

1A LDO Voltage Regulator with "Green Operation"

■ GENERAL DESCRIPTION

☆ Green Operation-Compatible

The XC6220 series is a highly accurate, low noise, high speed, low dropout, and large current CMOS voltage regulator with Green Operation function. The series consists of a voltage reference, an error amplifier, a current limiter, an inrush current prevention circuit and a phase compensation circuit plus a driver transistor.

With a 0.2Ω on-resistance driver transistor integrated, the ultra low dropout voltage performance with output currents up to 1A greatly extends battery life as does the Green Operation function which can switch between high speed and power save modes automatically. A low ESR ceramic capacitor can be used for the output stabilization capacitor (C_L).

Output voltage is selectable in 0.05V increments within the range of 0.8V~5.0V, using laser trimming technologies.

An over current protection circuit and a thermal shutdown circuit are built in. The over current protection circuit will operate when the output current reaches its limit current. The thermal shutdown circuit will operate when the junction temperature reaches its limit temperature. The inrush prevention circuit works by controlling the inrush current which charges to C_L when the IC starts up. In this way, voltage fluctuations in power supply caused by inrush current during system start up can be minimized.

The CE function enables the output to be turned off and the IC becomes a stand-by mode resulting in greatly reduced power consumption.

■ APPLICATIONS

- Optical disk drive
- Magnetic disk drive
- Digital still cameras / Camcorders
- Digital audio equipments

■ FEATURES

| | |
|--|--|
| Maximum Output Current | : 1000mA ($1.2V \leq V_{OUT} \leq 5.0V$) |
| Dropout Voltage | : 20mV @ 100mA ($V_{OUT}=3.0V$) |
| | : 60mV @ 300mA ($V_{OUT}=3.0V$) |
| Operating Voltage Range | : 1.6V ~ 6.0V |
| Output Voltage Range | : 0.8V ~ 5.0V (0.05V increments) |
| Accuracy | : $\pm 1\%$ ($V_{OUT} \geq 2.0V$) |
| | : $\pm 20mV$ ($V_{OUT} < 2.0V$) |
| Low Power Consumption | : 8μA (TYP.) in PS mode |
| | : 50μA (TYP.) in HS mode |
| Operating Ambient Temperature | : -40°C ~ 85°C |
| Thermal Shutdown | : Detect 150°C, Release 135°C(TYP.) |
| Inrush Current Prevention | : 700mA (MAX.) |
| C_L Auto Discharge | : XC6220 Series B/D type |
| CE Pull-Down Resistor | : XC6220 Series C/D type |
| Output Capacitor | : Ceramic Capacitor Compatible |
| Packages | : USP-6C, SOT-25, SOT-89-5 |
| Environmentally Friendly | : EU RoHS Compliant, Pb Free |

■ TYPICAL APPLICATION CIRCUIT



■ TYPICAL PERFORMANCE CHARACTERISTICS

XC6220x181



BLOCK DIAGRAMS



●XC6220 Series Type A (Semi-custom)



●XC6220 Series Type B



●XC6220 Series Type C (Semi-custom)



●XC6220 Series Type D (Semi-custom)

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

PRODUCT CLASSIFICATION

Ordering Information

XC6220 ①②③④⑤⑥-⑦^(*)

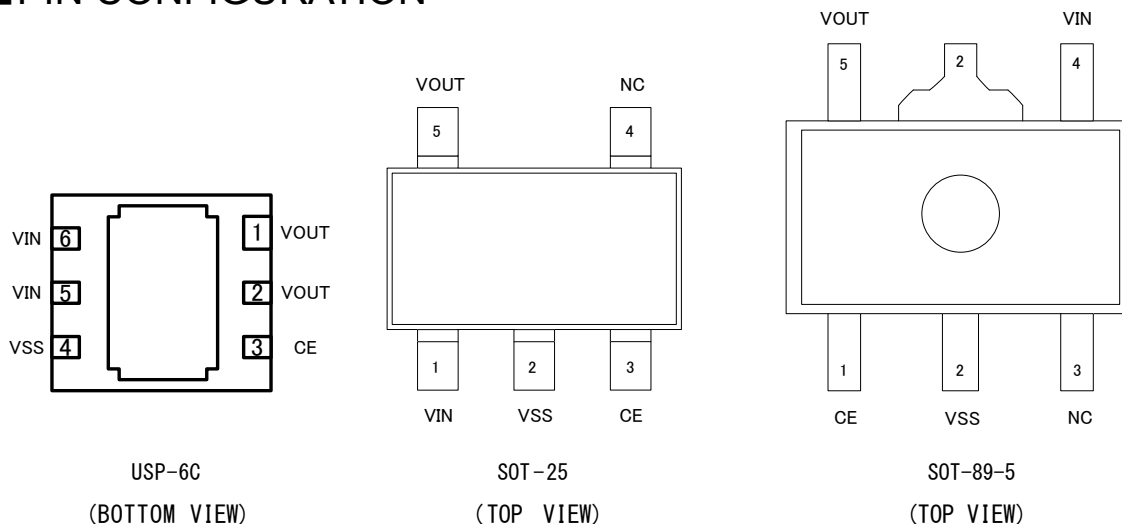
| DESIGNATOR | ITEM | SYMBOL | DESCRIPTION |
|------------|---|---------|---|
| ① | Type of CE | A | without CE Pull-down resistor, without C _L discharge (Semi-custom) |
| | | B | without CE Pull-down resistor, with C _L discharge (Standard) |
| | | C | with CE Pull-down resistor, without C _L discharge (Semi-custom) |
| | | D | with CE Pull-down resistor, with C _L discharge (Semi-custom) |
| ②③ | Output Voltage | 08 ~ 50 | e.g. 3.0V → ②=3, ③=0 |
| ④ | Output Voltage (the 2 nd decimal place) | 1 | Output voltage {0.00v} (the 2 nd decimal place is "0") |
| | | B | Output voltage {0.05v} (the 2 nd decimal place is "5") |
| ⑤⑥-⑦ | Packages (Order Unit) | MR | SOT-25 (3,000pcs/Reel) |
| | | MR-G | SOT-25 (3,000pcs/Reel) |
| | | PR | SOT-89-5 (1,000pcs/Reel) |
| | | PR-G | SOT-89-5 (1,000pcs/Reel) |
| | | ER | USP-6C (3,000pcs/Reel) |
| | | ER-G | USP-6C (3,000pcs/Reel) |

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

Selection Guide

| TYPE | CE PULL-DOWN RESISTOR | CL AUTO-DISCHARGE |
|------|-----------------------|-------------------|
| A | No | No |
| B | No | Yes |
| C | Yes | No |
| D | Yes | Yes |

■ PIN CONFIGURATION



* For the USP-6C, the No.5 and 6 V_{IN} pins should be connected. The No.1 and 2 pins V_{OUT} pins should be connected. The dissipation pad 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. 4) pin.

■ PIN ASSIGNMENT

| PIN NUMBER | | | PIN NAME | FUNCTIONS |
|------------|----------|--------|------------------|----------------|
| SOT-25 | SOT-89-5 | USP-6C | | |
| 3 | 1 | 3 | CE | ON/OFF Control |
| 1 | 4 | 6, 5 | V _{IN} | Power Input |
| 2 | 2 | 4 | V _{SS} | Ground |
| 5 | 5 | 1, 2 | V _{OUT} | Output |
| 4 | 3 | - | NC | No connection |

■ FUNCTIONS

| PIN NAME | DESIGNATOR | CONDITIONS | IC OPERATION |
|----------|------------|------------------------------|---|
| CE | L | $V_{CE} \leq 0.4V$ | OFF |
| | H | $1.2V \leq V_{CE} \leq 6.0V$ | ON |
| | OPEN | $V_{CE} = \text{OPEN}^{(*)}$ | Undefined state (XC6220A/B Series) OFF (XC6220C/D Series) |

(*) Please avoid the state of OPEN, and connect CE pin to any arbitrary voltage.

* For the XC6220C/D series, CE function logic is fixed as L level because of the CE pull-down resistor.

■ ABSOLUTE MAXIMUM RATINGS

| PARAMETER | | SYMBOL | RATINGS | UNITS |
|---|----------|-----------|--|-------|
| Input Voltage | | V_{IN} | $V_{SS} - 0.3 \sim 6.5$ | V |
| Output Voltage | | V_{OUT} | $V_{SS} - 0.3 \sim V_{IN} + 0.3$ | V |
| CE Input Voltage | | V_{CE} | $V_{SS} - 0.3 \sim 6.5$ | V |
| Power Dissipation ($T_a=25^\circ\text{C}$) | SOT-25 | Pd | 250 | mW |
| | | | 600 (40mm x 40mm Standard Board) ^(*) | |
| | | | 760 (JESD51-7 Board) ^(*) | |
| | SOT-89-5 | | 500 | |
| | | | 1300 (40mm x 40mm Standard Board) ^(*) | |
| | | | 1750 (JESD51-7 Board) ^(*) | |
| | USP-6C | | 120 | |
| | | | 1000 (40mm x 40mm Standard Board) ^(*) | |
| Operating Ambient Temperature | | T_{opr} | -40 ~ 85 | °C |
| Storage Temperature | | T_{stg} | -55 ~ 125 | °C |

^(*)The power dissipation figure shown is PCB mounted and is for reference only.
The mounting condition is please refer to PACKAGING INFORMATION.

■ ELECTRICAL CHARACTERISTICS

● XC6220A/B/C/D Series

Ta=25°C

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|--|--|---|-------|--------------------------|-------|--------|---------|
| Output Voltage | V _{OUT(E)} (*1) | High Speed Mode (HS) 2.0V ≤ V _{OUT(T)} ≤ 5.0V V _{CE} =V _{IN} , I _{OUT} =30mA | ×0.99 | V _{OUT(T)} (*2) | ×1.01 | V | ① |
| | | High Speed Mode (HS) 0.8V ≤ V _{OUT(T)} ≤ 1.95V V _{CE} =V _{IN} , I _{OUT} =30mA | -0.02 | | +0.02 | | |
| | | Power Save Mode (PS) 2.0V ≤ V _{OUT(T)} ≤ 5.0V V _{CE} =V _{IN} , I _{OUT} =0.1mA | ×0.98 | | ×1.02 | | |
| | | Power Save Mode (PS) 0.8V ≤ V _{OUT(T)} ≤ 1.95V V _{CE} =V _{IN} , I _{OUT} =0.1mA | -0.04 | | +0.04 | | |
| Output Current | I _{OUTMAX} | V _{CE} =V _{IN} V _{IN} =V _{OUT(T)} +1.0V 0.8V ≤ V _{OUT(T)} ≤ 1.15V | 700 | 1200 | - | mA | ① |
| | | V _{CE} =V _{IN} V _{IN} =V _{OUT(T)} +1.0V 1.2V ≤ V _{OUT(T)} ≤ 5.0V | 1000 | 1200 | - | | |
| Load Regulation | ΔV _{OUT} | High Speed Mode (HS), V _{CE} =V _{IN} , 10mA ≤ I _{OUT} ≤ 300mA | - | 10 | 45 | mV | ① |
| Dropout Voltage1 | V _{dif} (*3) | I _{OUT} =300mA, V _{CE} =V _{IN} | - | E-1 | | mV | ① |
| Dropout Voltage2 | V _{dif} (*3) | I _{OUT} =1000mA, V _{CE} =V _{IN} | - | - | E-2 | mV | ① |
| Supply Current 1 | I _{SS1} | High Speed Mode(HS) V _{IN} =V _{CE} =V _{OUT(T)} +1.0V I _{OUT} =10mA (A/B Series) | - | 50 | 108 | μA | ② |
| | | High Speed Mode(HS) V _{IN} =V _{CE} =V _{OUT(T)} +1.0V I _{OUT} =10mA (C/D Series) | - | 50 | E-3 | | |
| Supply Current 2 | I _{SS2} | Power Save Mode(PS) V _{IN} =V _{CE} =V _{OUT(T)} +1.0V I _{OUT} =0.1mA (A/B Series) | - | 8 | 18 | μA | ② |
| | | Power Save Mode(PS) V _{IN} =V _{CE} =V _{OUT(T)} +1.0V I _{OUT} =0.1mA (C/D Series) | - | 8 | E-4 | | |
| Stand-by Current | I _{STBY} | V _{IN} =6.0V, V _{CE} =V _{SS} | -0.1 | 0.01 | 0.1 | μA | ② |
| Line Regulation | ΔV _{OUT} / (ΔV _{IN} ·V _{OUT}) | V _{OUT(T)} +0.5V ≤ V _{IN} ≤ 6.0V 1.1V ≤ V _{OUT(T)} ≤ 5.0V V _{CE} =V _{IN} , I _{OUT} =100mA | - | 0.01 | 0.20 | %V | ① |
| | | 1.6V ≤ V _{IN} ≤ 6.0V 0.8V ≤ V _{OUT(T)} ≤ 1.05V V _{CE} =V _{IN} , I _{OUT} =100mA | | | | | |
| Input Voltage | V _{IN} | | 1.6 | - | 6.0 | V | ① |
| Output Voltage Temperature Characteristics | ΔV _{OUT} / (ΔTa·V _{OUT}) | V _{CE} =V _{IN} I _{OUT} =30mA -40°C ≤ Ta ≤ 85°C | - | ±100 | - | ppm/°C | ① |

ELECTRICAL CHARACTERISTICS (Continued)

Ta=25°C

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|--|--------------------|---|-----------------|------|------|-------|---------|
| Ripple Rejection Ratio | PSRR | $V_{IN}=5.75VDC+0.5Vp-pAC$ $4.75V \leq V_{OUT(T)} \leq 5.0V$ $V_{CE}=V_{IN}, I_{OUT}=30mA, f=1kHz$ | - | 50 | - | dB | ③ |
| | | $V_{IN}=\{V_{OUT(T)}+1.0\}VDC+0.5Vp-pAC$ $0.85V \leq V_{OUT(T)} \leq 4.7V$ $V_{CE}=V_{IN}, I_{OUT}=30mA, f=1kHz$ | | | | | |
| | | $V_{IN}=1.85VDC+0.5Vp-pAC$ $V_{OUT(T)}=0.8V$ $V_{CE}=V_{IN}, I_{OUT}=30mA, f=1kHz$ | | | | | |
| Limit Current | I _{LIM} | $V_{CE}=V_{IN}=V_{OUT(T)}+1.0V$ $0.8V \leq V_{OUT(T)} \leq 1.15V$ | 705 | 1200 | - | mA | ① |
| | | $V_{CE}=V_{IN}=V_{OUT(T)}+1.0V$ $1.2V \leq V_{OUT(T)} \leq 5.0V$ | 1005 | 1200 | - | | |
| Short Current | I _{SHORT} | $V_{CE}=V_{IN}$ Short V _{OUT} to V _{SS} level | - | 180 | - | mA | ① |
| PS Switching Current | I _{GOR} | : $1.45V \leq V_{OUT(T)} \leq 5.0V$ $V_{IN}=V_{OUT(T)}+1.0V, V_{CE}=V_{IN}$: $0.8V \leq V_{OUT(T)} \leq 1.4V$ $V_{IN}=1.6V, V_{CE}=V_{IN}$ I _{OUT} =heavy to light load | 1.0 | 2.0 | - | mA | ⑤ |
| HS Switching Current | I _{GO} | : $1.45V \leq V_{OUT(T)} \leq 5.0V$ $V_{IN}=V_{OUT(T)}+1.0V, V_{CE}=V_{IN}$: $0.8V \leq V_{OUT(T)} \leq 1.4V$ $V_{IN}=1.6V, V_{CE}=V_{IN}$ I _{OUT} =light to heavy load | - | 5.0 | 10 | mA | ⑤ |
| Switch Current Hysteresis Range | I _{GOhys} | I _{GOhys} =I _{GO} -I _{GOR} | - | 3.0 | - | mA | ⑤ |
| PS Switching Delay Time | t _{DPS} | $V_{IN}=V_{OUT(T)}+1.0V, V_{CE}=V_{IN}$ Time until HS mode is changed-over to PS mode by I _{GOR} . | - | - | E-5 | μs | ⑤ |
| CE High Level Voltage | V _{CEH} | | 1.2 | - | 6.0 | V | ④ |
| CE Low Level Voltage | V _{CEL} | | V _{SS} | - | 0.4 | V | ④ |
| CE High Level Current | I _{CEH} | $V_{CE}=V_{IN}=6.0V$ (A/B series) | -0.1 | - | 0.1 | μA | ④ |
| | | $V_{CE}=V_{IN}=6.0V$ (C/D series) | - | 9 | 15 | μA | |
| CE Low Level Current | I _{CEL} | $V_{CE}=V_{SS}$ | -0.1 | - | 0.1 | μA | ④ |
| CL Discharge Resistance ⁽⁴⁾ | R _{DCHG} | $V_{IN}=6.0V, V_{OUT}=5.0V, V_{CE}=V_{SS}$ | - | 460 | - | Ω | ① |
| Thermal Shutdown Detect Temperature | T _{TSD} | Junction Temperature | - | 150 | - | °C | ① |
| Thermal Shutdown Release Temperature | T _{TSR} | Junction Temperature | - | 135 | - | °C | ① |
| Inrush Current | I _{RUSH} | $V_{IN}=V_{OUT(T)}+1.0V, C_L=22\mu F$ $V_{CE}=0V \rightarrow V_{OUT(T)}+1.0V$ (Only when rising and within 1ms) | - | - | 700 | mA | ⑥ |

* 1: V_{OUT(E)} = Effective output voltage

(The output voltage when an amply stabilized "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. (Shown in the voltage chart E-0)

* 3: V_{dif} = {V_{IN1} - V_{OUT1}}

V_{IN1} is the input voltage when V_{OUT1} appears at the V_{OUT} pin while input voltage is gradually decreased.

V_{OUT1} is the voltage equal to 98% of the HS mode output voltage when an amply stabilized V_{OUT(T)} + 1.0V are supplied to the V_{IN} pin.

* 4: For the XC6220B/D series only. The XC6220A/C series (semi-custom) discharges by only R1 and R2 resistors as shown in the block diagrams.

■ ELECTRICAL CHARACTERISTICS (Continued)

● Voltage Chart 1

| SYMBOL | E-0 | | | | E-1 | | E-2 | E-3 | E-4 | E-5 | |
|--------|--|---|------------------|---|------------------|--|-------------------|---|--|--|---|
| | NOMINAL OUTPUT VOLTAGE VOLTAGE (V) | OUTPUT VOLTAGE 1 (HS Mode) (V) | | OUTPUT VOLTAGE 2 (PS Mode) (V) | | DROPOUT VOLTAGE 1 Vdif 1 (mV) I _{OUT} =300mA | | DROPOUT VOLTAGE 2 Vdif 2 (mV) I _{OUT} =1000mA | SUPPLY CURRENT 1 (XC6220C/D) (μ A) | SUPPLY CURRENT 2 (XC6220C/D) (μ A) | PS SWITCH DELAY TIME (μ S) |
| | | V _{OUT(T)} | V _{OUT} | | V _{OUT} | | V _{dif1} | | V _{dif2} | I _{SS1} | I _{SS2} |
| | MIN. | MAX. | MIN. | MAX. | TYP. | MAX. | MAX. | MAX. | MAX. | MAX. | MAX. |
| 0.80 | 0.7800 | 0.8200 | 0.7600 | 0.8400 | 400 | 575 | - | 112.500 | 22.500 | 650 | |
| 0.85 | 0.8300 | 0.8700 | 0.8100 | 0.8900 | | | | 112.625 | 22.625 | | |
| 0.90 | 0.8800 | 0.9200 | 0.8600 | 0.9400 | | | | 112.750 | 22.750 | | |
| 0.95 | 0.9300 | 0.9700 | 0.9100 | 0.9900 | | | | 112.875 | 22.875 | | |
| 1.00 | 0.9800 | 1.0200 | 0.9600 | 1.0400 | 240 | 405 | | 113.000 | 23.000 | | |
| 1.05 | 1.0300 | 1.0700 | 1.0100 | 1.0900 | | | | 113.125 | 23.125 | | |
| 1.10 | 1.0800 | 1.1200 | 1.0600 | 1.1400 | | | | 113.250 | 23.250 | | |
| 1.15 | 1.1300 | 1.1700 | 1.1100 | 1.1900 | 180 | 305 | | 113.375 | 23.375 | | |
| 1.20 | 1.1800 | 1.2200 | 1.1600 | 1.2400 | 150 | 215 | | 700 | 113.500 | | 23.500 |
| 1.25 | 1.2300 | 1.2700 | 1.2100 | 1.2900 | | | | | 113.625 | | 23.625 |
| 1.30 | 1.2800 | 1.3200 | 1.2600 | 1.3400 | | | 113.750 | | 23.750 | | |
| 1.35 | 1.3300 | 1.3700 | 1.3100 | 1.3900 | | | 113.875 | | 23.875 | | |
| 1.40 | 1.3800 | 1.4200 | 1.3600 | 1.4400 | | | 114.000 | | 24.000 | | |
| 1.45 | 1.4300 | 1.4700 | 1.4200 | 1.4800 | | | 114.125 | | 24.125 | | |
| 1.50 | 1.4800 | 1.5200 | 1.4700 | 1.5300 | 100 | 150 | 114.250 | 24.250 | | | |
| 1.55 | 1.5300 | 1.5700 | 1.5100 | 1.5900 | | | 114.375 | 24.375 | | | |
| 1.60 | 1.5800 | 1.6200 | 1.5600 | 1.6400 | | | 114.500 | 24.500 | | | |
| 1.65 | 1.6300 | 1.6700 | 1.6100 | 1.6900 | | | 114.625 | 24.625 | | | |
| 1.70 | 1.6800 | 1.7200 | 1.6600 | 1.7400 | | | 114.750 | 24.750 | | | |
| 1.75 | 1.7300 | 1.7700 | 1.7100 | 1.7900 | | | 114.875 | 24.875 | | | |
| 1.80 | 1.7800 | 1.8200 | 1.7600 | 1.8400 | | | 115.000 | 25.000 | | | |
| 1.85 | 1.8300 | 1.8700 | 1.8100 | 1.8900 | | | 115.125 | 25.125 | | | |
| 1.90 | 1.8800 | 1.9200 | 1.8600 | 1.9400 | | | 115.250 | 25.250 | | | |
| 1.95 | 1.9300 | 1.9700 | 1.9100 | 1.9900 | | | 115.375 | 25.375 | | | |
| 2.00 | 1.9800 | 2.0200 | 1.9600 | 2.0400 | 85 | 130 | 655 | 115.500 | 25.500 | | |
| 2.05 | 2.0295 | 2.0705 | 2.0090 | 2.0910 | | | | 115.625 | 25.625 | | |
| 2.10 | 2.0790 | 2.1210 | 2.0580 | 2.1420 | | | | 115.750 | 25.750 | | |
| 2.15 | 2.1285 | 2.1715 | 2.1070 | 2.1930 | | | | 115.875 | 25.875 | | |
| 2.20 | 2.1780 | 2.2220 | 2.1560 | 2.2440 | | | | 116.000 | 26.000 | | |
| 2.25 | 2.2275 | 2.2725 | 2.2050 | 2.2950 | | | | 116.125 | 26.125 | | |
| 2.30 | 2.2770 | 2.3230 | 2.2540 | 2.3460 | | | | 116.250 | 26.250 | | |
| 2.35 | 2.3265 | 2.3735 | 2.3030 | 2.3970 | | | | 116.375 | 26.375 | | |
| 2.40 | 2.3760 | 2.4240 | 2.3520 | 2.4480 | | | | 116.500 | 26.500 | | |
| 2.45 | 2.4255 | 2.4745 | 2.4010 | 2.4990 | | | | 116.625 | 26.625 | | |
| 2.50 | 2.4750 | 2.5250 | 2.4500 | 2.5500 | 116.750 | 26.750 | | | | | |
| 2.55 | 2.5245 | 2.5755 | 2.4990 | 2.6010 | 116.875 | 26.875 | | | | | |
| 2.60 | 2.5740 | 2.6260 | 2.5480 | 2.6520 | 117.000 | 27.000 | | | | | |
| 2.65 | 2.6235 | 2.6765 | 2.5970 | 2.7030 | 117.125 | 27.125 | | | | | |
| 2.70 | 2.6730 | 2.7270 | 2.6460 | 2.7540 | 117.250 | 27.250 | | | | | |
| 2.75 | 2.7225 | 2.7775 | 2.6950 | 2.8050 | 117.375 | 27.375 | | | | | |
| 2.80 | 2.7720 | 2.8280 | 2.7440 | 2.8560 | 117.500 | 27.500 | | | | | |
| 2.85 | 2.8215 | 2.8785 | 2.7930 | 2.9070 | 117.625 | 27.625 | | | | | |
| 2.90 | 2.8710 | 2.9290 | 2.8420 | 2.9580 | 117.750 | 27.750 | | | | | |
| 2.95 | 2.9205 | 2.9795 | 2.8910 | 3.0090 | 117.875 | 27.875 | | | | | |
| | | | | | 65 | 110 | | | 1200 | | |

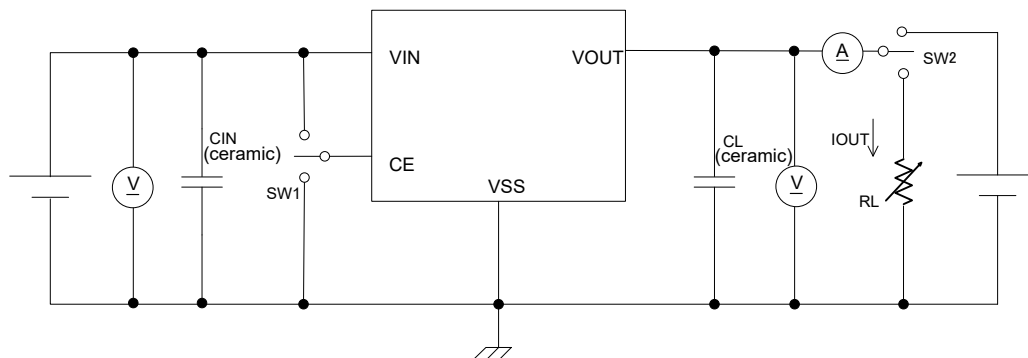
ELECTRICAL CHARACTERISTICS (Continued)

Voltage Chart 2

| SYMBOL | E-0 | | | | E-1 | | E-2 | E-3 | E-4 | E-5 | |
|--------|----------------------------|------------------------------|------------------|------------------------------|------------------|--|-------------------|---|---|---|------------------------------------|
| | NOMINAL OUTPUT VOLTAGE (V) | OUTPUT VOLTAGE (HS Mode) (V) | | OUTPUT VOLTAGE (PS Mode) (V) | | DROPOUT VOLTAGE 1 V _{dif1} (mV) I _{OUT} =300mA | | DROPOUT VOLTAGE 2 V _{dif2} (mV) I _{OUT} =1000mA | SUPPLY CURRENT 1 (XC6220C/D) (μ A) | SUPPLY CURRENT 2 (XC6220C/D) (μ A) | PS SWITCH DELAY TIME (μ S) |
| | | V _{OUT(T)} | V _{OUT} | | V _{OUT} | | V _{dif1} | | V _{dif2} | I _{SS1} | I _{SS2} |
| | MIN. | MAX. | MIN. | MAX. | TYP. | MAX. | MAX. | MAX. | MAX. | MAX. | MAX. |
| 3.00 | 2.9700 | 3.0300 | 2.9400 | 3.0600 | 60 | 95 | 655 | 118.000 | 28.000 | 1200 | |
| 3.05 | 3.0195 | 3.0805 | 2.9890 | 3.1110 | | | | 118.125 | 28.125 | | |
| 3.10 | 3.0690 | 3.1310 | 3.0380 | 3.1620 | | | | 118.250 | 28.250 | | |
| 3.15 | 3.1185 | 3.1815 | 3.0870 | 3.2130 | | | | 118.375 | 28.375 | | |
| 3.20 | 3.1680 | 3.2320 | 3.1360 | 3.2640 | | | | 118.500 | 28.500 | | |
| 3.25 | 3.2175 | 3.2825 | 3.1850 | 3.3150 | | | | 118.625 | 28.625 | | |
| 3.30 | 3.2670 | 3.3330 | 3.2340 | 3.3660 | | | | 118.750 | 28.750 | | |
| 3.35 | 3.3165 | 3.3835 | 3.2830 | 3.4170 | | | | 118.875 | 28.875 | | |
| 3.40 | 3.3660 | 3.4340 | 3.3320 | 3.4680 | | | | 119.000 | 29.000 | | |
| 3.45 | 3.4155 | 3.4845 | 3.3810 | 3.5190 | | | | 119.125 | 29.125 | | |
| 3.50 | 3.4650 | 3.5350 | 3.4300 | 3.5700 | | | | 119.250 | 29.250 | | |
| 3.55 | 3.5145 | 3.5855 | 3.4790 | 3.6210 | | | | 119.375 | 29.375 | | |
| 3.60 | 3.5640 | 3.6360 | 3.5280 | 3.6720 | | | | 119.500 | 29.500 | | |
| 3.65 | 3.6135 | 3.6865 | 3.5770 | 3.7230 | | | | 119.625 | 29.625 | | |
| 3.70 | 3.6630 | 3.7370 | 3.6260 | 3.7740 | | | | 119.750 | 29.750 | | |
| 3.75 | 3.7125 | 3.7875 | 3.6750 | 3.8250 | | | | 119.875 | 29.875 | | |
| 3.80 | 3.7620 | 3.8380 | 3.7240 | 3.8760 | | | | 120.000 | 30.000 | | |
| 3.85 | 3.8115 | 3.8885 | 3.7730 | 3.9270 | | | | 120.125 | 30.125 | | |
| 3.90 | 3.8610 | 3.9390 | 3.8220 | 3.9780 | | | | 120.250 | 30.250 | | |
| 3.95 | 3.9105 | 3.9895 | 3.8710 | 4.0290 | | | | 120.375 | 30.375 | | |
| 4.00 | 3.9600 | 4.0400 | 3.9200 | 4.0800 | 120.500 | 30.500 | | | | | |
| 4.05 | 4.0095 | 4.0905 | 3.9690 | 4.1310 | 120.625 | 30.625 | 1450 | | | | |
| 4.10 | 4.0590 | 4.1410 | 4.0180 | 4.1820 | 120.750 | 30.750 | | | | | |
| 4.15 | 4.1085 | 4.1915 | 4.0670 | 4.2330 | 120.875 | 30.875 | | | | | |
| 4.20 | 4.1580 | 4.2420 | 4.1160 | 4.2840 | 121.000 | 31.000 | | | | | |
| 4.25 | 4.2075 | 4.2925 | 4.1650 | 4.3350 | 121.125 | 31.125 | | | | | |
| 4.30 | 4.2570 | 4.3430 | 4.2140 | 4.3860 | 121.250 | 31.250 | | | | | |
| 4.35 | 4.3065 | 4.3935 | 4.2630 | 4.4370 | 121.375 | 31.375 | | | | | |
| 4.40 | 4.3560 | 4.4440 | 4.3120 | 4.4880 | 121.500 | 31.500 | | | | | |
| 4.45 | 4.4055 | 4.4945 | 4.3610 | 4.5390 | 121.625 | 31.625 | | | | | |
| 4.50 | 4.4550 | 4.5450 | 4.4100 | 4.5900 | 121.750 | 31.750 | | | | | |
| 4.55 | 4.5045 | 4.5955 | 4.4590 | 4.6410 | 121.875 | 31.875 | | | | | |
| 4.60 | 4.5540 | 4.6460 | 4.5080 | 4.6920 | 122.000 | 32.000 | | | | | |
| 4.65 | 4.6035 | 4.6965 | 4.5570 | 4.7430 | 122.125 | 32.125 | | | | | |
| 4.70 | 4.6530 | 4.7470 | 4.6060 | 4.7940 | 122.250 | 32.250 | | | | | |
| 4.75 | 4.7025 | 4.7975 | 4.6550 | 4.8450 | 122.375 | 32.375 | | | | | |
| 4.80 | 4.7520 | 4.8480 | 4.7040 | 4.8960 | 122.500 | 32.500 | | | | | |
| 4.85 | 4.8015 | 4.8985 | 4.7530 | 4.9470 | 122.625 | 32.625 | | | | | |
| 4.90 | 4.8510 | 4.9490 | 4.8020 | 4.9980 | 122.750 | 32.750 | | | | | |
| 4.95 | 4.9005 | 4.9995 | 4.8510 | 5.0490 | 122.875 | 32.875 | | | | | |
| 5.00 | 4.9500 | 5.0500 | 4.9000 | 5.1000 | 123.000 | 33.000 | | | | | |

■ TEST CIRCUITS

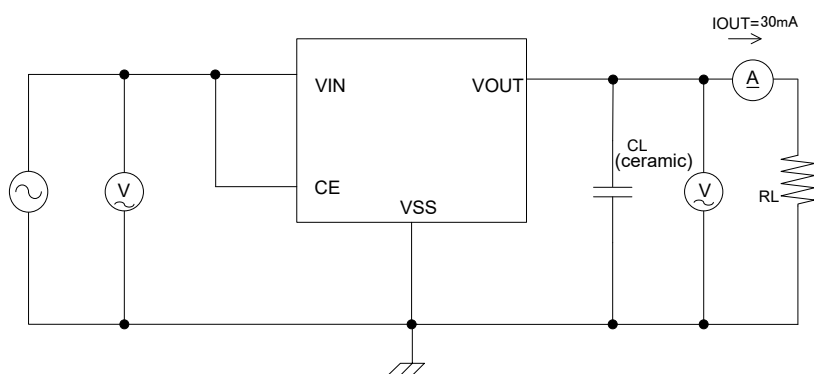
Circuit 1



Circuit 2



Circuit 3



TEST CIRCUITS (Continued)

Circuit 4



Circuit 5



Circuit 6



OPERATIONAL EXPLANATION



The voltage divided by resistors R1 & R2 is compared with the internal reference voltage by the error amplifier. The P-channel MOSFET which is connected to the V_{OUT} pin is then driven by the subsequent control signal. The output voltage at the V_{OUT} pin is controlled & stabilized by a system of negative feedback. The current limit circuit and short protect circuit operate in relation to the level of output current. The GO function monitors the output current and switches the IC between two operating modes according to the level of output current. Further, the IC's internal circuitry can be shutdown via the CE pin's signal.

<Green Operation>

The XC6220 series always operates in a green operation (GO) mode.

The GO mode enables the IC to switch automatically between the high speed (HS) mode or the power save (PS) mode according to the level of output current. The switching point of the HS mode and the PS mode is fixed inside the IC. When the output current becomes I_{GOR}=1.0mA (MIN.) or below, the mode changes automatically to the PS mode after a delay time of hundreds of microseconds. Supply current in light load is greatly reduced. Also when the output current becomes I_{GO} 10mA (MAX.) or more, the mode changes automatically to the HS mode and the IC returns to high speed operation.

<Low ESR capacitor>

The XC6220 series has a built-in phase compensation circuit which means that a stable output voltage is achieved even if the IC is used with low ESR capacitors. In order to ensure stable phase compensation it is recommended that a C_L capacitor is connected as close as possible to the V_{OUT} pin and V_{SS} pin. For a stable power supply, please connect an input capacitor (C_{IN}) between the V_{IN} pin and the V_{SS} pin.

Values required for the phase compensation are shown in the chart below. If a loss of the capacitance happens, the stable phase compensation may not be obtained. Please ensure to use a capacitor which does not depend on bias or temperature too much.

Recommended output capacitor (C_L)

| V _{OUT(T)} (V) | OUTPUT CAPACITOR VALUE(C _L) | | |
|-------------------------|---|------------------------|------------------------|
| | C _{IN} =4.7 μF | C _{IN} =10 μF | C _{IN} =22 μF |
| 0.80V ~ 0.95V | x | x | 22 μF |
| 1.00V ~ 1.45V | 47 μF | 47 μF | 22 μF |
| 1.50V ~ 1.75V | 47 μF | 22 μF | 10 μF |
| 1.80V ~ 2.95V | 47 μF | 6.8 μF | 6.8 μF |
| 3.00V ~ 3.50V | 47 μF | 4.7 μF | 4.7 μF |
| 3.55V ~ 5.00V | 47 μF | 10 μF | 6.8 μF |

x No option

<Current Limiter, Short-Circuit Protection>

The XC6220 series includes a fold-back circuit, which aids the operation of the current limiter and circuit protection. When the load current reaches the current limit level, the fold-back circuit operates and output voltage drops. As a result of this drop in output voltage, output current also decreases. When the output pin is shorted, a current of about 180mA flows.

<CE Pin>

The IC's internal circuitry can be shutdown via the signal from the CE pin with the XC6220 series. With the XC6220A/C series, output at the V_{OUT} pin will be pulled down to the V_{SS} level. However, with XC6220B/D series, the C_L auto-discharge N-channel transistor switch is connected in parallel to R1 and R2 while the power supply is applied to the V_{IN} pin. Therefore, the time until the V_{OUT} pin reaches the V_{SS} level is shortened.

The output voltage of the XC6220A/B series becomes unstable, when the CE pin is open. If this IC is used with the correct output voltage for the CE pin, the logic is fixed and the IC will operate normally. On the other hand, with the XC6220C/D series, the IC operation is stopped when the CE pin is open. However, the CE pin input current may increase as a result of through current in the pull-down resistor (R_{CE}) when the IC is under operation.

XC6220x301



■ OPERATIONAL EXPLANATION (Continued)

<C_L Discharge Function>

The XC6220B/D series can quickly discharge the electric charge at the output capacitor (C_L) via the N-channel transistor located between the V_{OUT} pin and the V_{SS} pin, when a low signal is inputted to the CE pin, which enables the whole IC circuit put into an OFF state (cf. BLOCK DIAGRAM).

(V_{OUT} pin voltage) ÷ (N-channel transistor through current) = C_L discharge resistance (R_{DCHG})

The C_L auto-discharge resistance value is fixed to 460 Ω (V_{IN}=6.0V, V_{OUT}=5.0V at TYP.). The discharge time of the output capacitor (C_L) is set by the C_L auto-discharge resistance (R_{DCHG}) and the output capacitor (C_L). By setting a time constant of the C_L auto-discharge resistance value [R_{DCHG}] and an output capacitor value (C_L) as τ ($\tau = C \times R_{DCHG}$), the output voltage after discharge via the N-channel transistor is calculated by the following formulas.

$$V = V_{OUT(E)} \times e^{-t/\tau}, \quad \text{or } t = \tau \ln(V_{OUT(E)} / V)$$

where

V : Output voltage after discharge

V_{OUT(E)} : Output voltage

t : Discharge time

τ : C_L auto-discharge resistance R_{DCHG} × Output capacitor (C_L) value C

<Inrush Current Prevention>

The XC6220 series includes an inrush current Prevention circuit.

The inrush current protection circuit suppresses inrush current charged to C_L when the IC starts up to 700 mA (MAX.) for approximately 1ms.

* Please note that the device can not provide the output current beyond 700 mA for a period of approximately 1ms after the CE pin goes high.

■ NOTES ON USE

1. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.
2. Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current. Please strengthen V_{IN} and V_{SS} wiring in particular.
3. Please wire the input capacitor (C_{IN}) and the output capacitor (C_L) as close to the IC as possible.
4. As for the XC6220A/C series (semi-custom), the output voltage may float with a leakage current of the driver transistor between V_{IN} and V_{OUT} and R1+R2 resistance while stand-by (operation stop). Please take consideration of this and check it before use.
5. Torex places an importance on improving our products and their reliability. We request that users incorporate fail-safe designs and post-aging protection treatment when using Torex products in their systems.

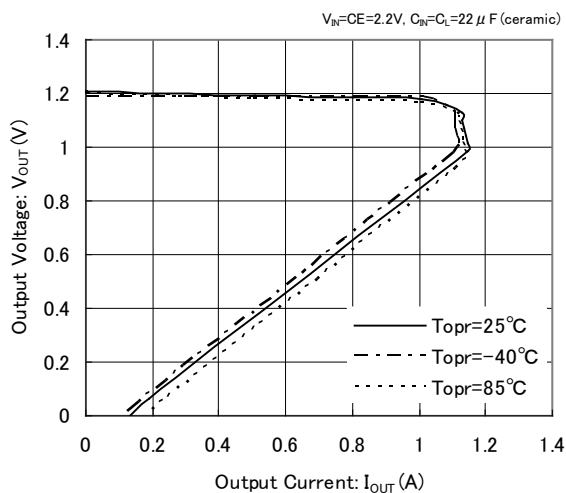
TYPICAL PERFORMANCE CHARACTERISTICS

(1) Output Voltage vs. Output Current

XC6220x121



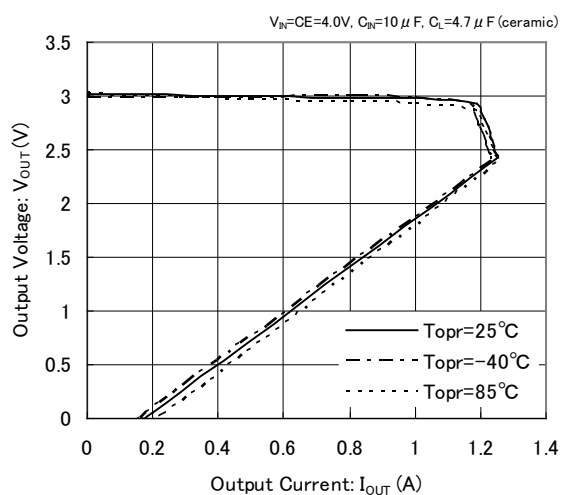
XC6220x121



XC6220x301



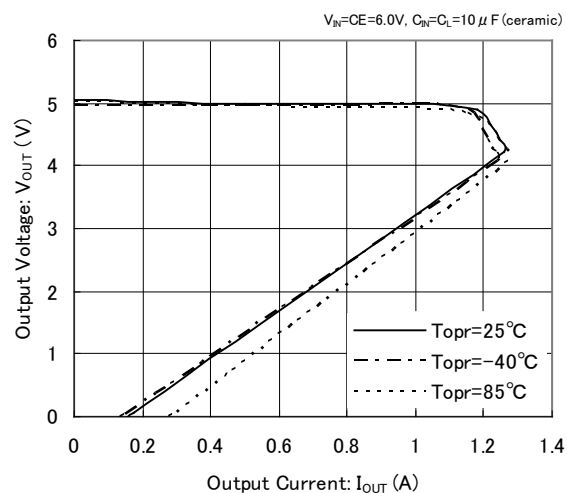
XC6220x301



XC6220x501



XC6220x501



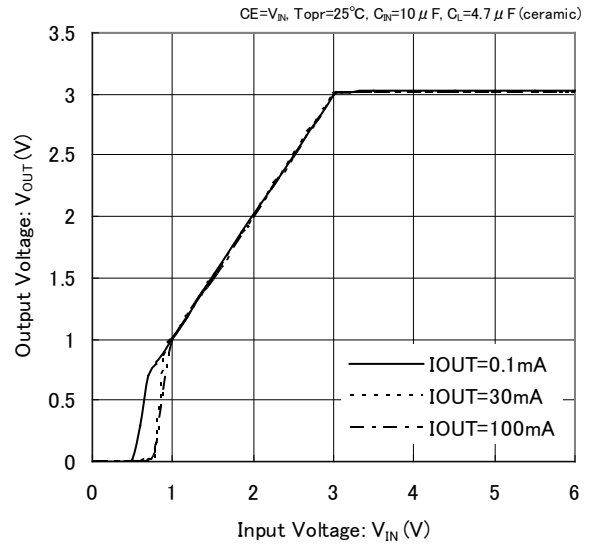
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(2) Output Voltage vs. Input Voltage

XC6220x121



XC6220x301

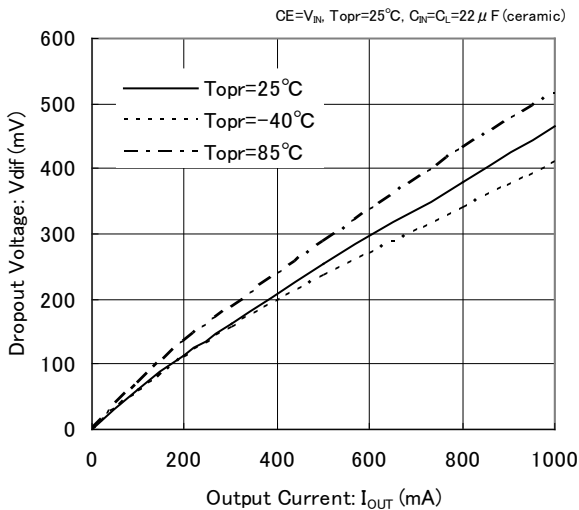


XC6220x501

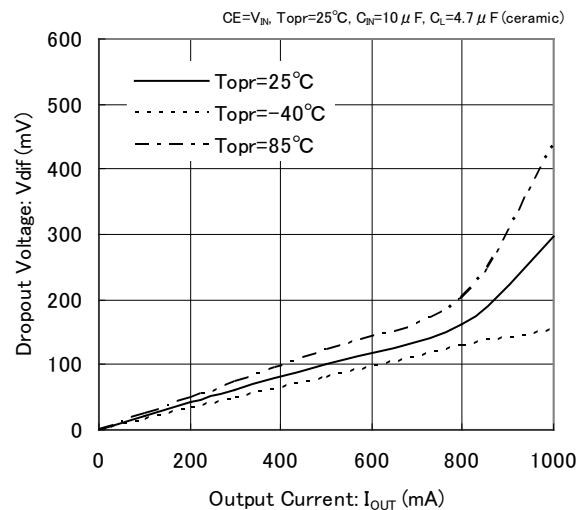


(3) Dropout Voltage vs. Output Current

XC6220x121



XC6220x301



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(3) Dropout Voltage vs. Output Current

XC6220x501



(4) Output Voltage vs. Ambient Temperature

XC6220x121



XC6220x301



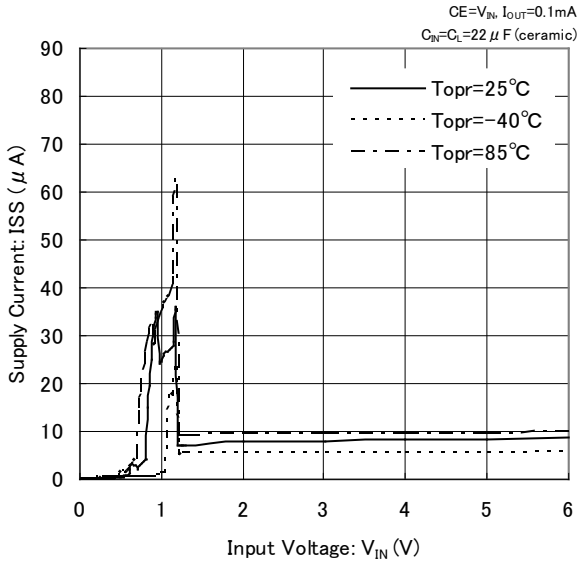
XC6220x501



TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(5) Supply Current vs. Input Voltage

XC6220x121



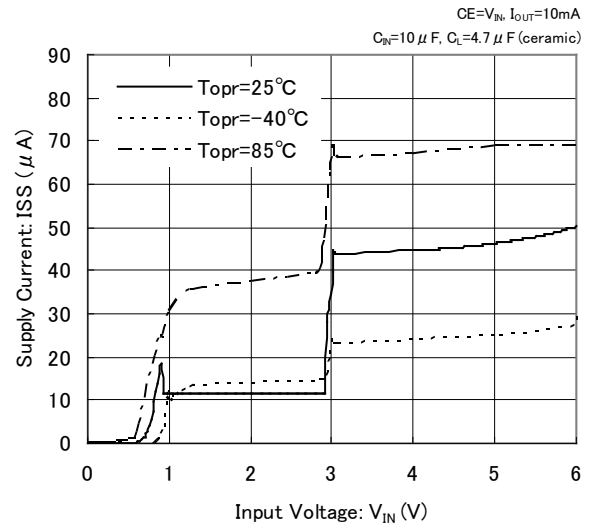
XC6220B121



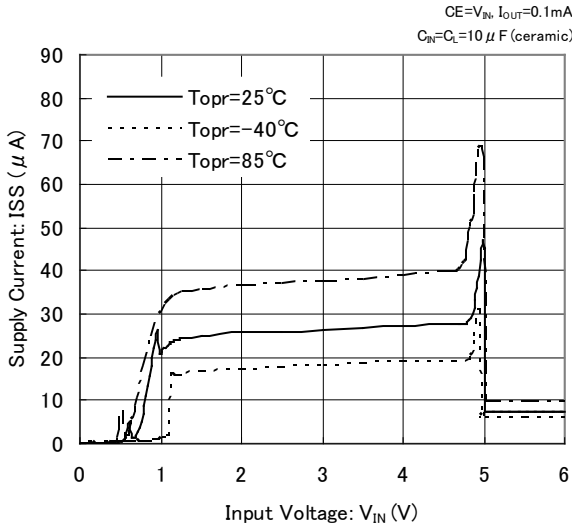
XC6220x301



XC6220x301



XC6220x501



XC6220x501

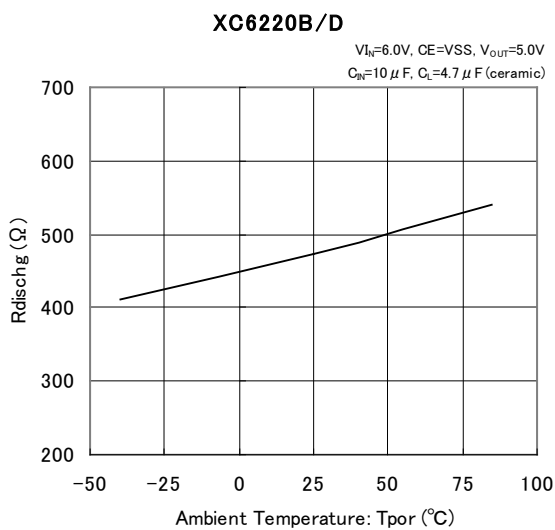


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

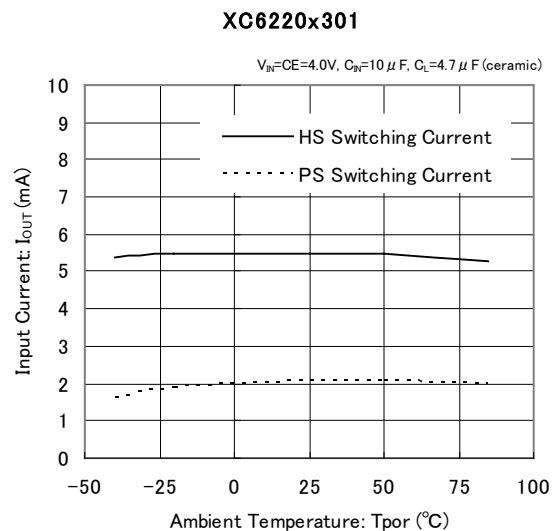
(6) PS Switching Delay Time vs. Ambient Temperature



(7) CL Discharge Resistance vs. Ambient Temperature



(8) PS/HS Switch Current vs. Ambient Temperature

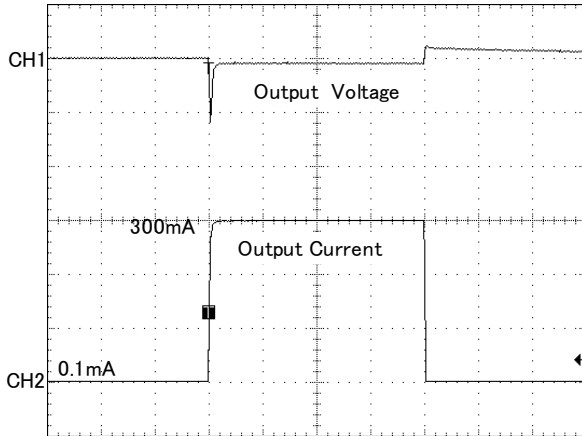


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) Load Transient Response

XC6220x121

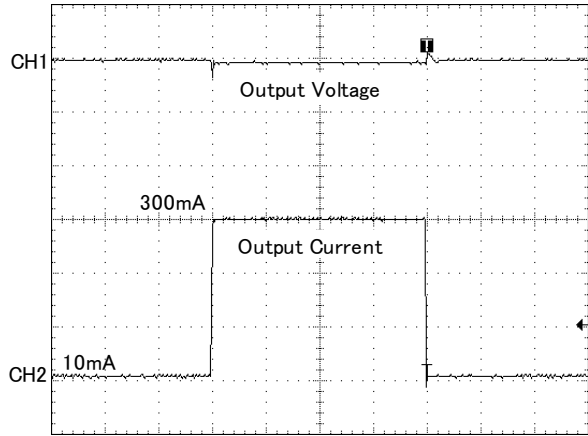
$V_{IN}=CE=2.2V$, $T_r=T_f=5\mu s$
 $T_{opr}=25^\circ C$, $C_{IN}=C_L=22\mu F$ (ceramic)



200 μs /div
 CH1: 100mV/div CH2: 100mA/div

XC6220x121

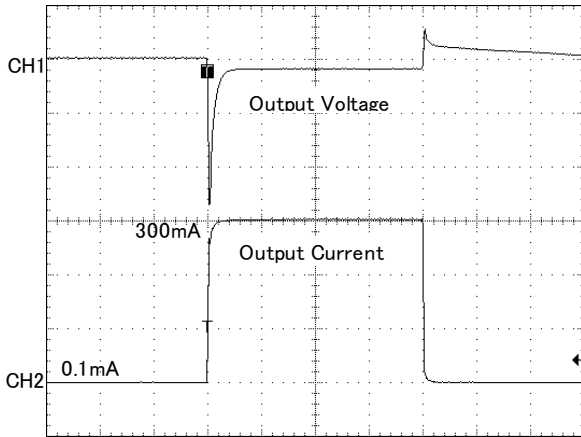
$V_{IN}=CE=2.2V$, $T_r=T_f=5\mu s$
 $T_{opr}=25^\circ C$, $C_{IN}=C_L=22\mu F$ (ceramic)



200 μs /div
 CH1: 100mV/div CH2: 100mA/div

XC6220x301

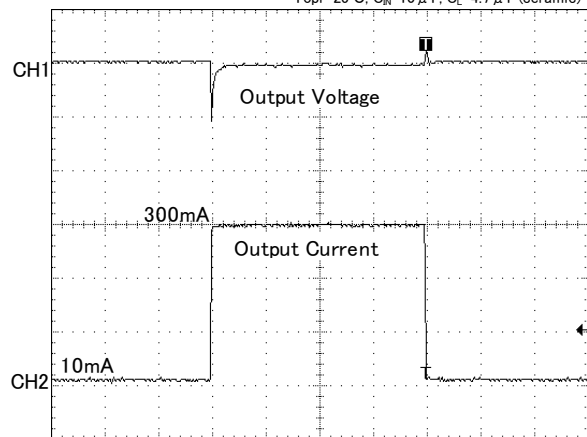
$V_{IN}=CE=4.0V$, $T_r=T_f=5\mu s$
 $T_{opr}=25^\circ C$, $C_{IN}=10\mu F$, $C_L=4.7\mu F$ (ceramic)



200 μs /div
 CH1: 100mV/div CH2: 100mA/div

XC6220x301

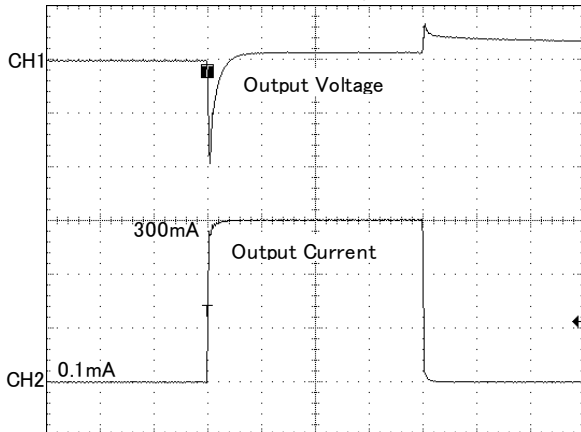
$V_{IN}=CE=4.0V$, $T_r=T_f=5\mu s$
 $T_{opr}=25^\circ C$, $C_{IN}=10\mu F$, $C_L=4.7\mu F$ (ceramic)



200 μs /div
 CH1: 100mV/div CH2: 100mA/div

XC6220x501

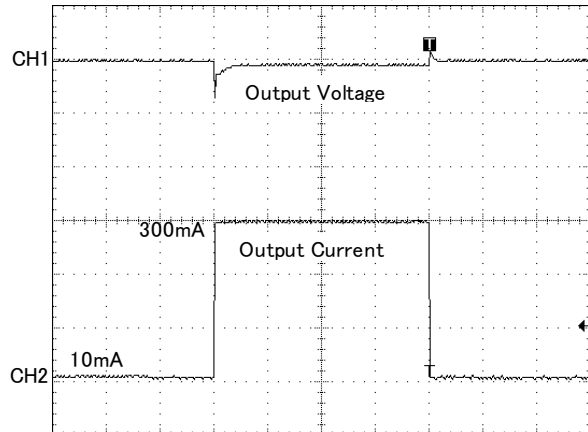
$V_{IN}=CE=6.0V$, $T_r=T_f=5\mu s$
 $T_{opr}=25^\circ C$, $C_{IN}=C_L=10\mu F$ (ceramic)



200 μs /div
 CH1: 100mV/div CH2: 100mA/div

XC6220x501

$V_{IN}=CE=6.0V$, $T_r=T_f=5\mu s$
 $T_{opr}=25^\circ C$, $C_{IN}=C_L=10\mu F$ (ceramic)



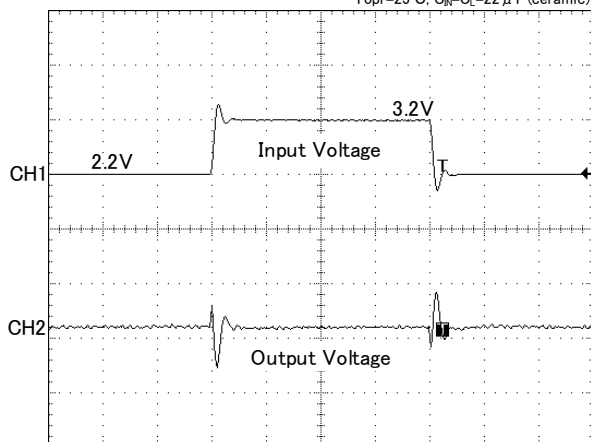
200 μs /div
 CH1: 100mV/div CH2: 100mA/div

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(10) Line Transient Response

XC6220x121

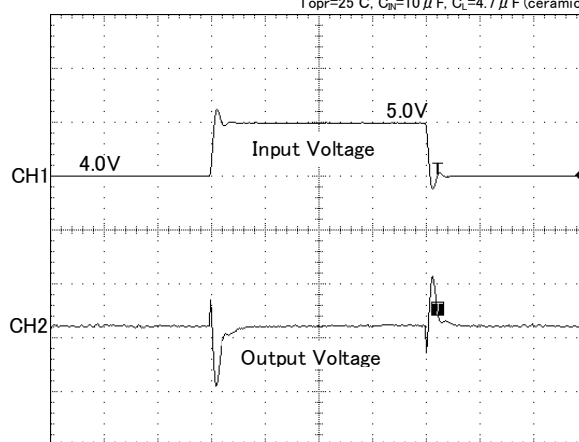
CE=V_{IN}, Tr=Tf=5 μs, I_{OUT}=100mA
T_{opr}=25°C, C_{IN}=C_L=22 μF (ceramic)



100 μs/div
CH1: 1V/div CH2: 20mV/div

XC6220x301

CE=V_{IN}, Tr=Tf=5 μs, I_{OUT}=100mA
T_{opr}=25°C, C_{IN}=10 μF, C_L=4.7 μF (ceramic)



100 μs/div
CH1: 1V/div CH2: 20mV/div

XC6220x501

CE=V_{IN}, Tr=Tf=5 μs, I_{OUT}=100mA
T_{opr}=25°C, C_{IN}=C_L=22 μF (ceramic)

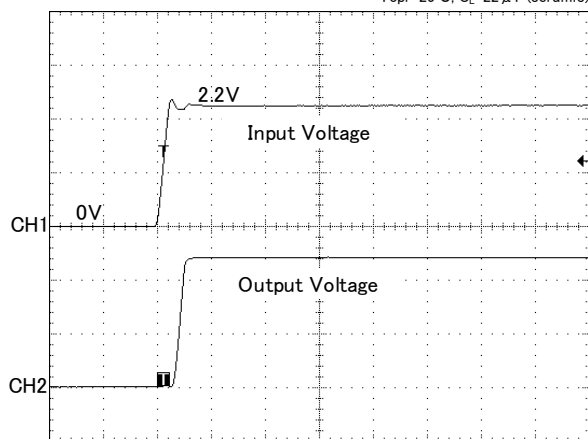


100 μs/div
CH1: 500mV/div CH2: 20mV/div

(11) Input Rise Characteristics

XC6220x121

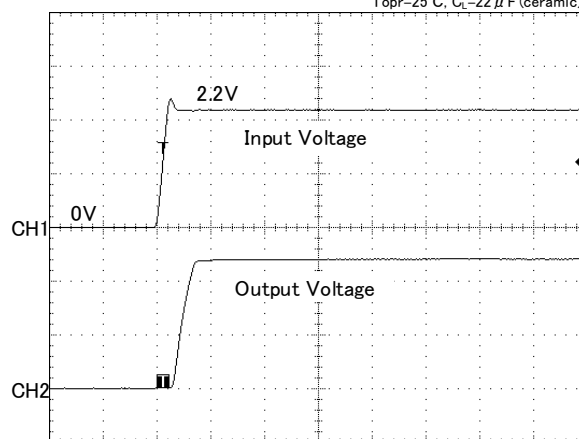
CE=V_{IN}, Tr=5 μs, I_{OUT}=0.1mA
T_{opr}=25°C, C_L=22 μF (ceramic)



200 μs/div
CH1: 1V/div CH2: 500mV/div

XC6220x121

CE=V_{IN}, Tr=5 μs, I_{OUT}=300mA
T_{opr}=25°C, C_L=22 μF (ceramic)



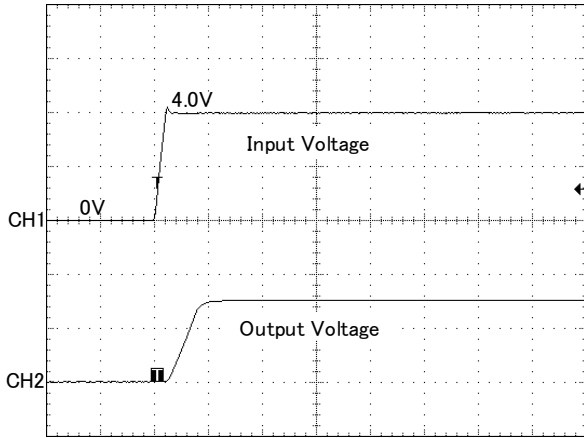
200 μs/div
CH1: 1V/div CH2: 500mV/div

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(11) Input Rise Characteristics

XC6220x301

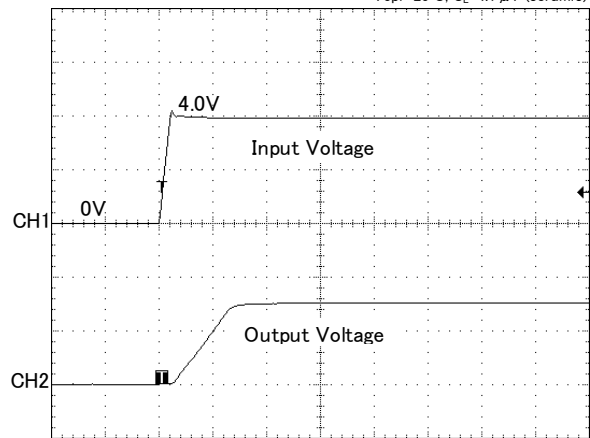
CE=V_{IN}, Tr=5 μs, I_{OUT}=0.1mA
T_{opr}=25°C, C_L=4.7 μF (ceramic)



200 μs/div
CH1: 2V/div CH2: 2V/div

XC6220x301

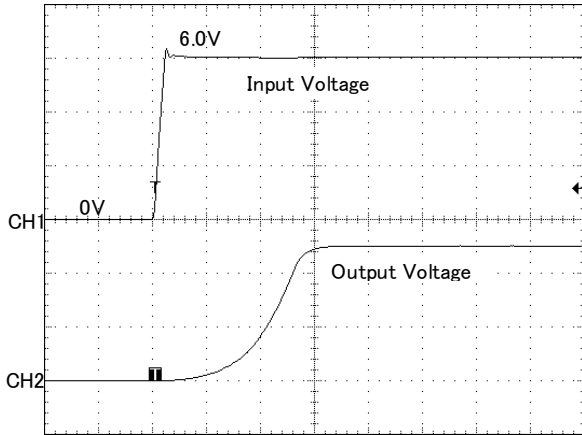
CE=V_{IN}, Tr=5 μs, I_{OUT}=300mA
T_{opr}=25°C, C_L=4.7 μF (ceramic)



200 μs/div
CH1: 2V/div CH2: 2V/div

XC6220x501

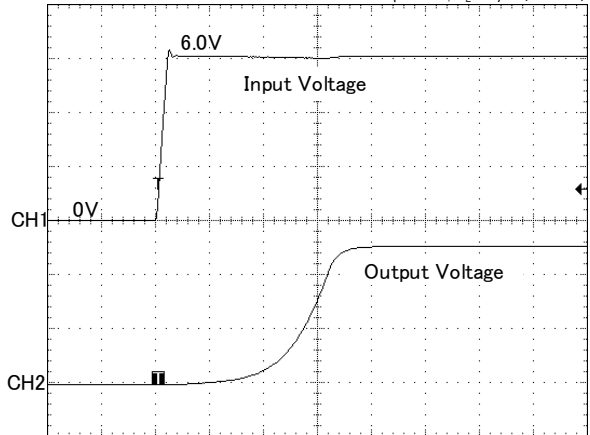
CE=V_{IN}, Tr=5 μs, I_{OUT}=0.1mA
T_{opr}=25°C, C_L=22 μF (ceramic)



200 μs/div
CH1: 2V/div CH2: 2V/div

XC6220x501

CE=V_{IN}, Tr=5 μs, I_{OUT}=300mA
T_{opr}=25°C, C_L=22 μF (ceramic)

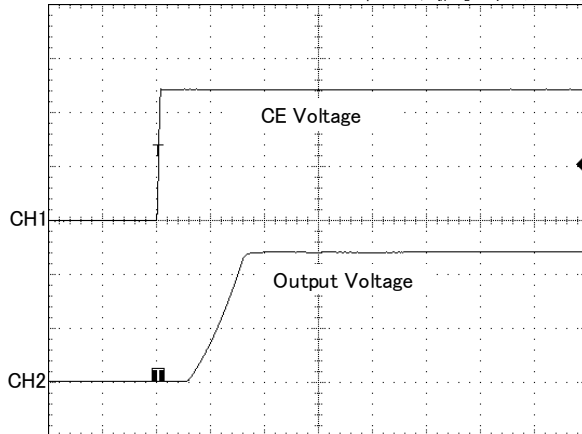


200 μs/div
CH1: 2V/div CH2: 2V/div

(12) CE Rise Characteristics

XC6220x121

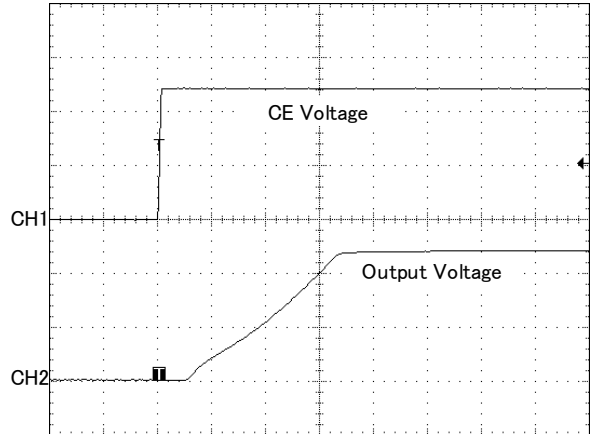
V_{IN}=2.2V, Tr=5 μs, I_{OUT}=0.1mA
T_{opr}=25°C, C_N=C_L=22 μF (ceramic)



100 μs/div
CH1: 500mV/div CH2: 500mV/div

XC6220x121

V_{IN}=2.2V, Tr=5 μs, I_{OUT}=300mA
T_{opr}=25°C, C_N=C_L=22 μF (ceramic)



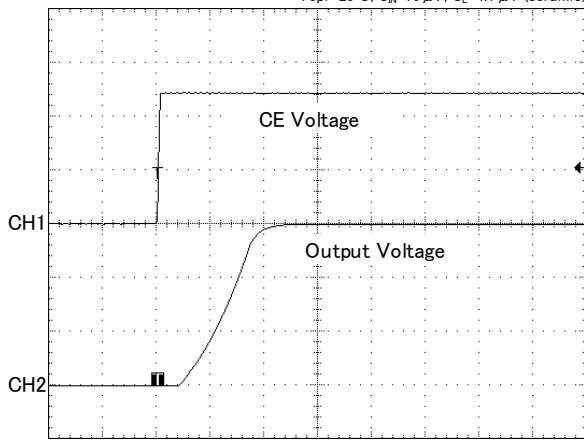
100 μs/div
CH1: 500mV/div CH2: 500mV/div

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(12) CE Rise Characteristics

XC6220x301

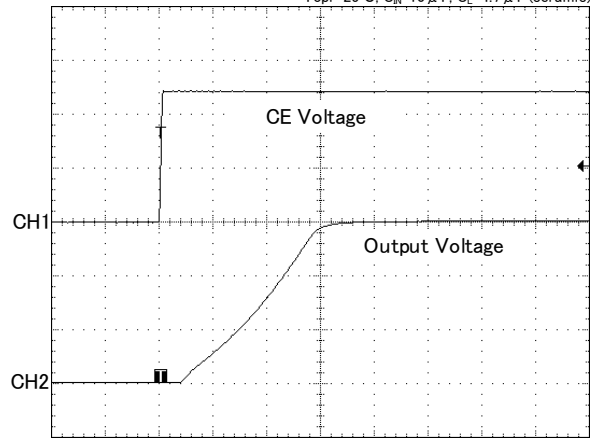
$V_N=4.0V$, $T_r=5\mu s$, $I_{OUT}=0.1mA$
 $T_{opr}=25^\circ C$, $C_N=10\mu F$, $C_L=4.7\mu F$ (ceramic)



100 μs /div
CH1 : 500mV/div CH2 : 1V/div

XC6220x301

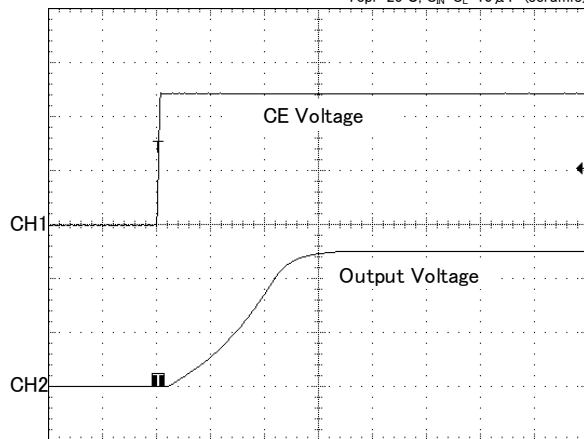
$V_N=4.0V$, $T_r=5\mu s$, $I_{OUT}=300mA$
 $T_{opr}=25^\circ C$, $C_N=10\mu F$, $C_L=4.7\mu F$ (ceramic)



100 μs /div
CH1 : 500mV/div CH2 : 1V/div

XC6220x501

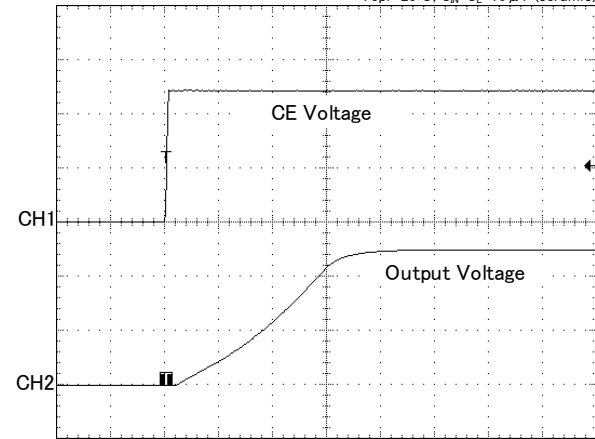
$V_N=6.0V$, $T_r=5\mu s$, $I_{OUT}=0.1mA$
 $T_{opr}=25^\circ C$, $C_N=C_L=10\mu F$ (ceramic)



100 μs /div
CH1 : 500mV/div CH2 : 2V/div

XC6220x501

$V_N=6.0V$, $T_r=5\mu s$, $I_{OUT}=300mA$
 $T_{opr}=25^\circ C$, $C_N=C_L=10\mu F$ (ceramic)



100 μs /div
CH1 : 500mV/div CH2 : 2V/div

(13) Inrush Current

XC6220x121

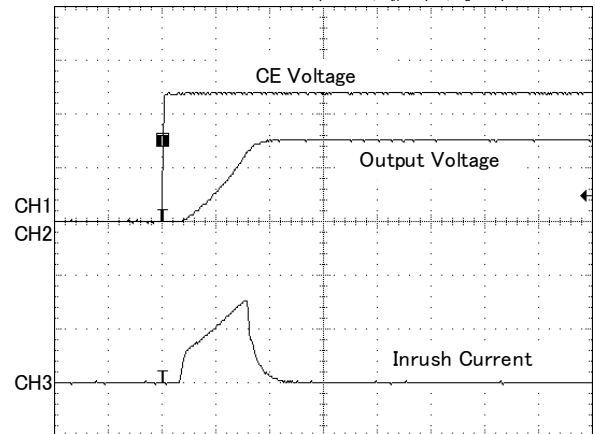
$V_N=2.2V$, $T_r=5\mu s$
 $T_{opr}=25^\circ C$, $C_N=C_L=22\mu F$ (ceramic)



100 μs /div
CH1 : 500mV/div CH2 : 1V/div CH3 : 100mA/div

XC6220x301

$V_N=4.0V$, $T_r=5\mu s$
 $T_{opr}=25^\circ C$, $C_N=10\mu F$, $C_L=4.7\mu F$ (ceramic)



100 μs /div
CH1 : 500mV/div CH2 : 1V/div CH3 : 100mA/div

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(13) Inrush Current

XC6220x501



(14) CL Discharge Time

XC6220x301 (B/D)



XC6220x301 (A/C)



(15) Ripple Rejection Ratio

XC6220x121 (HighSpeed mode)

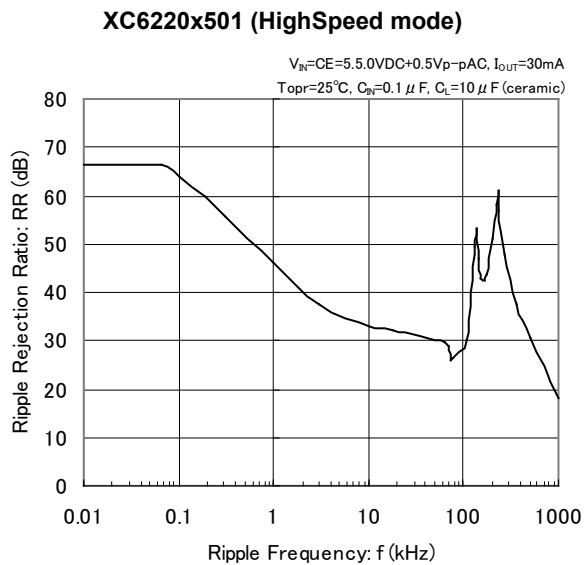


XC6220x121 (PowerSave mode)



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(15) Ripple Rejection Ratio



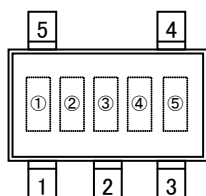
■ PACKAGING INFORMATION

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

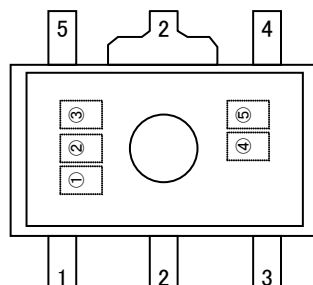
| PACKAGE | OUTLINE / LAND PATTERN | THERMAL CHARACTERISTICS | |
|----------|------------------------------|-------------------------|--|
| SOT-25 | SOT-25 PKG | Standard Board | SOT-25 Power Dissipation |
| | | JESD51-7 Board | |
| SOT-89-5 | SOT-89-5 PKG | Standard Board | SOT-89-5 Power Dissipation |
| | | JESD51-7 Board | |
| USP-6C | USP-6C PKG | Standard Board | USP-6C Power Dissipation |
| | | JESD51-7 Board | |

MARKING RULE

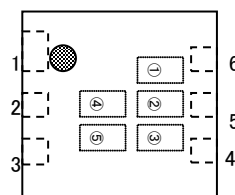
SOT25



SOT89-5



USP6C



① represents product series

| MARK | PRODUCT SERIES |
|------|----------------|
| H | XC6220***** |

② represents type of CE, voltage range, and accuracy

| MARK | CE | OUTPUT VOLTAGE RANGE | OUTPUT VOLTAGE ACCURACY | PRODUCT SERIES |
|------|----|----------------------|-------------------------|-----------------------------|
| 0 | A | 0.8~2.9 | 1 | XC6220A081** ~ XC6220A291** |
| 1 | A | 0.85~2.95 | B | XC6220A08B** ~ XC6220A29B** |
| 2 | A | 3.0~5.0 | 1 | XC6220A301** ~ XC6220A501** |
| 3 | A | 3.05~4.95 | B | XC6220A30B** ~ XC6220A49B** |
| 4 | B | 0.8~2.9 | 1 | XC6220B081** ~ XC6220B291** |
| 5 | B | 0.85~2.95 | B | XC6220B08B** ~ XC6220B29B** |
| 6 | B | 3.0~5.0 | 1 | XC6220B301** ~ XC6220B501** |
| 7 | B | 3.05~4.95 | B | XC6220B30B** ~ XC6220B49B** |
| 8 | C | 0.8~2.9 | 1 | XC6220C081** ~ XC6220C291** |
| 9 | C | 0.85~2.95 | B | XC6220C08B** ~ XC6220C29B** |
| A | C | 3.0~5.0 | 1 | XC6220C301** ~ XC6220C501** |
| B | C | 3.05~4.95 | B | XC6220C30B** ~ XC6220C49B** |
| C | D | 0.8~2.9 | 1 | XC6220D081** ~ XC6220D291** |
| D | D | 0.85~2.95 | B | XC6220D08B** ~ XC6220D29B** |
| E | D | 3.0~5.0 | 1 | XC6220D301** ~ XC6220D501** |
| F | D | 3.05~4.95 | B | XC6220D30B** ~ XC6220D49B** |

③ represents output voltage

| MARK | OUTPUT VOLTAGE (V) | | MARK | OUTPUT VOLTAGE (V) | | MARK | OUTPUT VOLTAGE (V) | |
|------|--------------------|------|------|--------------------|------|------|--------------------|------|
| 0 | — | 3.0x | A | 1.0x | 4.0x | N | 2.0x | 5.0x |
| 1 | — | 3.1x | B | 1.1x | 4.1x | P | 2.1x | — |
| 2 | — | 3.2x | C | 1.2x | 4.2x | R | 2.2x | — |
| 3 | — | 3.3x | D | 1.3x | 4.3x | S | 2.3x | — |
| 4 | — | 3.4x | E | 1.4x | 4.4x | T | 2.4x | — |
| 5 | — | 3.5x | F | 1.5x | 4.5x | U | 2.5x | — |
| 6 | — | 3.6x | H | 1.6x | 4.6x | V | 2.6x | — |
| 7 | — | 3.7x | K | 1.7x | 4.7x | X | 2.7x | — |
| 8 | 0.8x | 3.8x | L | 1.8x | 4.8x | Y | 2.8x | — |
| 9 | 0.9x | 3.9x | M | 1.9x | 4.9x | Z | 2.9x | — |

④,⑤ represents production lot number

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

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

*No character inversion used.

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