

XC6228 Series

ETR03116-001

300mA High Speed LDO Regulator with ON/OFF Switch

■ GENERAL DESCRIPTION

The XC6228 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.

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.

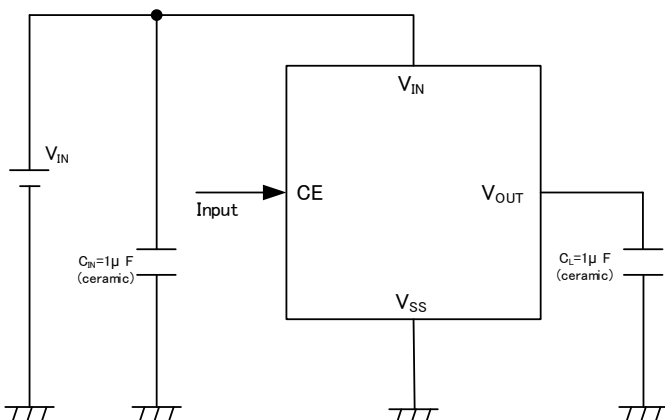
■ APPLICATIONS

- Mobile devices
- Wireless communications
- Modules
- Mobile phones

■ FEATURES

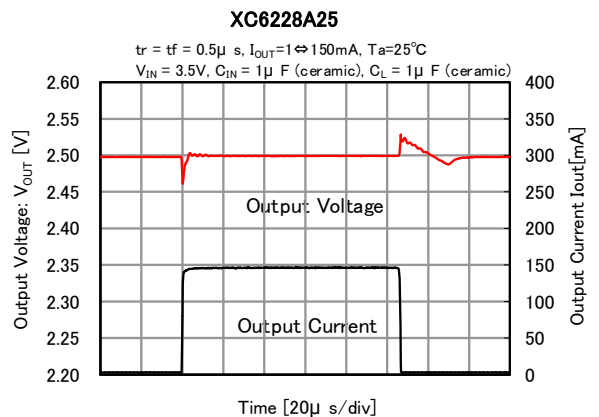
| | |
|--------------------------------------|--|
| Maximum Output Current | : 300mA |
| Input Voltage Range | : 1.6V ~ 5.5V |
| Output Voltages | : 1.2V ~ 4.0V (Accuracy $\pm 2\%$) 0.1V increments |
| Dropout Voltage | : 200mV@ $I_{OUT}=300mA$ ($V_{OUT}=3.0V$) |
| Low Power Consumption | : 100 μA |
| Stand-by Current | : 0.1 μA |
| High Ripple Rejection | : 80dB@f=1kHz |
| Protection Circuits | : Current Limit (400mA) |
| Low ESR Capacitors | : $C_{IN}=1\mu F$, $C_L=1\mu F$ |
| CE Function | : Active High, C_L High Speed Discharge |
| Operating Ambient Temperature | : -40°C ~ 85°C |
| Small Package | : USPQ-4B04 |
| Environmentally Friendly | : EU RoHS Compliant, Pb Free |

■ TYPICAL APPLICATION CIRCUIT

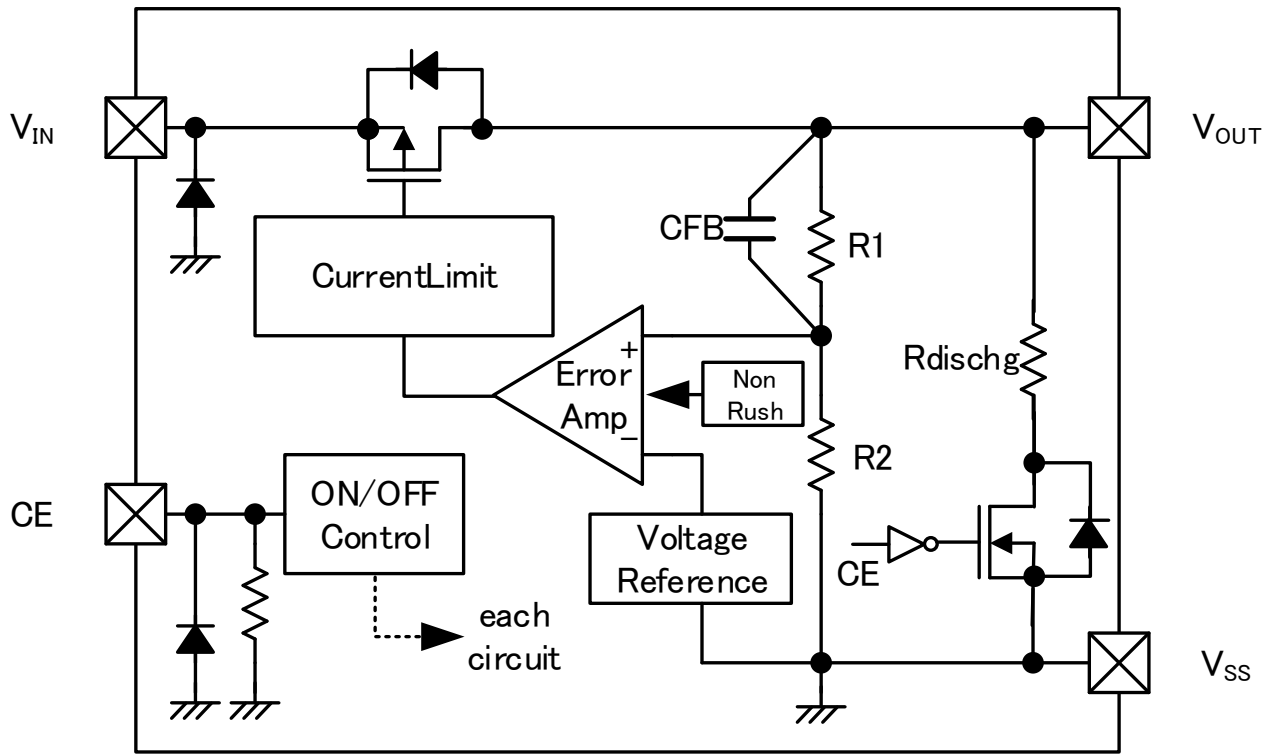


■ TYPICAL PERFORMANCE CHARACTERISTICS

- Load Transient Response



■ BLOCK DIAGRAMS



XC6228A

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

■ PRODUCT CLASSIFICATION

● Ordering Information

XC6228①②③④⑤⑥-⑦ (*1)

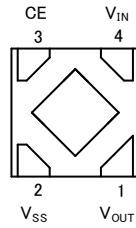
| DESIGNATOR | ITEM | SYMBOL | DESCRIPTION |
|------------|-------------------------|---------|--|
| ① | Regulator Type | A | Inrush Current Prevention Circuit Built-in |
| ②③ | Output Voltage | 12 ~ 40 | ex.) 2.80V → ②=2, ③=8 |
| ④ | Output Voltage Accuracy | 2 | Output Voltage Accuracy : ±2% |
| ⑤⑥-⑦ (*1) | Packages (Order Unit) | 9R-G | USPQ-4B04 (3,000/Reel) |

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

● Selection Guide

| TYPE | CURRENT LIMITER | CE PULL-DOWN RESISTOR | C _L DISCHARGE | INRUSH CURRENT PROTECTION |
|------|-----------------|-----------------------|--------------------------|---------------------------|
| A | Yes | Yes | Yes | Yes |

■ PIN CONFIGURATION



**USPQ-4B04
(BOTTOM VIEW)**

* The dissipation pad for the USPQ-4B04 package 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 |
|------------|-----------|----------------|
| 1 | V_{OUT} | Output |
| 2 | V_{SS} | Ground |
| 3 | CE | ON/OFF Control |
| 4 | V_{IN} | Power Input |

■ PIN FUNCTION ASSIGNMENT

| PIN NAME | SIGNAL | STATUS |
|----------|--------|------------|
| CE | L | Stand-by |
| | H | Active |
| | OPEN | Stand-by * |

* An internal pull-down resistor maintains the CE pin voltage to be low.

■ ABSOLUTE MAXIMUM RATINGS

| PARAMETER | | SYMBOL | RATINGS | UNITS |
|--|-----------|-----------|--|-------------|
| Input Voltage | | V_{IN} | -0.3 ~ 7.0 | V |
| Output Voltage | | V_{OUT} | 0.3 ~ $V_{IN} + 0.3$ or 7.0 ^(*) | V |
| CE Input Voltage | | V_{CE} | -0.3 ~ 7.0 | V |
| Power Dissipation ($T_a=25^{\circ}C$) | USPQ-4B04 | P_d | 550 (40mm x 40mm Standard board) ^(**) | mW |
| Operating Ambient Temperature | | T_{opr} | -40 ~ 85 | $^{\circ}C$ |
| Storage Temperature | | T_{stg} | -55 ~ 125 | $^{\circ}C$ |

All voltages are described based on the V_{SS} .

^(*) The maximum rating corresponds to the lowest value between $V_{IN}+0.3V$ or 7.0V

^(**) The power dissipation figure shown is PCB mounted and is for reference only.

The mounting condition is please refer to PACKAGING INFORMATION.

ELECTRICAL CHARACTERISTICS

Ta=25°C

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUITS |
|--|---|--|--|------------------------------|--|--------|----------|
| Output Voltage | $V_{OUT(E)}$ ^(*1) | $V_{CE}=V_{IN}$, $I_{OUT}=10mA$ | $V_{OUT(T)} \times 0.98$ ^(*2) | $V_{OUT(T)}$ ^(*2) | $V_{OUT(T)} \times 1.02$ ^(*2) | V | ① |
| Maximum Output Current | I_{OUTMAX} | $V_{CE}=V_{IN}$ | 300 | - | - | mA | ① |
| Load Regulation | ΔV_{OUT} | $V_{CE}=V_{IN}$, $0.1mA \leq I_{OUT} \leq 300mA$ | - | 25 | 45 | mV | ① |
| Dropout Voltage | V_{dif} ^(*3) | $V_{CE}=V_{IN}$, $I_{OUT}=300mA$ | - | 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 | $\frac{\Delta V_{OUT}}{\Delta V_{IN} \cdot V_{OUT}}$ | $V_{OUT(T)}+0.5V \leq V_{IN} \leq 5.5V$ $V_{CE}=V_{IN}$, $I_{OUT}=50mA$ | - | 0.01 | 0.1 | %/V | ① |
| Input Voltage | V_{IN} | - | 1.6 | - | 5.5 | V | ① |
| Output Voltage Temperature Characteristics | $\frac{\Delta V_{OUT}}{\Delta T_{opr} \cdot V_{OUT}}$ | $V_{CE}=V_{IN}$, $I_{OUT}=10mA$ $-40^{\circ}C \leq T_a \leq 85^{\circ}C$ | - | ±100 | - | ppm/°C | ① |
| Power Supply Rejection Ratio | PSRR | $V_{OUT(T)} < 2.5V$ $V_{IN}=3.0V_{DC}+0.5V_{p-pAC}$ $V_{CE}=V_{OUT(T)}+1.0V$ $I_{OUT}=30mA$, $f=1kHz$ $V_{OUT(T)} \geq 2.5V$ $V_{IN}=[V_{OUT(T)}+1.0]V_{DC}+0.5V_{p-pAC}$ $V_{CE}=V_{OUT(T)}+1.0V$ $I_{OUT}=30mA$, $f=1kHz$ | - | 80 | - | dB | ③ |
| Current Limit | I_{LIM} | $V_{CE}=V_{IN}$ | 310 | 400 | - | mA | ① |
| Short Current | I_{SHORT} | $V_{CE}=V_{IN}$, $V_{OUT}=V_{SS}$ | - | 140 | - | mA | ① |
| CE "H" Voltage | V_{CEH} | - | 1.0 | - | 5.5 | V | ④ |
| CE "L" Voltage | V_{CEL} | - | V_{SS} | - | 0.3 | V | ④ |
| CE "H" Current | I_{CEH} | $V_{CE}=V_{IN}=5.5V$ | 3.0 | 5.5 | 9.0 | μA | ④ |
| CE "L" Current | I_{CEL} | $V_{CE}=V_{SS}$ | -0.1 | - | 0.1 | μA | ④ |
| C_L Discharge Resistance | R_{DCHG} | $V_{IN}=5.5V$, $V_{OUT}=2.0V$, $V_{CE}=V_{SS}$ | - | 300 | - | Ω | ① |
| Inrush Current | I_{RUSH} | $V_{IN}=5.5V$, $V_{CE}=0 \rightarrow 5.5V$ | - | 150 | - | mA | ⑤ |

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) $V_{dif}=V_{IN1}$ ^(*4)- V_{OUT1} ^(*5) ($V_{IN1} \geq 1.6V$)

(*4) V_{IN1} =The input voltage when V_{OUT1} appears as input voltage is gradually decreased.

(*5) V_{OUT1} =A voltage equal to 98% of the output voltage whenever an amply stabilized $V_{OUT(T)}+1.0V$ is input for every I_{OUT} .

(*6) Unless otherwise stated regarding input voltage conditions, $V_{IN}=V_{OUT(T)}+1.0V$.

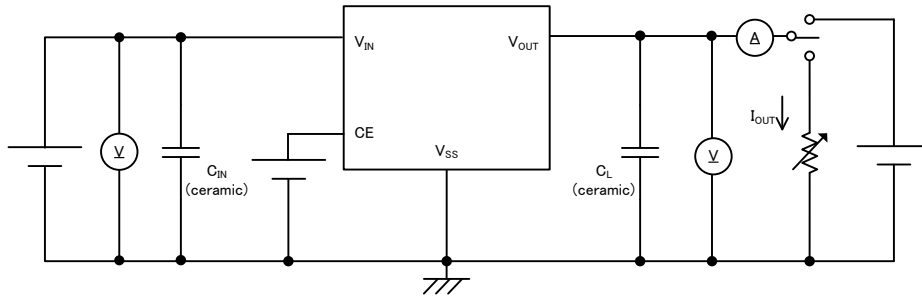
■ OUTPUT VOLTAGE CHART

● Voltage Chart 1

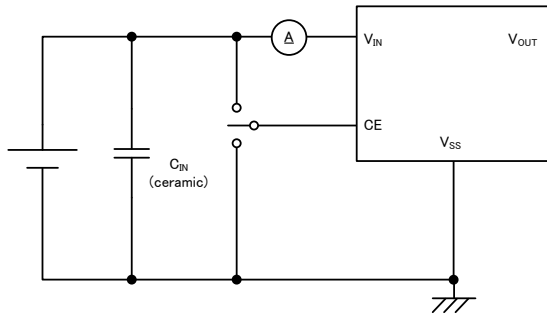
| NOMINAL OUTPUT VOLTAGE (V) | OUTPUT VOLTAGE (V) | | DROPOUT VOLTAGE (mV) E-1 | |
|-------------------------------------|-----------------------|-------|--------------------------------|------|
| $V_{OUT(T)}$ | $V_{OUT(E)}$ | | Vdif | |
| | MIN. | MAX. | TYP. | MAX. |
| 1.20 | 1.176 | 1.224 | 480 | 630 |
| 1.30 | 1.274 | 1.326 | 440 | 580 |
| 1.40 | 1.372 | 1.428 | 420 | 520 |
| 1.50 | 1.470 | 1.530 | 420 | 460 |
| 1.60 | 1.568 | 1.632 | 400 | 440 |
| 1.70 | 1.666 | 1.734 | | |
| 1.80 | 1.764 | 1.836 | 300 | 410 |
| 1.90 | 1.862 | 1.938 | | |
| 2.00 | 1.960 | 2.040 | 270 | 380 |
| 2.10 | 2.058 | 2.142 | | |
| 2.20 | 2.156 | 2.244 | | |
| 2.30 | 2.254 | 2.346 | | |
| 2.40 | 2.352 | 2.448 | | |
| 2.50 | 2.450 | 2.550 | 240 | 350 |
| 2.60 | 2.548 | 2.652 | | |
| 2.70 | 2.646 | 2.754 | | |
| 2.80 | 2.744 | 2.856 | | |
| 2.90 | 2.842 | 2.958 | | |
| 3.00 | 2.940 | 3.060 | 200 | 305 |
| 3.10 | 3.038 | 3.162 | | |
| 3.20 | 3.136 | 3.264 | | |
| 3.30 | 3.234 | 3.366 | | |
| 3.40 | 3.332 | 3.468 | | |
| 3.50 | 3.430 | 3.570 | | |
| 3.60 | 3.528 | 3.672 | | |
| 3.70 | 3.626 | 3.774 | | |
| 3.80 | 3.724 | 3.876 | | |
| 3.90 | 3.822 | 3.978 | | |
| 4.00 | 3.920 | 4.080 | | |

TEST CIRCUITS

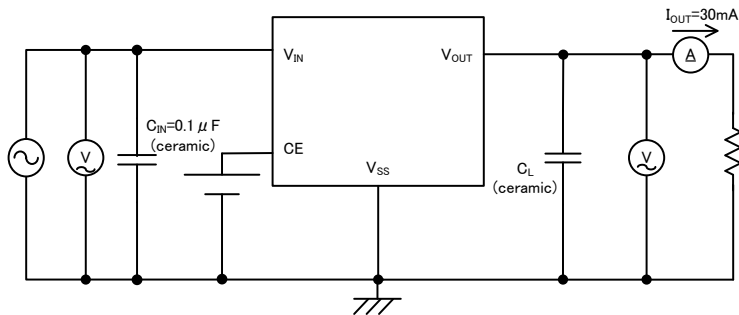
● Circuit ①



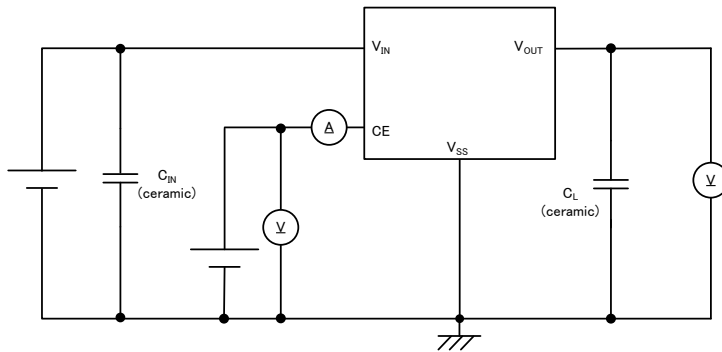
● Circuit ②



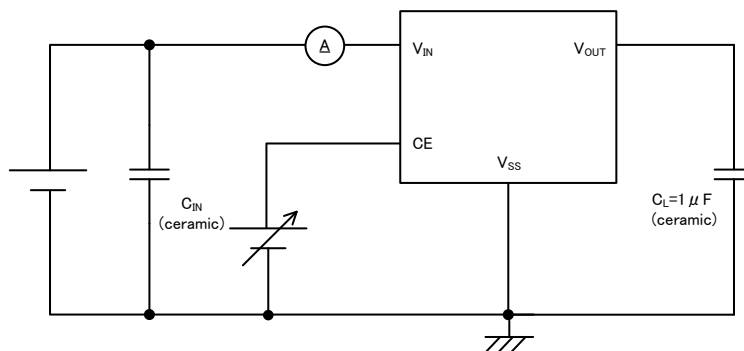
● Circuit ③



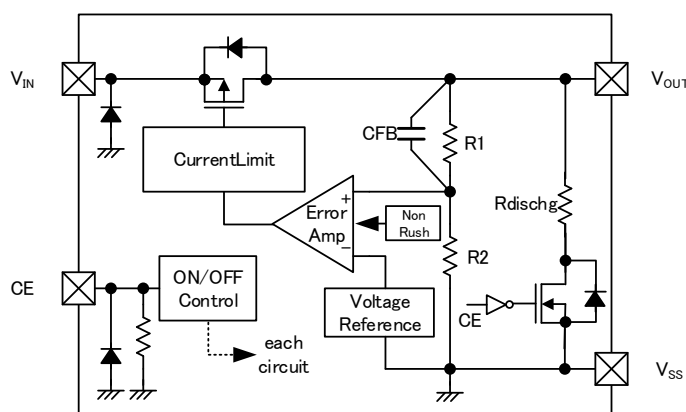
● Circuit ④



● Circuit ⑤



■ OPERATIONAL EXPLANATION



XC6228A

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 V_{OUT} pin is then driven by the subsequent output signal. The output voltage at the V_{OUT} pin 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 signal.

<Low ESR Capacitor>

The XC6228 series needs an output capacitor C_L for phase compensation. Please place an output capacitor (C_L) at the output pin (V_{OUT}) and the ground pin (V_{SS}) as close as possible. Please use the output capacitor (C_L) is 1.0 μ F or larger. For a stable power input, please connect an input capacitor (C_{IN}) of 1.0 μ F between the V_{IN} pin and the V_{SS} pin.

<Current Limiter >

The XC6228 has current limiter and droop shape of fold-back circuit. When the load current reaches the current limit, the droop current limiter circuit operates and the output voltage drops. When the output voltage dropped, the fold-back circuit operates and the output current goes to decrease.

<CE Pin>

The IC's internal circuitry can be shutdown via the signal from the CE pin. In shutdown mode, the XC6228 series enables the electric charge at the output capacitor (C_L) to be discharged via the internal switch located between the V_{OUT} and V_{SS} pins, and as a result the V_{OUT} pin quickly returns to the V_{SS} level. The XC6228 series has a pull-down resistor at the CE pin inside, so that the CE pin input current flows.

<Inrush Current Protection>

The XC6228 series has a built-in inrush current protection function

This function is activated when the output voltage reaches within 30%(Typ.) of the set V_{OUT} after starting up.

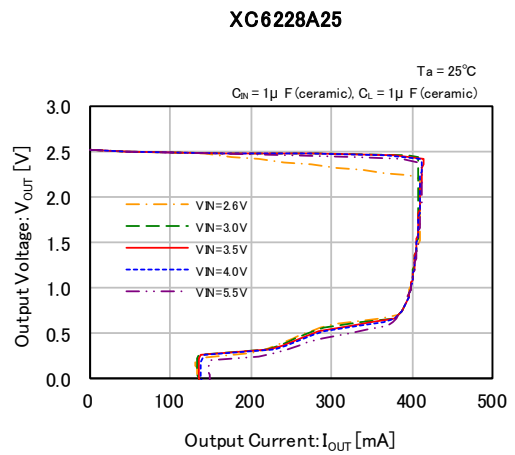
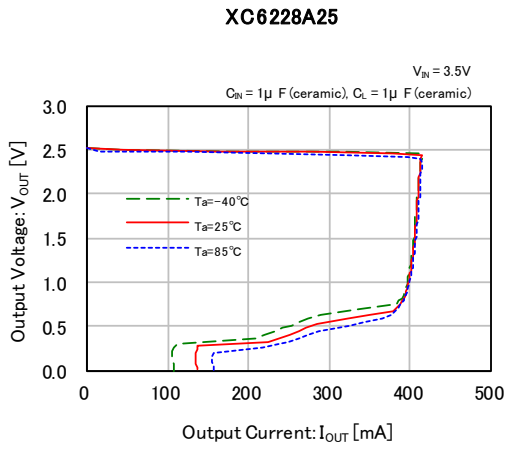
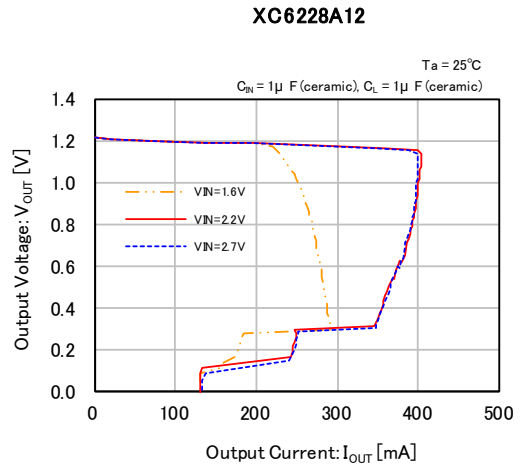
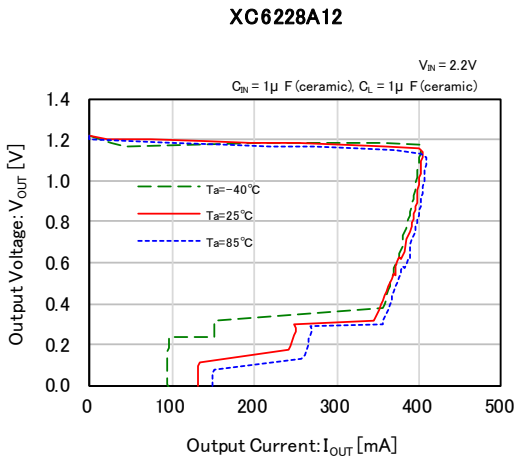
The duration time of this function is 120 μ s(TYP.), and during operation of the function, the current flowing from the input(V_{IN})to the output(V_{OUT}) is restrained within the IRUSH, Typ.150mA.

■ NOTES ON USE

1. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.
2. Where wiring impedance is high, operations may become unstable due to the noise and/or phase lag depending on output current. Please strengthen V_{IN} and V_{SS} wiring in particular.
3. The input capacitor C_{IN} and the output capacitor C_L should be placed to the as close as possible with a shorter wiring.
4. 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.
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.

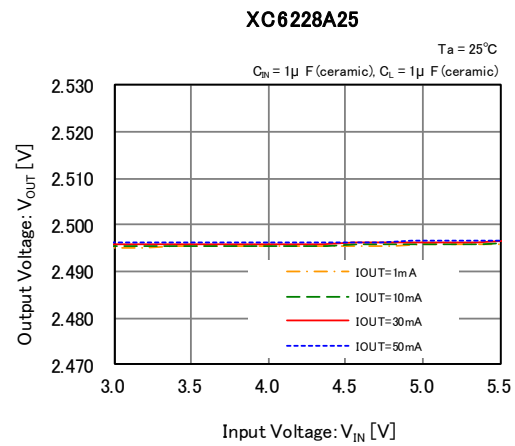
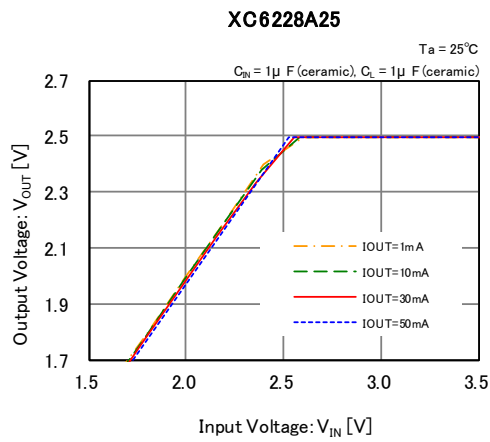
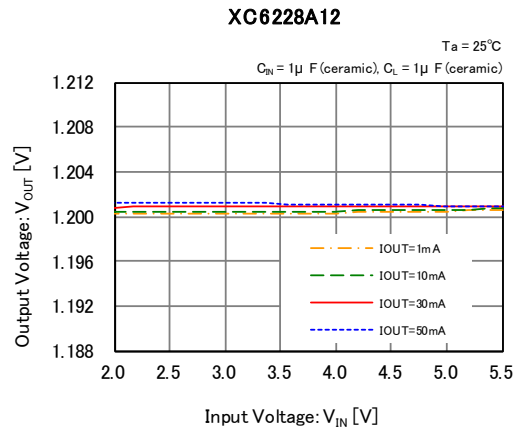
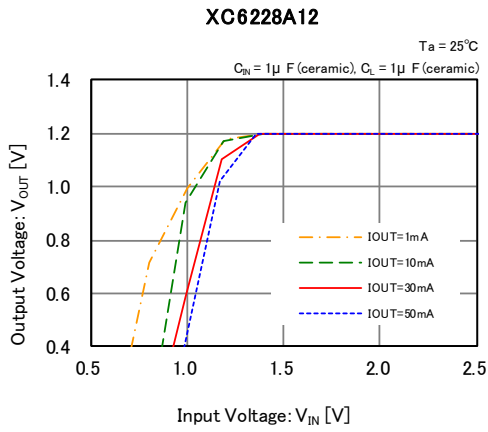
TYPICAL PERFORMANCE CHARACTERISTICS

(1) Output Voltage vs. Output Current



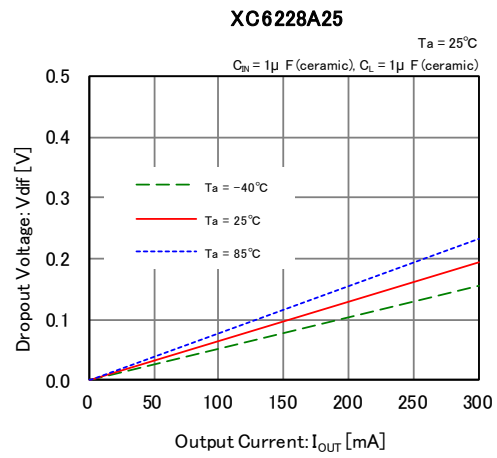
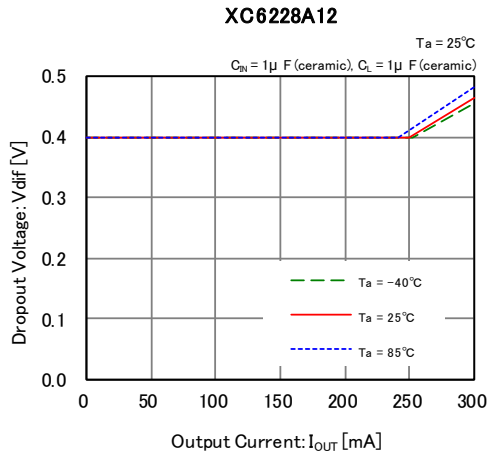
■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(2) Output Voltage vs. Input Voltage

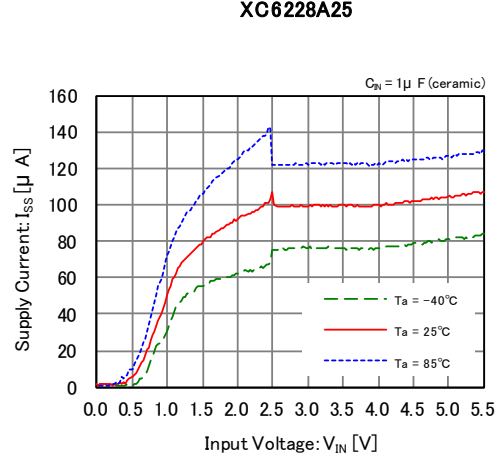
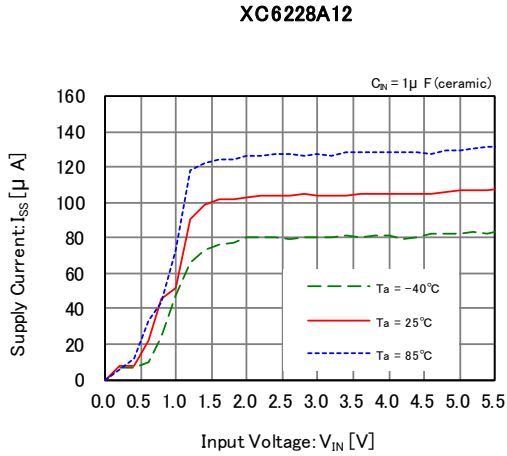


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(3) Dropout Voltage vs. Output Current



(4) Supply Current vs. Input Voltage

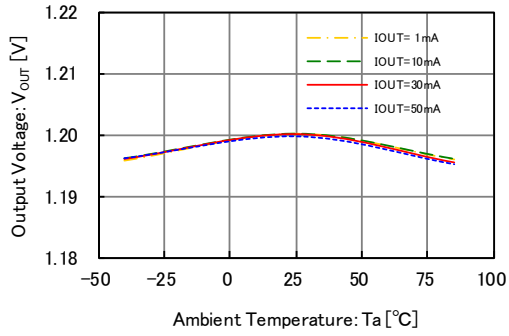


■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(5) Output Voltage vs. Ambient Temperature

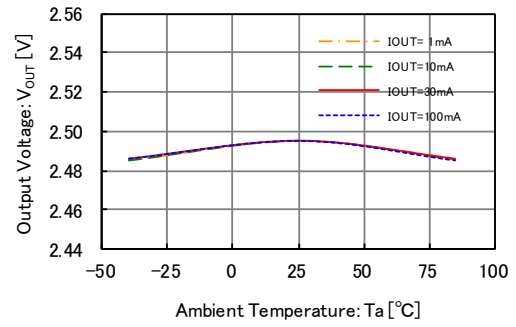
XC6228A12

$V_N = 2.2V$
 $C_N = 1\mu F$ (ceramic), $C_L = 1\mu F$ (ceramic)



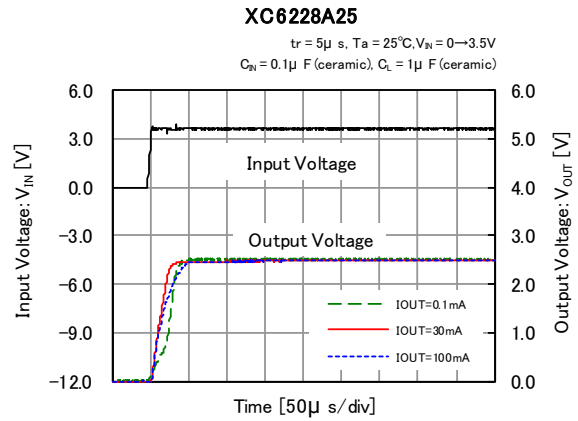
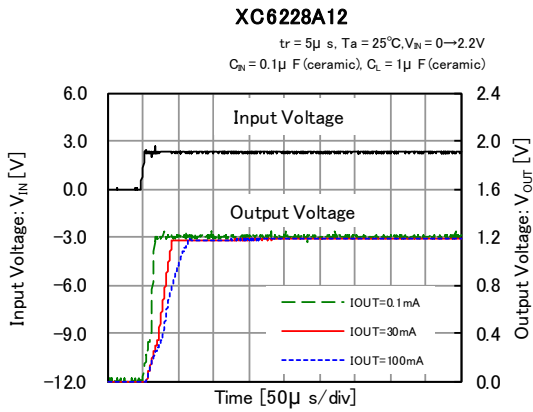
XC6228A25

$V_N = 3.5V$
 $C_N = 1\mu F$ (ceramic), $C_L = 1\mu F$ (ceramic)

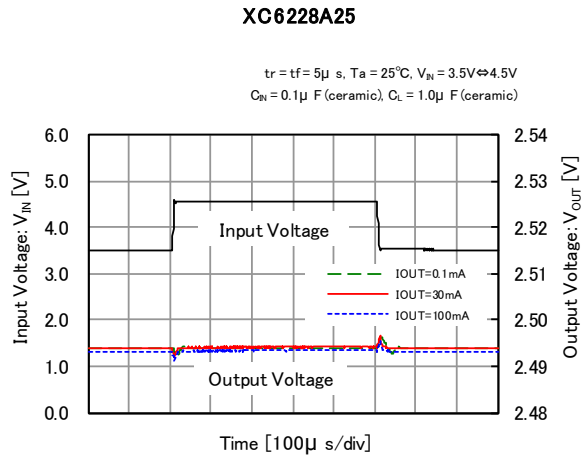
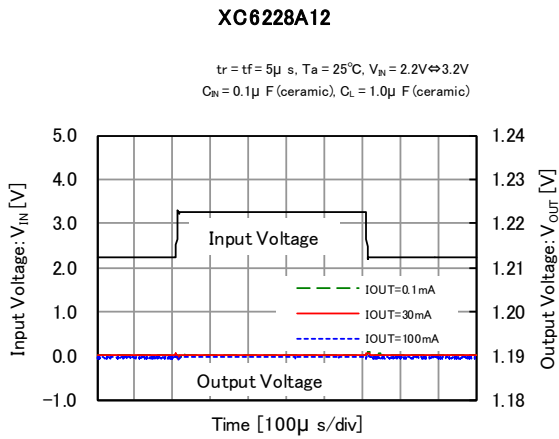


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(6) Rising Response Time



(7) Input Transient Response

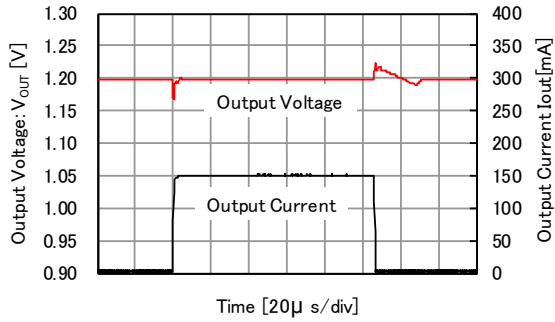


■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(8) Load Transient Response

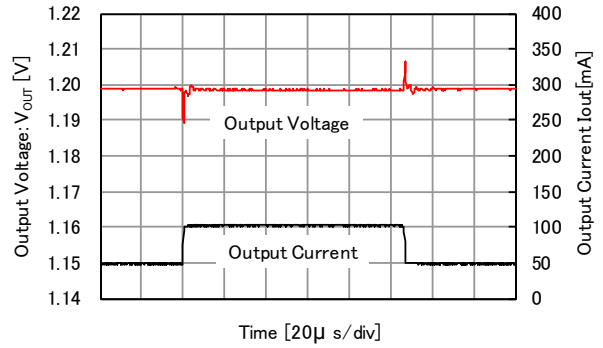
XC6228A12

$t_r = t_f = 0.5\mu\text{ s}$, $T_a = 25^\circ\text{C}$, $I_{OUT} = 1\text{mA} \leftrightarrow 150\text{mA}$
 $V_{IN} = 2.2\text{V}$, $C_{IN} = 1\mu\text{ F (ceramic)}$, $C_L = 1\mu\text{ F (ceramic)}$



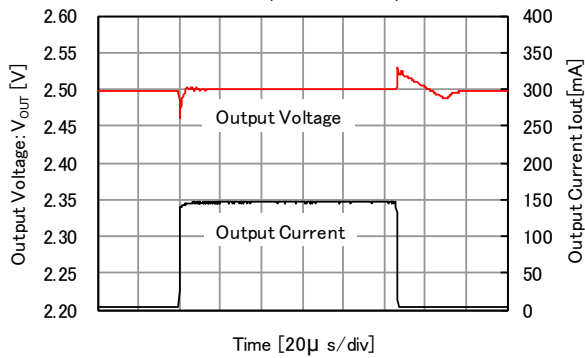
XC6228A12

$t_r = t_f = 0.5\mu\text{ s}$, $T_a = 25^\circ\text{C}$, $I_{OUT} = 50\text{mA} \leftrightarrow 100\text{mA}$
 $V_{IN} = 2.2\text{V}$, $C_{IN} = 1\mu\text{ F (ceramic)}$, $C_L = 1\mu\text{ F (ceramic)}$



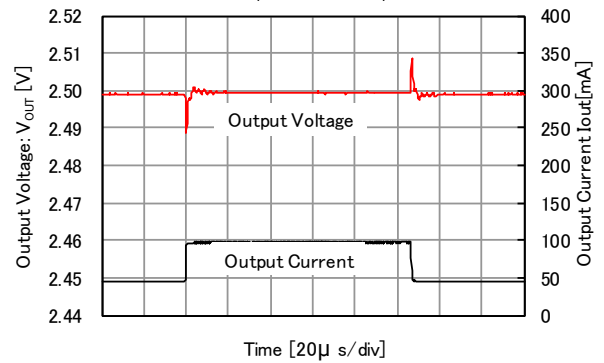
XC6228A25

$t_r = t_f = 0.5\mu\text{ s}$, $T_a = 25^\circ\text{C}$, $I_{OUT} = 1\text{mA} \leftrightarrow 150\text{mA}$
 $V_{IN} = 3.5\text{V}$, $C_{IN} = 1\mu\text{ F (ceramic)}$, $C_L = 1\mu\text{ F (ceramic)}$



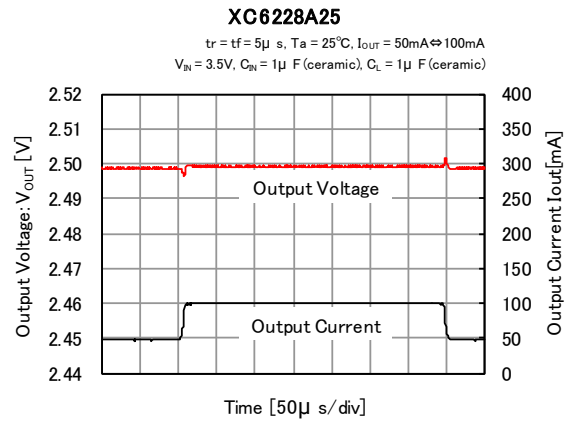
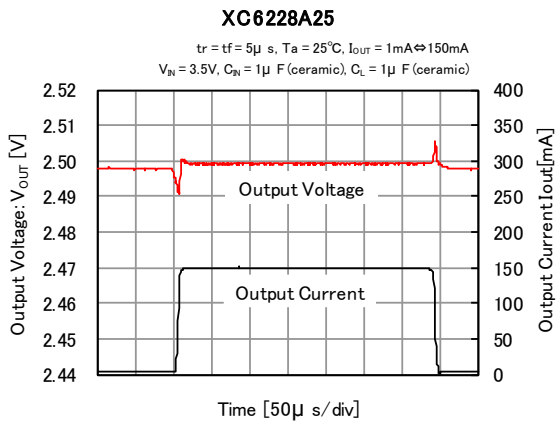
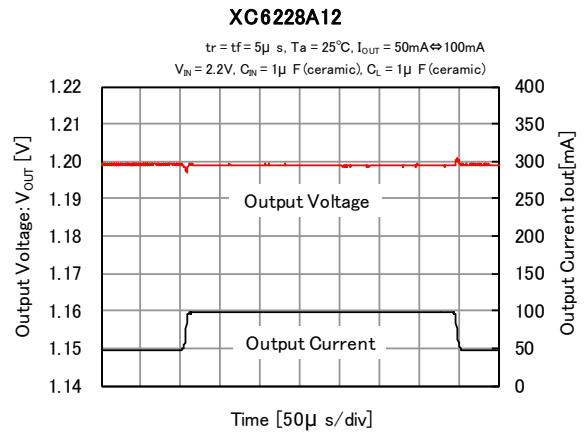
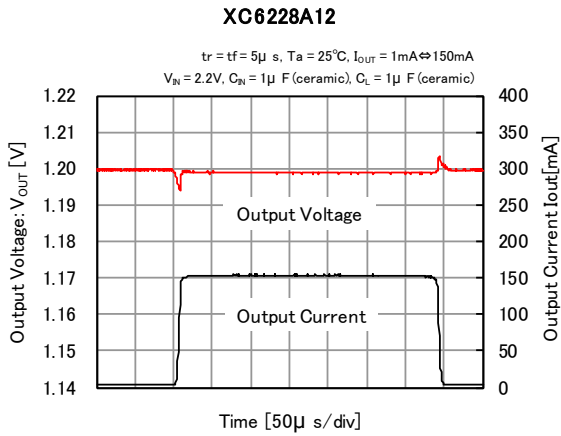
XC6228A25

$t_r = t_f = 0.5\mu\text{ s}$, $T_a = 25^\circ\text{C}$, $I_{OUT} = 50\text{mA} \leftrightarrow 100\text{mA}$
 $V_{IN} = 3.5\text{V}$, $C_{IN} = 1\mu\text{ F (ceramic)}$, $C_L = 1\mu\text{ F (ceramic)}$



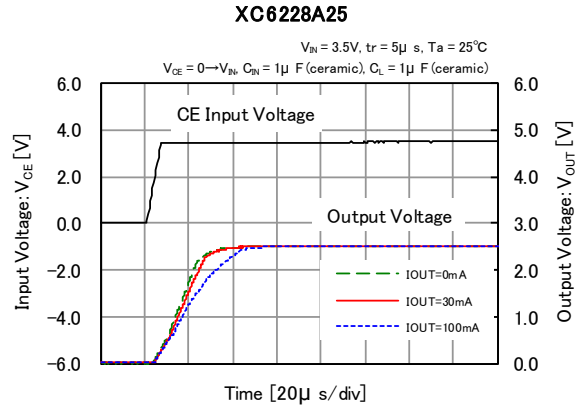
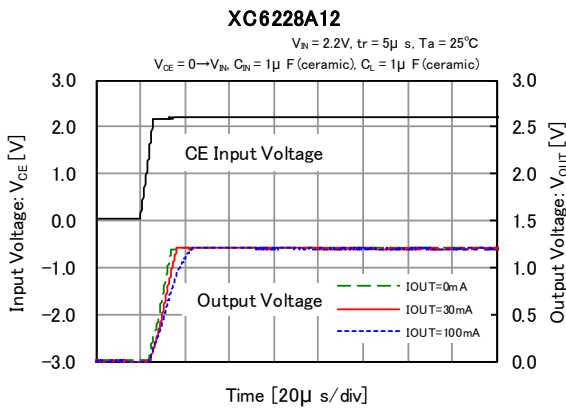
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) Load Transient Response

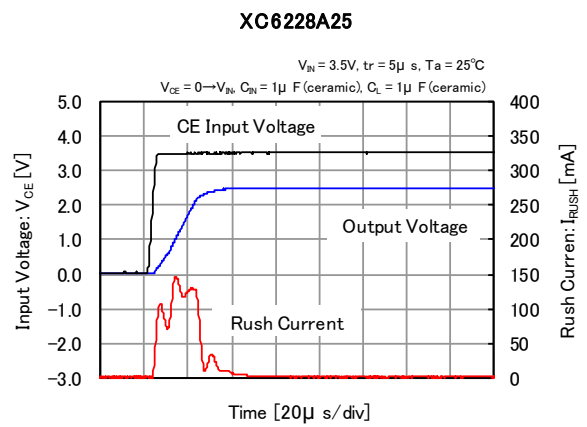
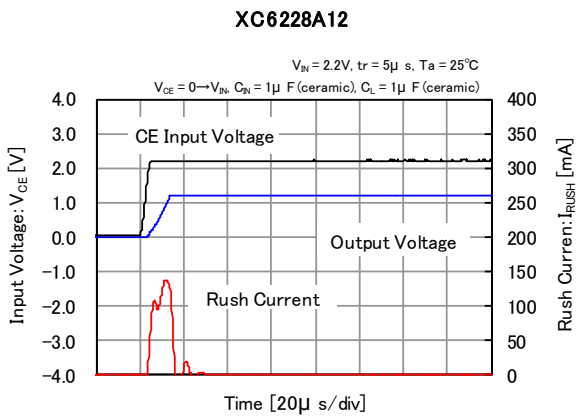


■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(10) CE Rising Response Time



(11) Inrush Current Response Time

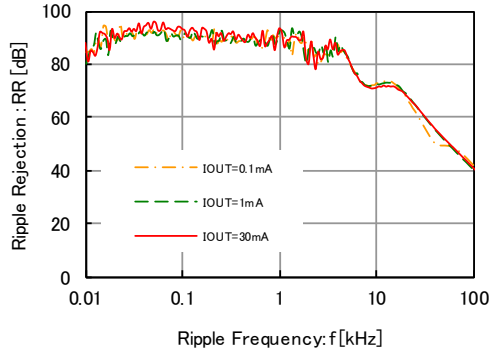


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(12) Ripple Rejection Rate

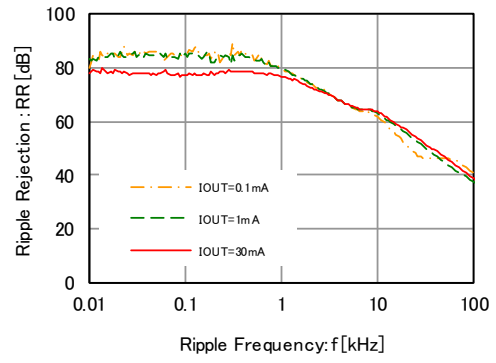
XC6228A12

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



XC6228A25

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



■ PACKAGING INFORMATION

For the latest package information go to, www.torexsemi.com/technical-support/packages

| PACKAGE | OUTLIN / LAND PATTERN | THERMAL CHARACTERISTICS | |
|-----------|-------------------------------|-------------------------|---|
| USPQ-4B04 | USPQ-4B04 PKG | Standard Board | USPQ-4B04 Power Dissipation |

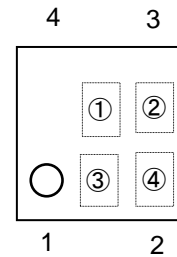
MARKING RULE

● USPQ-4B04

① represents product series.

| MARK | PRODUCT SERIES |
|------|----------------|
| T | XC6228A****-G |

USPQ-4B04



② represents products series, type of regulator and output voltage.

| MARK | OUTPUT VOLTAGE (V) | PRODUCT SERIES | MARK | OUTPUT VOLTAGE (V) | PRODUCT SERIES |
|------|--------------------|----------------|------|--------------------|----------------|
| 0 | 1.2 | XC6228*12***-G | F | 2.7 | XC6228*27***-G |
| 1 | 1.3 | XC6228*13***-G | H | 2.8 | XC6228*28***-G |
| 2 | 1.4 | XC6228*14***-G | K | 2.9 | XC6228*29***-G |
| 3 | 1.5 | XC6228*15***-G | L | 3.0 | XC6228*30***-G |
| 4 | 1.6 | XC6228*16***-G | M | 3.1 | XC6228*31***-G |
| 5 | 1.7 | XC6228*17***-G | N | 3.2 | XC6228*32***-G |
| 6 | 1.8 | XC6228*18***-G | P | 3.3 | XC6228*33***-G |
| 7 | 1.9 | XC6228*19***-G | R | 3.4 | XC6228*34***-G |
| 8 | 2.0 | XC6228*20***-G | S | 3.5 | XC6228*35***-G |
| 9 | 2.1 | XC6228*21***-G | T | 3.6 | XC6228*36***-G |
| A | 2.2 | XC6228*22***-G | U | 3.7 | XC6228*37***-G |
| B | 2.3 | XC6228*23***-G | V | 3.8 | XC6228*38***-G |
| C | 2.4 | XC6228*24***-G | X | 3.9 | XC6228*39***-G |
| D | 2.5 | XC6228*25***-G | Y | 4.0 | XC6228*40***-G |
| E | 2.6 | XC6228*26***-G | | | |

③,④ represents production lot number 01~09, 0A~0Z, 11~9Z, A1~A9, AA~AZ, B1~ZZ repeated (G, I, J, O, Q, W excluded)* No character inversion used.

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