sub>DF(T)</sub>: Nominal detect voltage

\*2: V<sub>ROUT(E)</sub>: Effective output voltage, V<sub>DF(E)</sub>: Effective detect voltage

\*3: V<sub>dif</sub> = {V<sub>IN1</sub><sup>(\*)5</sup> - V<sub>ROUT1</sub><sup>(\*)4</sup>}

\*4: V<sub>ROUT1</sub>: In case of V<sub>ROUT(T)</sub> < 3.0V, the V<sub>OUT1</sub> is equal to 98% of the I<sub>ROUT(T)</sub> when a stabilized input voltage is applied in V<sub>ROUT(T)</sub>+3.0V. In case of V<sub>ROUT(T)</sub> ≥ 3.0V, the V<sub>OUT1</sub> is equal to 98% of the I<sub>ROUT(T)</sub> when a stabilized input voltage is applied in V<sub>ROUT(T)</sub>+2.0V.

\*5: V<sub>IN1</sub>: The input voltage when V<sub>ROUT1</sub> appears as input voltage is gradually decreased.

\*6: Unless otherwise stated, V<sub>IN</sub>=V<sub>ROUT(T)</sub>+2.0V



## ■ ELECTRICAL CHARACTERISTICS (Continued)

### ● Voltage Chart

(\*1) $V_{ROUT}$ : Accuracy  $\pm 2\%$ ,  $V_{DF}$ : Accuracy  $\pm 2.5\%$

| SYMBOL   | E-1                         |       | E-2                         |       | E-3                     |                        | E-4  |      | E-5   |      | E-6                                   |     |
|--|-----------------------------|-------|-----------------------------|-------|-------------------------|------------------------|--|------|---|------|---------------------------------------|-----|
| NOMINAL<br>VR OUTPUT VOLTAGE<br>VD DETECT VOLTAGE<br>(V) | VR<br>OUTPUT VOLTAGE<br>(V) |       | VD<br>DETECT VOLTAGE<br>(V) |       | HYSTERESIS WIDTH<br>(V) |                        | DROPOUT<br>VOLTAGE1<br>$I_{ROUT}=20mA$<br>(mV) |      | DROPOUT<br>VOLTAGE2<br>$I_{ROUT}=100mA$<br>(mV) |      | SENSE<br>INPUT CURRENT<br>( $\mu A$ ) |     |
| $V_{ROUT(T)}$<br>$V_{DF(T)}$                             | $V_{ROUT(E)}$               |       | $V_{DF(E)}$                 |       | $V_{HYS}$               |                        | Vdif1  |      | Vdif2   |      | Isense                                |     |
|  | MIN.                        | MAX.  | MIN.                        | MAX.  | MIN.                    | MAX.                   | TYP  | MAX  | TYP   | MAX  | MIN                                   | MAX |
| 2.0  | 1.960                       | 2.040 | 1.950                       | 2.050 | $V_{DF(E)} \times 2\%$  | $V_{DF(E)} \times 8\%$ | 500  | 680  | 2300  | 3300 | 0.1                                   | 2.2 |
| 2.1  | 2.058                       | 2.142 | 2.048                       | 2.153 |                         |                        |  |      |   |      |                                       |     |
| 2.2  | 2.156                       | 2.244 | 2.145                       | 2.255 |                         |                        |  |      |   |      |                                       |     |
| 2.3  | 2.254                       | 2.346 | 2.243                       | 2.358 |                         |                        | 430  | 600  | 1950  | 2950 |                                       |     |
| 2.4  | 2.352                       | 2.448 | 2.340                       | 2.460 |                         |                        |  |      |   |      |                                       |     |
| 2.5  | 2.450                       | 2.550 | 2.438                       | 2.563 |                         |                        |  |      |   |      |                                       |     |
| 2.6  | 2.548                       | 2.652 | 2.535                       | 2.665 |                         |                        |  |      |   |      |                                       |     |
| 2.7  | 2.646                       | 2.754 | 2.633                       | 2.768 |                         |                        | 360  | 530  | 1550  | 2550 |                                       |     |
| 2.8  | 2.744                       | 2.856 | 2.730                       | 2.870 |                         |                        |  |      |   |      |                                       |     |
| 2.9  | 2.842                       | 2.958 | 2.828                       | 2.973 |                         |                        |  |      |   |      |                                       |     |
| 3.0  | 2.940                       | 3.060 | 2.925                       | 3.075 |                         |                        |  |      |   |      |                                       |     |
| 3.1  | 3.038                       | 3.162 | 3.023                       | 3.178 |                         |                        |  |      |   |      |                                       |     |
| 3.2  | 3.136                       | 3.264 | 3.120                       | 3.280 |                         |                        |  |      |   |      |                                       |     |
| 3.3  | 3.234                       | 3.366 | 3.218                       | 3.383 |                         |                        |  |      |   |      |                                       |     |
| 3.4  | 3.332                       | 3.468 | 3.315                       | 3.485 |                         |                        | 250  | 380  | 1100  | 1800 |                                       |     |
| 3.5  | 3.430                       | 3.570 | 3.413                       | 3.588 |                         |                        |  |      |   |      |                                       |     |
| 3.6  | 3.528                       | 3.672 | 3.510                       | 3.690 |                         |                        |  |      |   |      |                                       |     |
| 3.7  | 3.626                       | 3.774 | 3.608                       | 3.793 |                         |                        |  |      |   |      |                                       |     |
| 3.8  | 3.724                       | 3.876 | 3.705                       | 3.895 |                         |                        |  |      |   |      |                                       |     |
| 3.9  | 3.822                       | 3.978 | 3.803                       | 3.998 |                         |                        |  |      |   |      |                                       |     |
| 4.0  | 3.920                       | 4.080 | 3.900                       | 4.100 |                         |                        |  |      |   |      |                                       |     |
| 4.1  | 4.018                       | 4.182 | 3.998                       | 4.203 |                         |                        |  |      |   |      |                                       |     |
| 4.2  | 4.116                       | 4.284 | 4.095                       | 4.305 |                         |                        |  |      |   |      |                                       |     |
| 4.3  | 4.214                       | 4.386 | 4.193                       | 4.408 |                         |                        |  |      |   |      |                                       |     |
| 4.4  | 4.312                       | 4.488 | 4.290                       | 4.510 |                         |                        | 230  | 350  | 850   | 1650 |                                       |     |
| 4.5  | 4.410                       | 4.590 | 4.388                       | 4.613 |                         |                        |  |      |   |      |                                       |     |
| 4.6  | 4.508                       | 4.692 | 4.485                       | 4.715 |                         |                        |  |      |   |      |                                       |     |
| 4.7  | 4.606                       | 4.794 | 4.583                       | 4.818 |                         |                        |  |      |   |      |                                       |     |
| 4.8  | 4.704                       | 4.896 | 4.680                       | 4.920 |                         |                        |  |      |   |      |                                       |     |
| 4.9  | 4.802                       | 4.998 | 4.778                       | 5.023 |                         |                        |  |      |   |      |                                       |     |
| 5.0  | 4.900                       | 5.100 | 4.875                       | 5.125 |                         |                        |  |      |   |      |                                       |     |
| 5.1  | 4.998                       | 5.202 | 4.973                       | 5.228 |                         |                        |  |      |   |      |                                       |     |
| 5.2  | 5.096                       | 5.304 | 5.070                       | 5.330 |                         |                        |  |      |   |      |                                       |     |
| 5.3  | 5.194                       | 5.406 | 5.168                       | 5.433 |                         |                        |  |      |   |      |                                       |     |
| 5.4  | 5.292                       | 5.508 | 5.265                       | 5.535 | 180                     | 300                    | 750  | 1350 |   |      |                                       |     |
| 5.5  | 5.390                       | 5.610 | 5.363                       | 5.638 |                         |                        |  |      |   |      |                                       |     |
| 5.6  | 5.488                       | 5.712 | 5.460                       | 5.740 |                         |                        |  |      |   |      |                                       |     |
| 5.7  | 5.586                       | 5.814 | 5.558                       | 5.843 |                         |                        |  |      |   |      |                                       |     |
| 5.8  | 5.684                       | 5.916 | 5.655                       | 5.945 |                         |                        |  |      |   |      |                                       |     |
| 5.9  | 5.782                       | 6.018 | 5.753                       | 6.048 |                         |                        |  |      |   |      |                                       |     |

## ■ ELECTRICAL CHARACTERISTICS (Continued)

### ● Voltage Chart (Continued)

(\*1) $V_{ROUT}$ : Accuracy  $\pm 2\%$ ,  $V_{DF}$ : Accuracy  $\pm 2.5\%$

| SYMBOL   | E-1                         |        | E-2                         |        | E-3                     |                        | E-4  |     | E-5   |      | E-6                                      |     |
|--|-----------------------------|--------|-----------------------------|--------|-------------------------|------------------------|--|-----|---|------|--|-----|
| NOMINAL<br>VR OUTPUT VOLTAGE<br>VD DETECT VOLTAGE<br>(V) | VR<br>OUTPUT VOLTAGE<br>(V) |        | VD<br>DETECT VOLTAGE<br>(V) |        | HYSTERESIS WIDTH<br>(V) |                        | DROPOUT<br>VOLTAGE1<br>$I_{ROUT}=20mA$<br>(mV) |     | DROPOUT<br>VOLTAGE2<br>$I_{ROUT}=100mA$<br>(mV) |      | SENSE<br>INPUT<br>CURRENT<br>( $\mu A$ ) |     |
| $V_{ROUT(T)}$<br>$V_{DF(T)}$                             | $V_{ROUT(E)}$               |        | $V_{DF(E)}$                 |        | $V_{HYS}$               |                        | $V_{dif1}$                                     |     | $V_{dif2}$                                      |      | $I_{sense}$                              |     |
|  | MIN.                        | MAX.   | MIN.                        | MAX.   | MIN.                    | MAX.                   | TYP  | MAX | TYP   | MAX  | MIN                                      | MAX |
| 6.0  | 5.880                       | 6.120  | 5.850                       | 6.150  | $V_{DF(E)} \times 2\%$  | $V_{DF(E)} \times 8\%$ | 180  | 300 | 750   | 1350 | 0.1                                      | 4.1 |
| 6.1  | 5.978                       | 6.222  | 5.948                       | 6.253  |                         |                        |  |     |   |      |  |     |
| 6.2  | 6.076                       | 6.324  | 6.045                       | 6.355  |                         |                        |  |     |   |      |  |     |
| 6.3  | 6.174                       | 6.426  | 6.143                       | 6.458  |                         |                        |  |     |   |      |  |     |
| 6.4  | 6.272                       | 6.528  | 6.240                       | 6.560  |                         |                        |  |     |   |      |  |     |
| 6.5  | 6.370                       | 6.630  | 6.338                       | 6.663  |                         |                        |  |     |   |      |  |     |
| 6.6  | 6.468                       | 6.732  | 6.435                       | 6.765  |                         |                        |  |     |   |      |  |     |
| 6.7  | 6.566                       | 6.834  | 6.533                       | 6.868  |                         |                        |  |     |   |      |  |     |
| 6.8  | 6.664                       | 6.936  | 6.630                       | 6.970  |                         |                        |  |     |   |      |  |     |
| 6.9  | 6.762                       | 7.038  | 6.728                       | 7.073  |                         |                        |  |     |   |      |  |     |
| 7.0  | 6.860                       | 7.140  | 6.825                       | 7.175  |                         |                        |  |     |   |      |  |     |
| 7.1  | 6.958                       | 7.242  | 6.923                       | 7.278  |                         |                        |  |     |   |      |  |     |
| 7.2  | 7.056                       | 7.344  | 7.020                       | 7.380  |                         |                        |  |     |   |      |  |     |
| 7.3  | 7.154                       | 7.446  | 7.118                       | 7.483  |                         |                        |  |     |   |      |  |     |
| 7.4  | 7.252                       | 7.548  | 7.215                       | 7.585  |                         |                        |  |     |   |      |  |     |
| 7.5  | 7.350                       | 7.650  | 7.313                       | 7.688  |                         |                        |  |     |   |      |  |     |
| 7.6  | 7.448                       | 7.752  | 7.410                       | 7.790  |                         |                        |  |     |   |      |  |     |
| 7.7  | 7.546                       | 7.854  | 7.508                       | 7.893  |                         |                        |  |     |   |      |  |     |
| 7.8  | 7.644                       | 7.956  | 7.605                       | 7.995  |                         |                        |  |     |   |      |  |     |
| 7.9  | 7.742                       | 8.058  | 7.703                       | 8.098  |                         |                        |  |     |   |      |  |     |
| 8.0  | 7.840                       | 8.160  | 7.800                       | 8.200  |                         |                        |  |     |   |      |  |     |
| 8.1  | 7.938                       | 8.262  | 7.898                       | 8.303  |                         |                        |  |     |   |      |  |     |
| 8.2  | 8.036                       | 8.364  | 7.995                       | 8.405  |                         |                        |  |     |   |      |  |     |
| 8.3  | 8.134                       | 8.466  | 8.093                       | 8.508  |                         |                        |  |     |   |      |  |     |
| 8.4  | 8.232                       | 8.568  | 8.190                       | 8.610  |                         |                        |  |     |   |      |  |     |
| 8.5  | 8.330                       | 8.670  | 8.288                       | 8.713  |                         |                        |  |     |   |      |  |     |
| 8.6  | 8.428                       | 8.772  | 8.385                       | 8.815  |                         |                        |  |     |   |      |  |     |
| 8.7  | 8.526                       | 8.874  | 8.483                       | 8.918  |                         |                        |  |     |   |      |  |     |
| 8.8  | 8.624                       | 8.976  | 8.580                       | 9.020  |                         |                        |  |     |   |      |  |     |
| 8.9  | 8.722                       | 9.078  | 8.678                       | 9.123  |                         |                        |  |     |   |      |  |     |
| 9.0  | 8.820                       | 9.180  | 8.775                       | 9.225  |                         |                        |  |     |   |      |  |     |
| 9.1  | 8.918                       | 9.282  | 8.873                       | 9.328  |                         |                        |  |     |   |      |  |     |
| 9.2  | 9.016                       | 9.384  | 8.970                       | 9.430  |                         |                        |  |     |   |      |  |     |
| 9.3  | 9.114                       | 9.486  | 9.068                       | 9.533  |                         |                        |  |     |   |      |  |     |
| 9.4  | 9.212                       | 9.588  | 9.165                       | 9.635  |                         |                        |  |     |   |      |  |     |
| 9.5  | 9.310                       | 9.690  | 9.263                       | 9.738  |                         |                        |  |     |   |      |  |     |
| 9.6  | 9.408                       | 9.792  | 9.360                       | 9.840  |                         |                        |  |     |   |      |  |     |
| 9.7  | 9.506                       | 9.894  | 9.458                       | 9.943  |                         |                        |  |     |   |      |  |     |
| 9.8  | 9.604                       | 9.996  | 9.555                       | 10.045 |                         |                        |  |     |   |      |  |     |
| 9.9  | 9.702                       | 10.098 | 9.653                       | 10.148 |                         |                        |  |     |   |      |  |     |
| 10.0   | 9.800                       | 10.200 | 9.750                       | 10.250 |                         |                        |  |     |   |      |  |     |

**■ ELECTRICAL CHARACTERISTICS (Continued)**

(\*1) $V_{ROUT}$ : Accuracy  $\pm 2\%$ ,  $V_{DF}$ : Accuracy  $\pm 2.5\%$

| SYMBOL   | E-1                         |        | E-2                         |        | E-3                     |                        | E-4  |     | E-5   |     | E-6                                   |     |
|--|-----------------------------|--------|-----------------------------|--------|-------------------------|------------------------|--|-----|---|-----|---------------------------------------|-----|
| NOMINAL<br>VR OUTPUT VOLTAGE<br>VD DETECT VOLTAGE<br>(V) | VR<br>OUTPUT VOLTAGE<br>(V) |        | VD<br>DETECT VOLTAGE<br>(V) |        | HYSTERESIS WIDTH<br>(V) |                        | DROPOUT<br>VOLTAGE1<br>$I_{ROUT}=20mA$<br>(mV) |     | DROPOUT<br>VOLTAGE2<br>$I_{ROUT}=100mA$<br>(mV) |     | SENSE<br>INPUT CURRENT<br>( $\mu A$ ) |     |
| $V_{ROUT(T)}$<br>$V_{DF(T)}$                             | $V_{ROUT(E)}$               |        | $V_{DF(E)}$                 |        | $V_{HYS}$               |                        | Vdif1  |     | Vdif2   |     | Isense                                |     |
|  | MIN.                        | MAX.   | MIN.                        | MIN.   | MIN.                    | MIN.                   | TYP  | MAX | TYP   | MAX | MIN                                   | MAX |
| 10.1   | 9.898                       | 10.302 | 9.848                       | 10.353 | $V_{DF(E)} \times 2\%$  | $V_{DF(E)} \times 8\%$ |  |     |   |     |                                       |     |
| 10.2   | 9.996                       | 10.404 | 9.945                       | 10.455 |                         |                        |  |     |   |     |                                       |     |
| 10.3   | 10.094                      | 10.506 | 10.043                      | 10.558 |                         |                        |  |     |   |     |                                       |     |
| 10.4   | 10.192                      | 10.608 | 10.140                      | 10.660 |                         |                        |  |     |   |     |                                       |     |
| 10.5   | 10.290                      | 10.710 | 10.238                      | 10.763 |                         |                        |  |     |   |     |                                       |     |
| 10.6   | 10.388                      | 10.812 | 10.335                      | 10.865 |                         |                        |  |     |   |     |                                       |     |
| 10.7   | 10.486                      | 10.914 | 10.433                      | 10.968 |                         |                        |  |     |   |     |                                       |     |
| 10.8   | 10.584                      | 11.016 | 10.530                      | 11.070 |                         |                        |  |     |   |     |                                       |     |
| 10.9   | 10.682                      | 11.118 | 10.628                      | 11.173 |                         |                        |  |     |   |     |                                       |     |
| 11.0   | 10.780                      | 11.220 | 10.725                      | 11.275 |                         |                        |  |     |   |     |                                       |     |
| 11.1   | 10.878                      | 11.322 | 10.823                      | 11.378 | $V_{DF(E)} \times 1\%$  | $V_{DF(E)} \times 7\%$ | 150  | 200 | 400   | 850 | 0.1                                   | 4.1 |
| 11.2   | 10.976                      | 11.424 | 10.920                      | 11.480 |                         |                        |  |     |   |     |                                       |     |
| 11.3   | 11.074                      | 11.526 | 11.018                      | 11.583 |                         |                        |  |     |   |     |                                       |     |
| 11.4   | 11.172                      | 11.628 | 11.115                      | 11.685 |                         |                        |  |     |   |     |                                       |     |
| 11.5   | 11.270                      | 11.730 | 11.213                      | 11.788 |                         |                        |  |     |   |     |                                       |     |
| 11.6   | 11.368                      | 11.832 | 11.310                      | 11.890 |                         |                        |  |     |   |     |                                       |     |
| 11.7   | 11.466                      | 11.934 | 11.408                      | 11.993 |                         |                        |  |     |   |     |                                       |     |
| 11.8   | 11.564                      | 12.036 | 11.505                      | 12.095 |                         |                        |  |     |   |     |                                       |     |
| 11.9   | 11.662                      | 12.138 | 11.603                      | 12.198 |                         |                        |  |     |   |     |                                       |     |
| 12.0   | 11.760                      | 12.240 | 11.700                      | 12.300 |                         |                        |  |     |   |     |                                       |     |
| 12.1   | 11.858                      | 12.342 | 11.798                      | 12.403 |                         |                        |  |     |   |     |                                       |     |
| 12.2   | 11.956                      | 12.444 | 11.895                      | 12.505 |                         |                        |  |     |   |     |                                       |     |
| 12.3   | 12.054                      | 12.546 | 11.993                      | 12.608 |                         |                        |  |     |   |     |                                       |     |
| 12.4   | 12.152                      | 12.648 | 12.090                      | 12.710 |                         |                        |  |     |   |     |                                       |     |
| 12.5   | 12.250                      | 12.750 | 12.188                      | 12.813 |                         |                        |  |     |   |     |                                       |     |
| 12.6   | 12.348                      | 12.852 | 12.285                      | 12.915 |                         |                        |  |     |   |     |                                       |     |
| 12.7   | 12.446                      | 12.954 | 12.383                      | 13.018 |                         |                        |  |     |   |     |                                       |     |
| 12.8   | 12.544                      | 13.056 | 12.480                      | 13.120 |                         |                        |  |     |   |     |                                       |     |
| 12.9   | 12.642                      | 13.158 | 12.578                      | 13.223 |                         |                        |  |     |   |     |                                       |     |
| 13.0   | 12.740                      | 13.260 | 12.675                      | 13.325 |                         |                        |  |     |   |     |                                       |     |
| 13.1   | 12.838                      | 13.362 | 12.773                      | 13.428 | 120                     | 170                    | 350  | 800 | 0.6   | 6.6 |                                       |     |
| 13.2   | 12.936                      | 13.464 | 12.870                      | 13.530 |                         |                        |  |     |   |     |                                       |     |
| 13.3   | 13.034                      | 13.566 | 12.968                      | 13.633 |                         |                        |  |     |   |     |                                       |     |
| 13.4   | 13.132                      | 13.668 | 13.065                      | 13.735 |                         |                        |  |     |   |     |                                       |     |
| 13.5   | 13.230                      | 13.770 | 13.163                      | 13.838 |                         |                        |  |     |   |     |                                       |     |
| 13.6   | 13.328                      | 13.872 | 13.260                      | 13.940 |                         |                        |  |     |   |     |                                       |     |
| 13.7   | 13.426                      | 13.974 | 13.358                      | 14.043 |                         |                        |  |     |   |     |                                       |     |
| 13.8   | 13.524                      | 14.076 | 13.455                      | 14.145 |                         |                        |  |     |   |     |                                       |     |
| 13.9   | 13.622                      | 14.178 | 13.553                      | 14.248 |                         |                        |  |     |   |     |                                       |     |
| 14.0   | 13.720                      | 14.280 | 13.650                      | 14.350 |                         |                        |  |     |   |     |                                       |     |

## ELECTRICAL CHARACTERISTICS (Continued)

(\*1) $V_{ROUT}$ : Accuracy  $\pm 2\%$ ,  $V_{DF}$ : Accuracy  $\pm 2.5\%$

| SYMBOL   | E-1                         |        | E-2                         |        | E-3                     |                        | E-4  |     | E-5   |     | E-6                                      |     |
|--|-----------------------------|--------|-----------------------------|--------|-------------------------|------------------------|--|-----|---|-----|--|-----|
| NOMINAL<br>VR OUTPUT VOLTAGE<br>VD DETECT VOLTAGE<br>(V) | VR<br>OUTPUT VOLTAGE<br>(V) |        | VD<br>DETECT VOLTAGE<br>(V) |        | HYSTERESIS WIDTH<br>(V) |                        | DROPOUT<br>VOLTAGE1<br>$I_{ROUT}=20mA$<br>(mV) |     | DROPOUT<br>VOLTAGE2<br>$I_{ROUT}=100mA$<br>(mV) |     | SENSE<br>INPUT<br>CURRENT<br>( $\mu A$ ) |     |
| $V_{ROUT(T)}$<br>$V_{DF(T)}$                             | $V_{ROUT(E)}$               |        | $V_{DF(E)}$                 |        | $V_{HYS}$               |                        | Vdif1  |     | Vdif2   |     | Isense                                   |     |
|  | MIN.                        | MAX.   | MIN.                        | MAX.   | MIN.                    | MAX.                   | TYP  | MAX | TYP   | MAX | MIN                                      | MAX |
| 14.1   | 13.818                      | 14.382 | 13.748                      | 14.453 | $V_{DF(E)} \times 1\%$  | $V_{DF(E)} \times 7\%$ |  |     |   |     | 0.6                                      | 6.6 |
| 14.2   | 13.916                      | 14.484 | 13.845                      | 14.555 |                         |                        |  |     |   |     |  |     |
| 14.3   | 14.014                      | 14.586 | 13.943                      | 14.658 |                         |                        |  |     |   |     |  |     |
| 14.4   | 14.112                      | 14.688 | 14.040                      | 14.760 |                         |                        |  |     |   |     |  |     |
| 14.5   | 14.210                      | 14.790 | 14.138                      | 14.863 |                         |                        |  |     |   |     |  |     |
| 14.6   | 14.308                      | 14.892 | 14.235                      | 14.965 |                         |                        |  |     |   |     |  |     |
| 14.7   | 14.406                      | 14.994 | 14.333                      | 15.068 |                         |                        |  |     |   |     |  |     |
| 14.8   | 14.504                      | 15.096 | 14.430                      | 15.170 |                         |                        |  |     |   |     |  |     |
| 14.9   | 14.602                      | 15.198 | 14.528                      | 15.273 |                         |                        |  |     |   |     |  |     |
| 15.0   | 14.700                      | 15.300 | 14.625                      | 15.375 |                         |                        |  |     |   |     |  |     |
| 15.1   | 14.798                      | 15.402 | 14.723                      | 15.478 |                         |                        |  |     |   |     |  |     |
| 15.2   | 14.896                      | 15.504 | 14.820                      | 15.580 |                         |                        |  |     |   |     |  |     |
| 15.3   | 14.994                      | 15.606 | 14.918                      | 15.683 |                         |                        |  |     |   |     |  |     |
| 15.4   | 15.092                      | 15.708 | 15.015                      | 15.785 |                         |                        |  |     |   |     |  |     |
| 15.5   | 15.190                      | 15.810 | 15.113                      | 15.888 |                         |                        |  |     |   |     |  |     |
| 15.6   | 15.288                      | 15.912 | 15.210                      | 15.990 |                         |                        |  |     |   |     |  |     |
| 15.7   | 15.386                      | 16.014 | 15.308                      | 16.093 |                         |                        |  |     |   |     |  |     |
| 15.8   | 15.484                      | 16.116 | 15.405                      | 16.195 |                         |                        |  |     |   |     |  |     |
| 15.9   | 15.582                      | 16.218 | 15.503                      | 16.298 |                         |                        |  |     |   |     |  |     |
| 16.0   | 15.680                      | 16.320 | 15.600                      | 16.400 |                         |                        |  |     |   |     |  |     |
| 16.1   | 15.778                      | 16.422 |                             |        |                         |                        | 120  | 170 | 350   | 800 |  |     |
| 16.2   | 15.876                      | 16.524 |                             |        |                         |                        |  |     |   |     |  |     |
| 16.3   | 15.974                      | 16.626 |                             |        |                         |                        |  |     |   |     |  |     |
| 16.4   | 16.072                      | 16.728 |                             |        |                         |                        |  |     |   |     |  |     |
| 16.5   | 16.170                      | 16.830 |                             |        |                         |                        |  |     |   |     |  |     |
| 16.6   | 16.268                      | 16.932 |                             |        |                         |                        |  |     |   |     |  |     |
| 16.7   | 16.366                      | 17.034 |                             |        |                         |                        |  |     |   |     |  |     |
| 16.8   | 16.464                      | 17.136 |                             |        |                         |                        |  |     |   |     |  |     |
| 16.9   | 16.562                      | 17.238 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.0   | 16.660                      | 17.340 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.1   | 16.758                      | 17.442 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.2   | 16.856                      | 17.544 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.3   | 16.954                      | 17.646 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.4   | 17.052                      | 17.748 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.5   | 17.150                      | 17.850 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.6   | 17.248                      | 17.952 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.7   | 17.346                      | 18.054 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.8   | 17.444                      | 18.156 |                             |        |                         |                        |  |     |   |     |  |     |
| 17.9   | 17.542                      | 18.258 |                             |        |                         |                        |  |     |   |     |  |     |
| 18.0   | 17.640                      | 18.360 |                             |        |                         |                        |  |     |   |     |  |     |

## ■ OPERATIONAL EXPLANATION

XC6408 D Series



XC6408 E Series



### <Voltage Regulator>

The voltage divided by resistors R11 & R12 is compared with the internal reference voltage by the error amplifier. The P-channel MOSFET which is connected to the  $V_{ROUT}$  pin is then driven by the subsequent output signal. The output voltage at the  $V_{ROUT}$  pin is controlled and stabilized by a system of negative feedback. The current limit circuit, short protect circuit and thermal protection circuit operate in relation to the level of output current and heat generation. For the XC6408E, regulator operation returns active state when  $V_{SEN}$  pin voltage rises higher than the release voltage (\*when  $V_{SEN}$  pin voltage is higher than VD detect voltage + hysteresis width).

### <Limit Current, Short-Circuit Protection>

The XC6408 series includes a current fold-back circuit as a short circuit protection. When the load current reaches the current limit, the current fold-back circuit starts to operate. As a result, the output voltage drops further and output current decreases. When the  $V_{ROUT}$  pin is short-circuited, a flow current minimizes to around 30mA.

### <Thermal Protection>

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.

### <Minimum Operating Voltage>

For the stable operation of the IC, over 2.0V of input voltage is necessary. The output voltage may not be generated normally if the input voltage is less than 2.0V.

## OPERATIONAL EXPLANATION (Continued)

### <Voltage detector>

The detector function of the XC6408 series has hysteresis, and when the VD detected voltage rises higher than the release voltage (about 105% (TYP.) of the detect voltage), the output of the  $V_{DOUT}$  pin inverts.

### (D series)

The detector function of the XC6408D series is connected to the  $V_{ROUT}$  pin inside the IC and detects the  $V_{ROUT}$  output voltage.

The voltage divided by the detector's internal resistance which is connected to the  $V_{ROUT}$  pin is compared to the IC internal reference voltage, and if the voltage of the  $V_{ROUT}$  pin falls below the threshold value, low level signal is output from  $V_{DOUT}$ .

A capacitor ( $C_d$ ) can be connected to the  $C_d$  pin to add a delay time to the output signal of the  $V_{DOUT}$  pin at voltage release. The delay time is determined by the constant current value determined by the internal current generator circuit, and the  $C_d$  capacitance value. The relationship between the  $C_d$  capacitance value and the release delay time is shown below.

### (E series)

The detector function of the XC6408E series detects the  $V_{SEN}$  pin voltage.

The voltage divided by the detector internal resistance that is connected to the  $V_{SEN}$  pin is compared to the IC internal reference voltage, and if the voltage of the  $V_{SEN}$  pin falls below the threshold value, low level signal is output from  $V_{DOUT}$ .

● Release Delay Time vs.  $C_d$  connected Capacitance  
XC6408D series



## ■ NOTES ON USE

1. Please use this IC within the stated maximum ratings. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.
2. The power input pin voltage will falls down because of a resistance between power supply and power input pin and shoot through current when IC operates. At this time, if the power input pin voltage is lower than operating voltage range, the IC may cause device malfunction.
3. Please note if the power input pin voltage will fluctuated, the IC may cause device malfunction.
4. If assumed the power input pin voltage falls suddenly (e.g. falls from 28.0V to 0V) at release operation when VD delay capacitor pin is connected to a capacitor, please connect a schottky barrier diode between the power input pin and delay capacitance pin. Please refer below; (XC6408D).
5. The  $V_{DOUT}$  output is configured as N-ch open drain, so please use a pull-up resistance more than  $100k\Omega$  for connecting to the output pin.  
\* When the pull-up resistor connects to another power supply, high level value will be equal to the voltage which the pull-up resistor is connected.
6. If the input voltage fluctuates more than 1.5V in the speed higher than  $100mV/\mu s$ , the output voltage may fluctuate widely. In this case, one capacitor should be added between  $V_{IN}$ - $V_{SS}$  to adjust the input fluctuation speed less than  $100mV/\mu s$ .
7. For a delay capacitor pin of the XC6408D is designed in high impedance. When this pin is left open for use, the IC may get noise. It is recommended that a capacitor more than 3pF is connected to the delay capacitor pin.
8. Phase compensation is performed in the XC6408 inside. Therefore, an abnormal oscillation does not occur even if there is no output capacitor  $C_L$ . An input capacitor  $C_{IN}$  around  $0.1\mu F \sim 1.0\mu F$  between the  $V_{IN}$  pin and the  $V_{SS}$  pin is required for input stability. Also, the output voltage fluctuation such as under shoot or over shoot, which occurs because of the load change can be controlled by placing the output capacitor  $C_L$  around  $0.1\mu F \sim 1.0\mu F$  between the  $V_{ROUT}$  pin and  $V_{SS}$  pin. The input capacitor ( $C_{IN}$ ) and the output capacitor ( $C_L$ ) should be placed to the IC as close as possible with a shorter wiring.
9. 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.



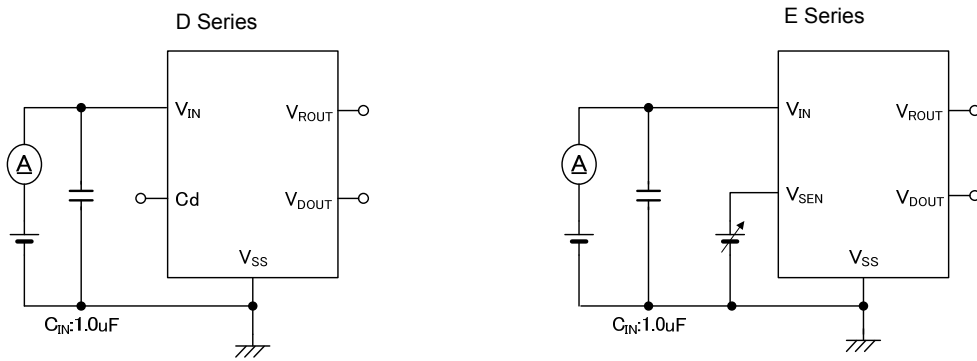
e.g. A circuit which delay capacitance pin is connected to a schottky barrier diode.

## TEST CIRCUITS

Circuit ①



Circuit ②



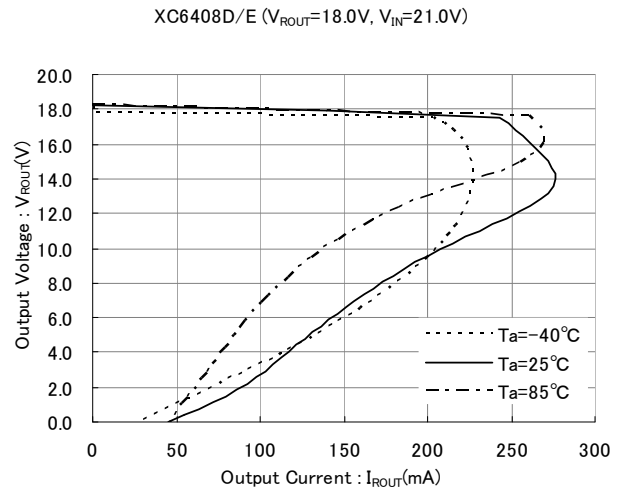
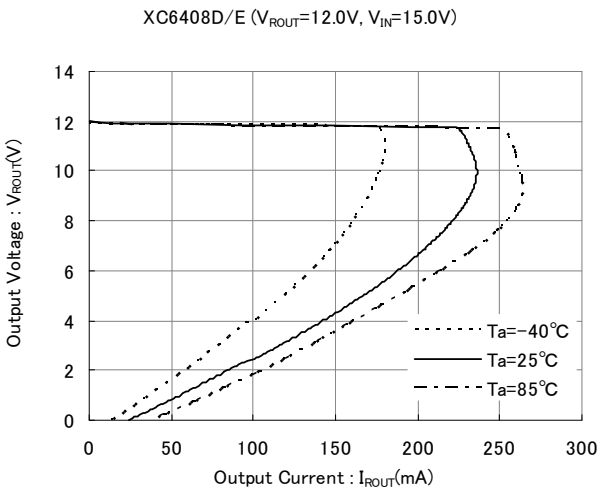
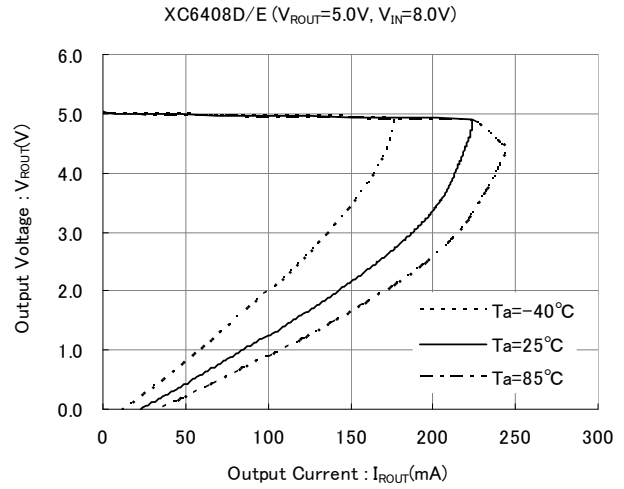
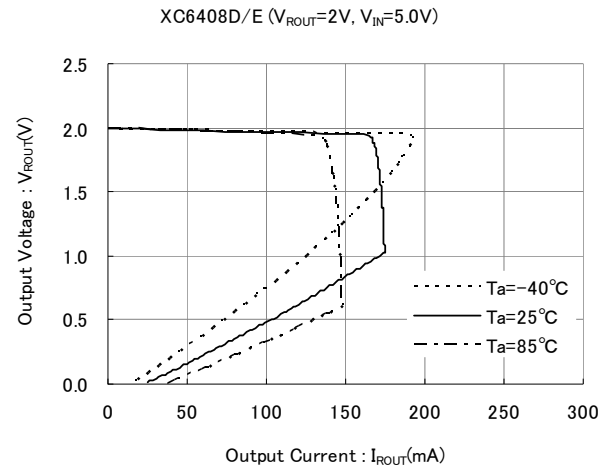




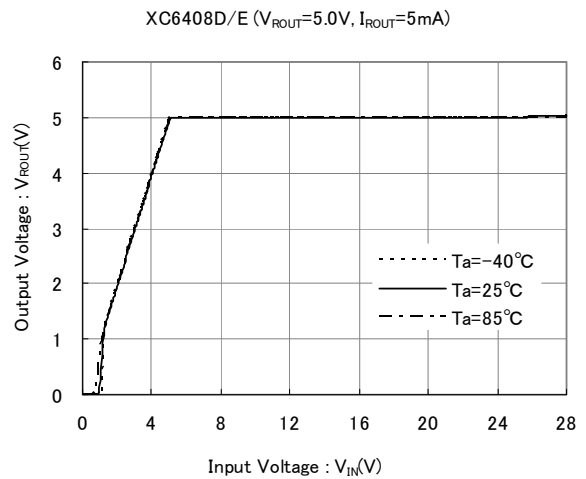
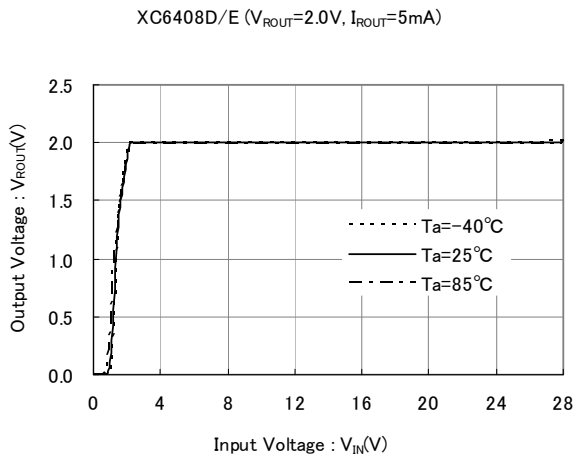
## TYPICAL PERFORMANCE CHARACTERISTICS

### ● XC6408 Series

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



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



## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

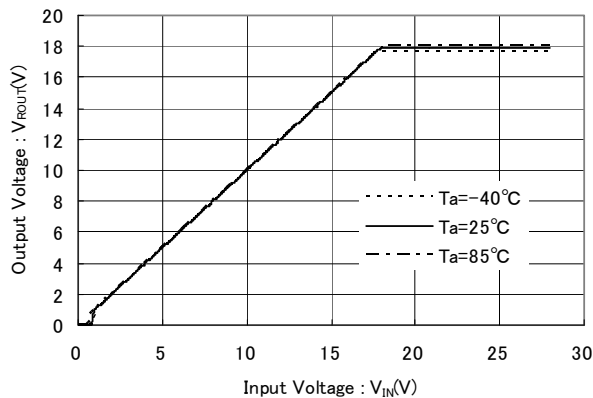
● XC6408 Series

(2) Output Voltage vs. Input Voltage

XC6408D/E ( $V_{ROUT}=12.0V$ ,  $I_{ROUT}=5mA$ )

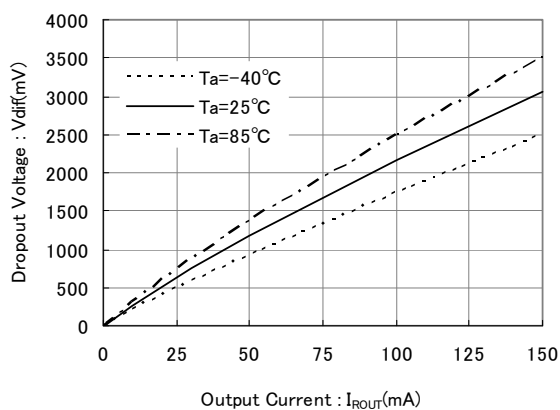


XC6408D/E ( $V_{ROUT}=18.0V$ ,  $I_{ROUT}=5mA$ )



(3) Dropout Voltage vs. Output Current

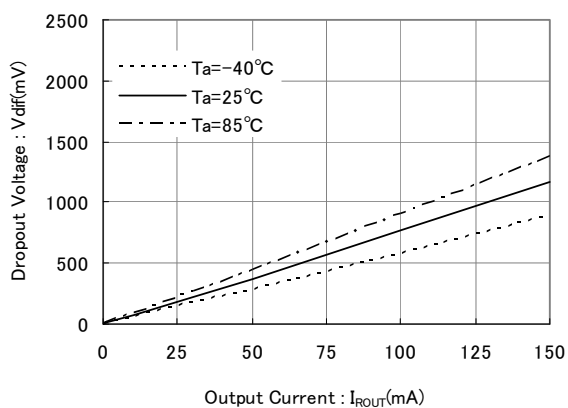
XC6408D/E ( $V_{ROUT}=2.0V$ )



XC6408D/E ( $V_{ROUT}=5.0V$ )



XC6408D/E ( $V_{ROUT}=12.0V$ )



XC6408D/E ( $V_{ROUT}=18.0V$ )



## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

● XC6408 Series

### (4) Output Voltage vs. Ambient Temperature

XC6408D/E ( $V_{ROUT}=2.0V$ ,  $I_{ROUT}=20mA$ )



XC6408D/E ( $V_{ROUT}=5.0V$ ,  $I_{ROUT}=20mA$ )



XC6408D/E ( $V_{ROUT}=12.0V$ ,  $I_{ROUT}=20mA$ )



XC6408D/E ( $V_{ROUT}=18.0V$ ,  $I_{ROUT}=20mA$ )

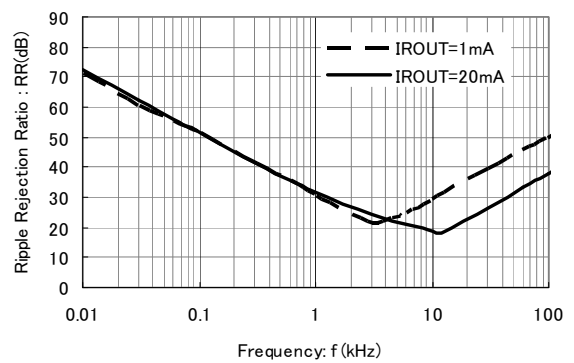


### (5) Ripple Rejection Ratio

XC6408D/E ( $V_{ROUT}=2.0V$ ,  $V_{IN}=4.0V_{DC}+0.5V_{P-PAC}$ )  
( $C_L=1.0\mu F$ (Ceramic),  $T_a=25^\circ C$ )



XC6408D/E ( $V_{ROUT}=5.0V$ ,  $V_{IN}=7.0V_{DC}+0.5V_{P-PAC}$ )  
( $C_L=1.0\mu F$ (Ceramic),  $T_a=25^\circ C$ )

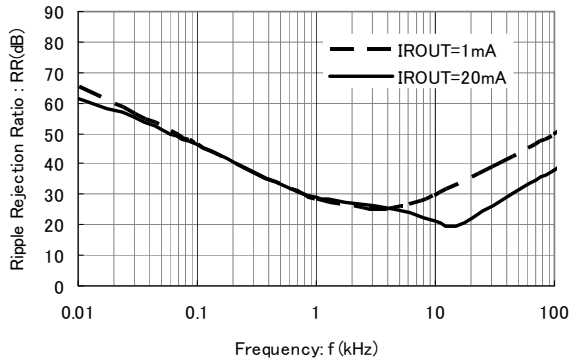


## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

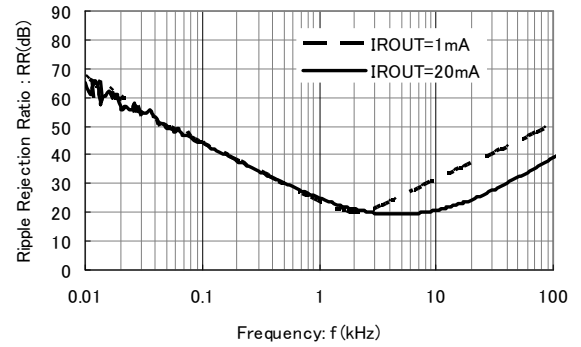
● XC6408 Series

(5) Ripple Rejection Ratio (Continued)

XC6408D/E ( $V_{ROUT}=12.0V$ ,  $V_{IN}=14.0V_{DC}+0.5V_{p-pAC}$ )  
( $C_L=1.0\mu F$ (Ceramic),  $T_a=25^\circ C$ )



XC6408D/E ( $V_{ROUT}=18.0V$ ,  $V_{IN}=20.0V_{DC}+0.5V_{p-pAC}$ )  
( $C_L=1.0\mu F$ (Ceramic),  $T_a=25^\circ C$ )

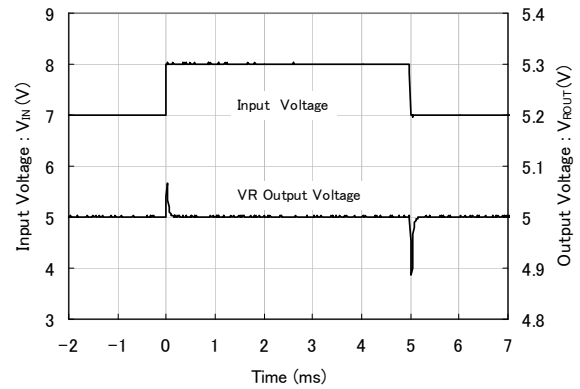


(6) Line Transient Response

XC6408D/E ( $V_{ROUT}=2.0V$ ,  $I_{ROUT}=30mA$ ,  $tr=tf=5\mu s$ )  
( $C_L=1\mu F$ (ceramic),  $T_a=25^\circ C$ )



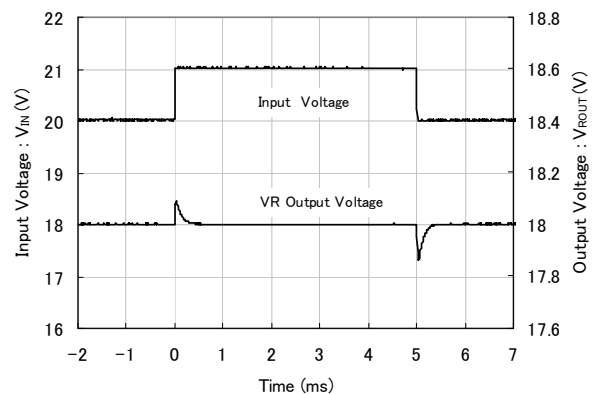
XC6408D/E ( $V_{ROUT}=5.0V$ ,  $I_{ROUT}=30mA$ ,  $tr=tf=5\mu s$ )  
( $C_L=1\mu F$ (ceramic),  $T_a=25^\circ C$ )



XC6408D/E ( $V_{ROUT}=12.0V$ ,  $I_{ROUT}=30mA$ ,  $tr=tf=5\mu s$ )  
( $C_L=1\mu F$ (ceramic),  $T_a=25^\circ C$ )



XC6408D/E ( $V_{ROUT}=18.0V$ ,  $I_{ROUT}=30mA$ ,  $tr=tf=5\mu s$ )  
( $C_L=1\mu F$ (ceramic),  $T_a=25^\circ C$ )



## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

- XC6408 Series

### (7) Load Transient Response

XC6408D/E ( $V_{ROUT}=2.0V$ ,  $V_{IN}=5.0V$ ,  $tr=tf=5\mu s$ )  
( $C_{IN}=C_L=1\mu F$ (ceramic),  $T_a=25^\circ C$ )



XC6408D/E ( $V_{ROUT}=5.0V$ ,  $V_{IN}=7.0V$ ,  $tr=tf=5\mu s$ )  
( $C_{IN}=C_L=1\mu F$ (ceramic),  $T_a=25^\circ C$ )



XC6408D/E ( $V_{ROUT}=12.0V$ ,  $V_{IN}=14.0V$ ,  $tr=tf=5\mu s$ )  
( $C_{IN}=C_L=1\mu F$ (ceramic),  $T_a=25^\circ C$ )



XC6408D/E ( $V_{ROUT}=18.0V$ ,  $V_{IN}=20.0V$ ,  $tr=tf=5\mu s$ )  
( $C_{IN}=C_L=1\mu F$ (ceramic),  $T_a=25^\circ C$ )



## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

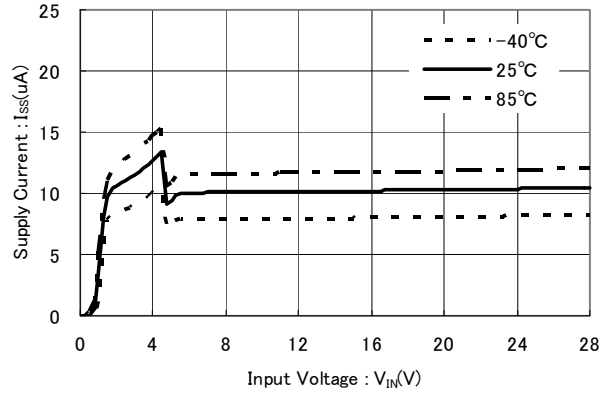
● XC6408D Series

(8) Supply Current vs. Input Voltage

XC6408D ( $V_{ROUT}=2.0V$ ,  $V_{DF}=2.0V$ )



XC6408D ( $V_{ROUT}=5.0V$ ,  $V_{DF}=4.5V$ )



XC6408D ( $V_{ROUT}=12.0V$ ,  $V_{DF}=11.0V$ )



XC6408D ( $V_{ROUT}=18.0V$ ,  $V_{DF}=16.0V$ )



## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

### ● XC6408E Series

#### (8) Supply Current vs. Input Voltage (Continued)



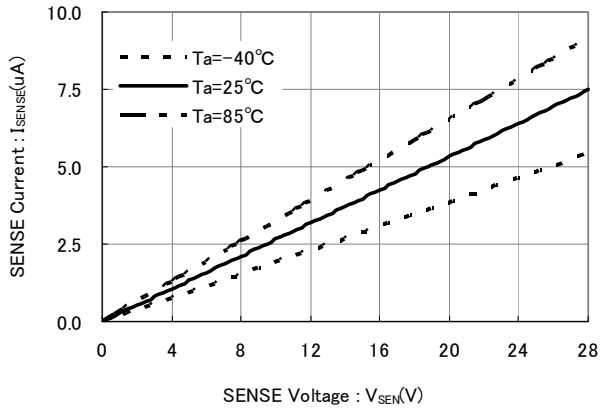


## ■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

● XC6408E Series

(9) SENSE Current vs. SENSE Voltage

XC6408E ( $V_{DF}=2.0V$ )



XC6408E ( $V_{DF}=4.5V$ )



XC6408E ( $V_{DF}=11.0V$ )



XC6408E ( $V_{DF}=16.0V$ )



## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

### ● XC6408E Series

(10) VD Supply Current vs. Input Voltage



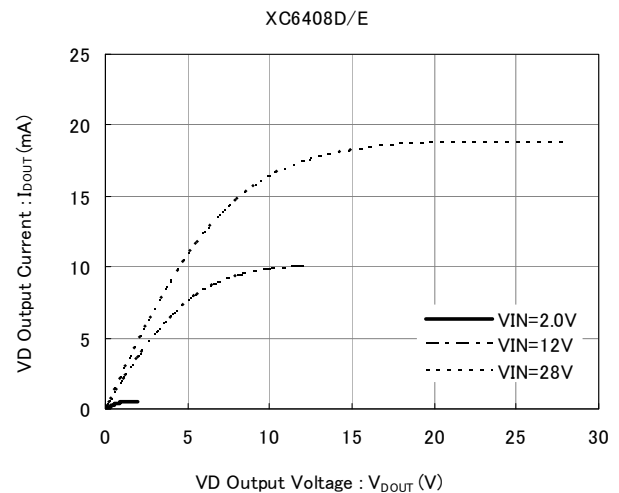
### ● XC6408D Series

(11) Cd Pin Current



### ● XC6408 Series

(12) VD N-ch Driver Output Current vs. N-ch Driver  $V_{DS}$



## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

● XC6408 Series

(13) VD N-ch Driver Output Current vs. Input Voltage



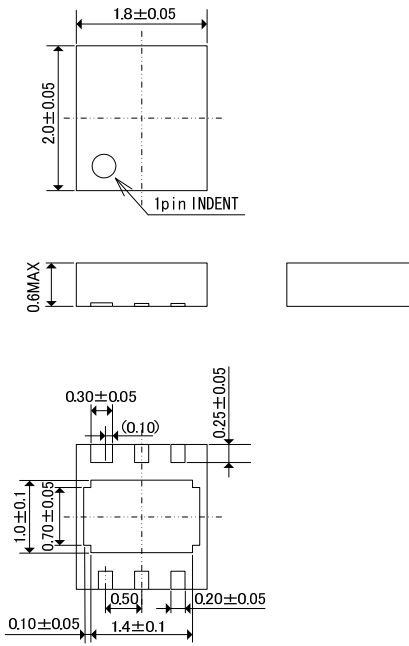
(14) Detect Voltage vs. Ambient Temperature  
Release Voltage vs. Ambient Temperature



## PACKAGING INFORMATION

### ● USP-6C

(unit : mm)



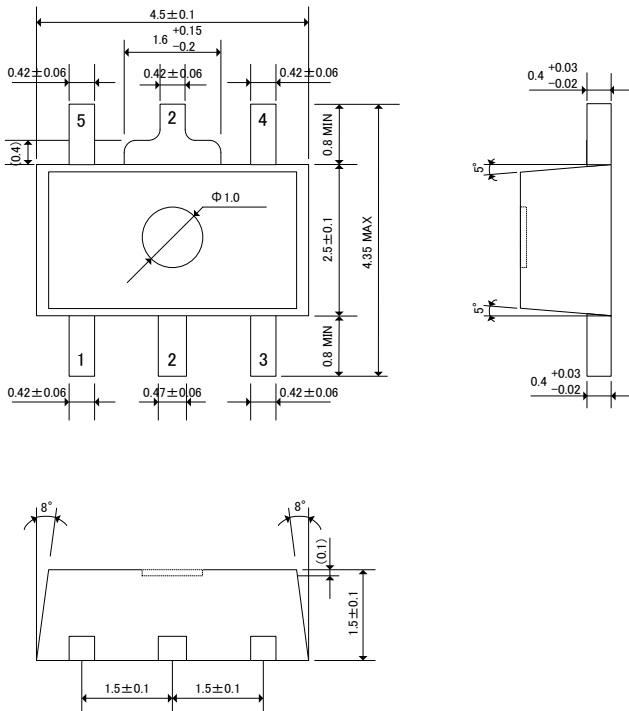
### ● SOT-25

(unit : mm)



### ● SOT-89-5

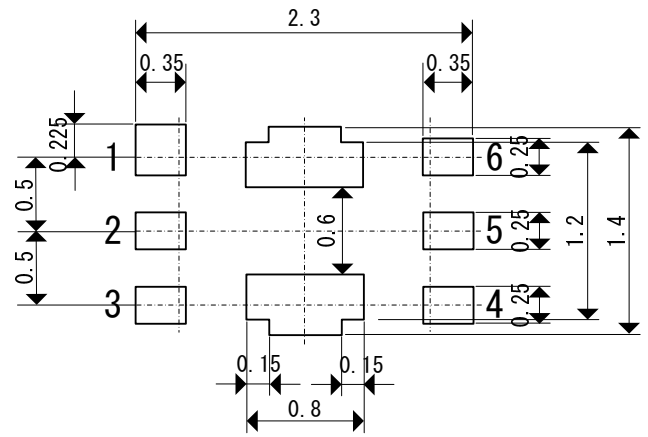
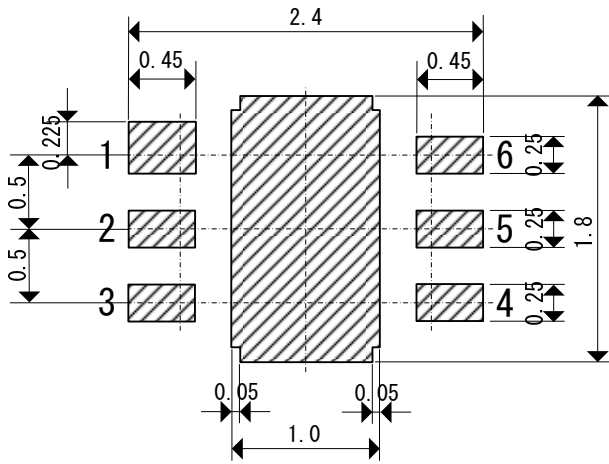
(unit : mm)



**PACKAGING INFORMATION (Continued)**

●USP-6C Reference Pattern Layout

●USP-6C Reference Metal Mask Design



## PACKAGING INFORMATION (Continued)

### ● USP-6C Power Dissipation

Power dissipation data for the USP-6C is shown in this page.

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

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

#### 1. Measurement Condition (Reference data)

- Condition: Mount on a board
- Ambient: Natural convection
- Soldering: Lead (Pb) free
- Board: Dimensions 40 x 40 mm (1600 mm<sup>2</sup> in one side)  
Copper (Cu) traces occupy 50% of the board area  
In top and back faces  
Package heat-sink is tied to the copper traces
- Material: Glass Epoxy (FR-4)
- Thickness: 1.6 mm
- Through-hole: 4 x 0.8 Diameter



Evaluation Board (Unit: mm)

#### 2. Power Dissipation vs. Ambient temperature

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

| Ambient Temperature ( $^\circ\text{C}$ ) | Power Dissipation Pd (mW) | Thermal Resistance ( $^\circ\text{C}/\text{W}$ ) |
|--|---------------------------|--|
| 25                                       | 1000                      | 100.00   |
| 85                                       | 400                       |  |



## ■ PACKAGING INFORMATION (Continued)

● SOT-25 Power Dissipation

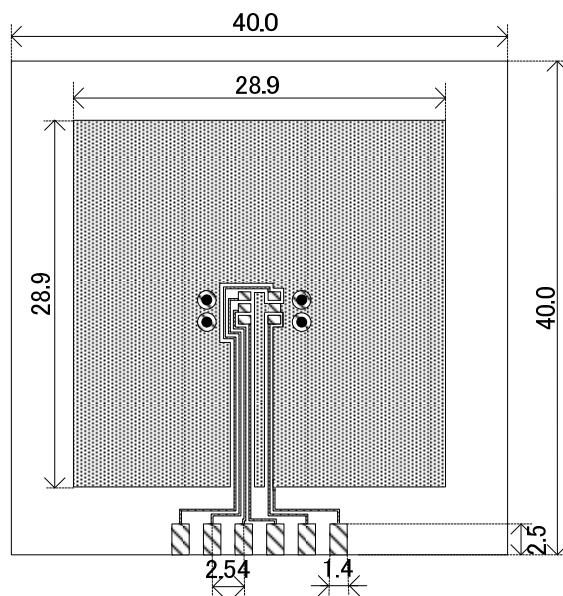
Power dissipation data for the SOT-25 is shown in this page.

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

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

1. Measurement Condition (Reference data)

- Condition: Mount on a board
- Ambient: Natural convection
- Soldering: Lead (Pb) free
- Board: Dimensions 40 x 40 mm (1600 mm<sup>2</sup> in one side)  
Copper (Cu) traces occupy 50% of the board area  
In top and back faces  
Package heat-sink is tied to the copper traces  
(Board of SOT-26 is used.)
- Material: Glass Epoxy (FR-4)
- Thickness: 1.6 mm
- Through-hole: 4 x 0.8 Diameter

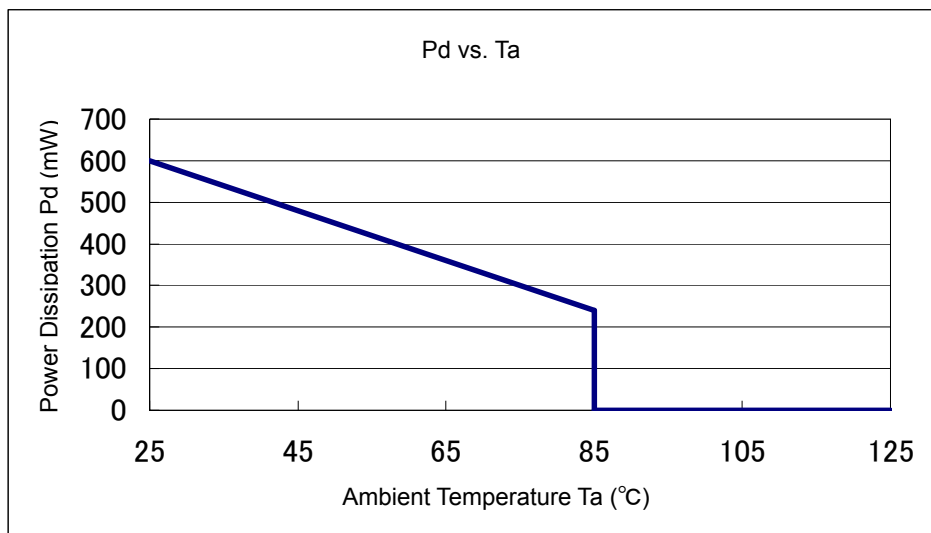


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient temperature

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

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



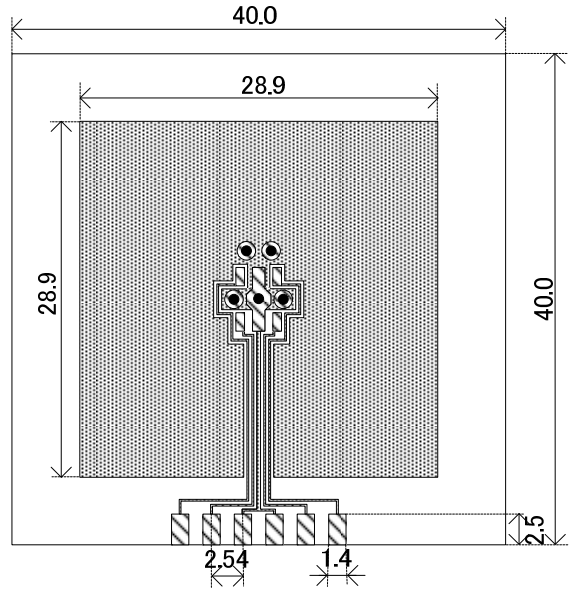
## PACKAGING INFORMATION (Continued)

### SOT-89-5 Power Dissipation

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

#### 1. Measurement Condition (Reference data)

- Condition: Mount on a board
- Ambient: Natural convection
- Soldering: Lead (Pb) free
- Board: Dimensions 40 x 40 mm (1600 mm<sup>2</sup> in one side)  
 Copper (Cu) traces occupy 50% of the board area  
 In top and back faces  
 Package heat-sink is tied to the copper traces
- Material: Glass Epoxy (FR-4)
- Thickness: 1.6 mm
- Through-hole: 5 x 0.8 Diameter

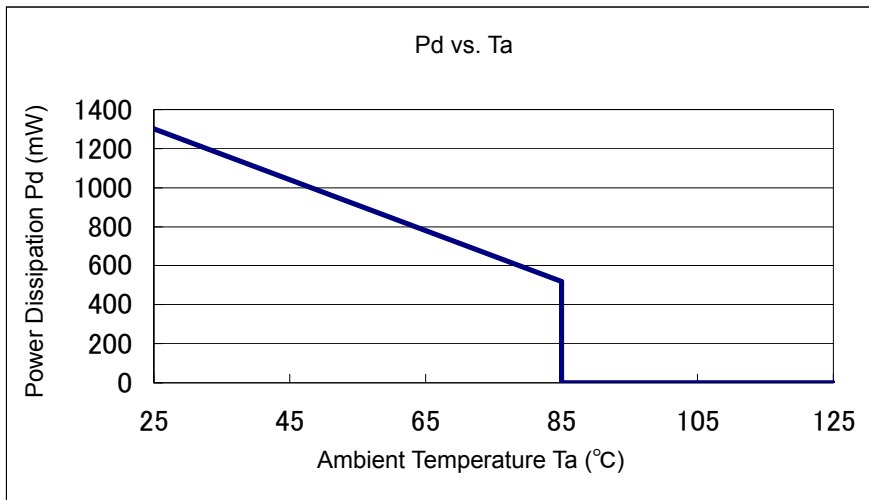


Evaluation Board (Unit: mm)

#### 2. Power Dissipation vs. Ambient temperature

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

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





## ■ MARKING RULE

● SOT-25, SOT-89-5, USP-6C

① represents additional function.

| MARK | PRODUCT SERIES |
|------|----------------|
| D    | XC6408D****-G  |
| E    | XC6408E****-G  |

②③ represents combination of output voltage and detect voltage for each IC.  
Numbers are sequence.

| MARK | PRODUCT SERIES |
|------|----------------|
| 01   | XC6408**01**-G |

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.

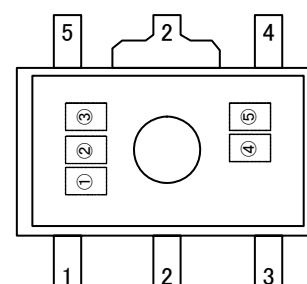
(G, I, J, O, Q, W excepted)

\*No character inversion used.

SOT25



SOT89-5



USP6C

