

Low ESR Caps Compatible High Speed LDO Voltage Regulator with ON/OFF Switch

■ GENERAL DESCRIPTION

The XC6221 series is a high accuracy, low noise, high speed, low dropout CMOS regulator with high ripple rejection. The series includes a reference voltage source, an error amplifier, a current limiter, and a phase compensation circuit.

The CE function enables the entire circuit to be in stand-by state by inputting low level signal. In this stand-by mode, the electric charge at the output capacitor (CL) will be discharged by the internal auto-discharge switch, and as a result the VOUT pin quickly returns to the VSS level. The output stabilization capacitor (CL) is also compatible with low ESR ceramic capacitors. Output voltage is selectable in 0.05V increments within a range of 0.8V~5.0V, using the laser trimming technology set in factory. The current limiter's fold-back circuit also operates as a short circuit protection and an output current limiter at the output pin. The series achieves a fast response with only 25 μ A of low power consumption. Also the series has low dropout voltage characteristics, which is 80mV at IOU=100mA and VOUT=3.0V.

With the use of small USP-4 and ultra small USPN-4 packages, a small footprint circuit can be designed.

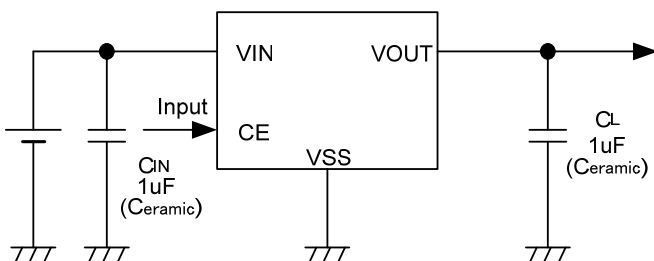
■ APPLICATIONS

- Cellular phones
- Cordless phones
- Wireless communication equipment
- Portable games
- Cameras, VCRs
- Portable AV equipment
- PDAs

■ FEATURES

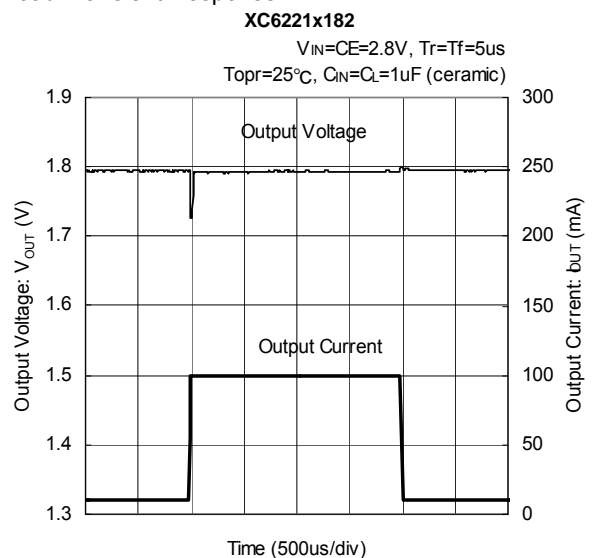
| | |
|---|---|
| Output Current | : 200mA <Up to 250mA (TYP.)> |
| Dropout Voltage | : 80mV @ IOU=100mA, VOUT=3.0V |
| Operating Voltage Range | : 1.6V ~ 6.0V |
| Output Voltages | : 0.8V~5.0V (0.05V increments) |
| Accuracy | : $\pm 2\%$ (VOUT $\geq 1.5V$) ($\pm 1\%$ option is available) $\pm 30mV$ (VOUT $\leq 1.45V$) ($\pm 20mV$ option is available) |
| Low Power Consumption | : 25 μ A (TYP.) |
| Stand-by Current | : Less than 0.1 μ A |
| High Ripple Rejection | : 70dB @ 1kHz |
| Operating Temperature | : -40°C~85°C |
| Low ESR Capacitor | : 1.0 μ F ceramic capacitor |
| CL High-Speed Auto-Discharge (XC6221B) | |
| CE Pin internally pulled-down | |
| Low Output Noise | |
| Ultra Small Packages | : USP-4, SOT-25, SSOT-24 USPN-4 |

■ TYPICAL APPLICATION CIRCUIT

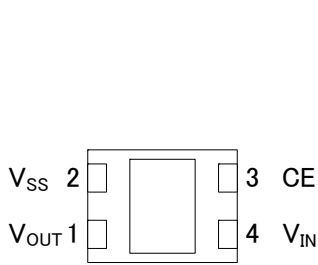


■ TYPICAL PERFORMANCE CHARACTERISTICS

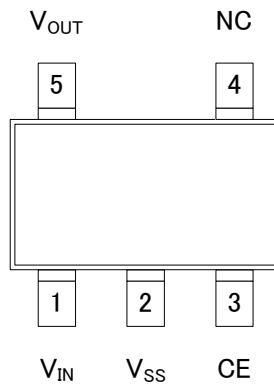
● Load Transient Response



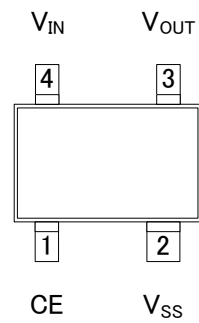
PIN CONFIGURATION



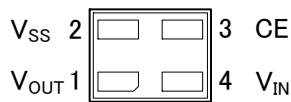
USP-4
(BOTTOM VIEW)



SOT-25
(TOP VIEW)



SSOT-24
(TOP VIEW)



USPN-4
(BOTTOM VIEW)

*The heat dissipation pad of the USP-4 package is recommended to solder as the recommended mount pattern and metal mask pattern for mounting strength. The mount pattern should be electrically opened or connected to the V_{SS} (No.2) pin.

PIN ASSIGNMENT

| PIN NUMBER | | | | PIN NAME | FUNCTIONS |
|------------|--------|---------|--------|------------------|----------------|
| USP-4 | SOT-25 | SSOT-24 | USPN-4 | | |
| 4 | 1 | 4 | 4 | V _{IN} | Power Input |
| 1 | 5 | 3 | 1 | V _{OUT} | Output |
| 2 | 2 | 2 | 2 | V _{SS} | Ground |
| 3 | 3 | 1 | 3 | CE | ON/OFF Control |
| - | 4 | - | - | NC | No Connection |

■ PRODUCT CLASSIFICATION

● Ordering Information

XC6221 ①②③④⑤⑥-⑦^(*)

| DESIGNATOR | DESCRIPTION | SYMBOL | DESCRIPTION |
|------------|---|---------|---|
| ① | Type of Regulator (All CE high active) | A | No CE pull-down resistor without C _L auto discharge |
| | | B | No CE pull-down resistor with C _L auto discharge |
| | | C | CE pull-down resistor without C _L auto discharge |
| | | D | CE pull-down resistor with C _L auto discharge |
| ② ③ | Output Voltage | 08 ~ 40 | ex.) V _{OUT(T)} = 3.0V → ② = 3, ③ = 0 |
| ④ | Output Accuracy | 2 | +30mV @ 0.8V ≤ V _{OUT(T)} ≤ 1.40V When 0.1V steps such as V _{OUT(T)} = 0.8V → ② = 0, ③ = 8, ④ = 2 |
| | | | +2% @ V _{OUT(T)} ≥ 1.5V When 0.1V steps such as V _{OUT(T)} = 1.5V → ② = 1, ③ = 5, ④ = 2 |
| | | A | +30mV @ 0.85V ≤ V _{OUT(T)} ≤ 1.45V When 0.05V steps such as V _{OUT(T)} = 0.85V → ② = 0, ③ = 8, ④ = A |
| | | | +2% @ V _{OUT(T)} ≥ 1.55V When 0.05V steps such as V _{OUT(T)} = 1.55V → ② = 1, ③ = 5, ④ = A |
| | | 1 | +20mV @ 0.8V ≤ V _{OUT(T)} ≤ 1.90V When 0.1V steps such as V _{OUT(T)} = 0.8V → ② = 0, ③ = 8, ④ = 1 |
| | | | +1% @ V _{OUT(T)} ≥ 2.0V When 0.1V steps such as V _{OUT(T)} = 2.0V → ② = 2, ③ = 0, ④ = 1 |
| | | B | +20mV @ 0.85V ≤ V _{OUT(T)} ≤ 1.95V When 0.05V steps such as V _{OUT(T)} = 0.85V → ② = 0, ③ = 8, ④ = B |
| | | | +1% @ V _{OUT(T)} ≥ 2.0V When 0.05V steps such as V _{OUT(T)} = 2.05V → ② = 2, ③ = 0, ④ = B |
| ⑤⑥-⑦ | Packages Taping Type ^(*) | GR | USP-4 |
| | | GR-G | USP-4 (Halogen & Antimony free) |
| | | MR | SOT-25 |
| | | MR-G | SOT-25 (Halogen & Antimony free) |
| | | NR | SSOT-24 |
| | | NR-G | SSOT-24 (Halogen & Antimony free) |
| | | 7R-G | USPN-4 (Halogen & Antimony free) |

* For the USPN-4 package, 0.8V ≤ V_{OUT(T)} ≤ 1.15V is under development.

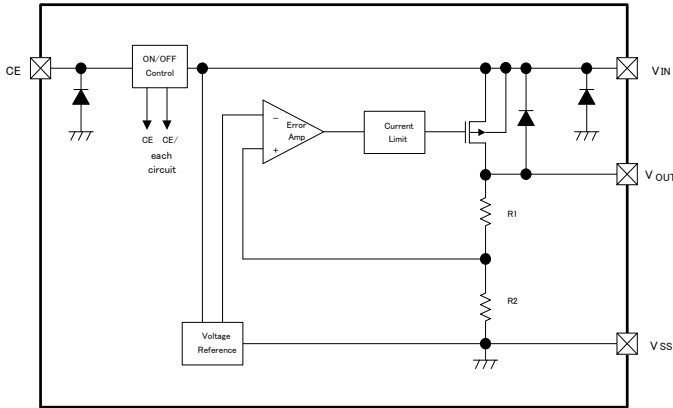
^(*) The "-G" suffix indicates that the products are Halogen and Antimony free as well as being fully RoHS compliant.

^(*) The device orientation is fixed in its embossed tape pocket.

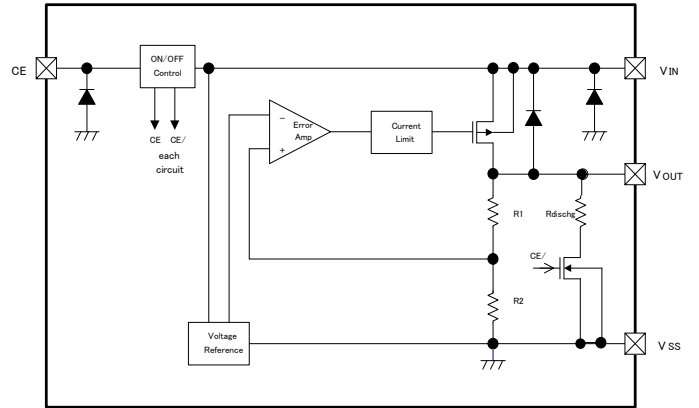
For reverse orientation, please contact your local Torex sales office or representative.

(Standard orientation: ⑤R-⑦, Reverse orientation: ⑤L-⑦)

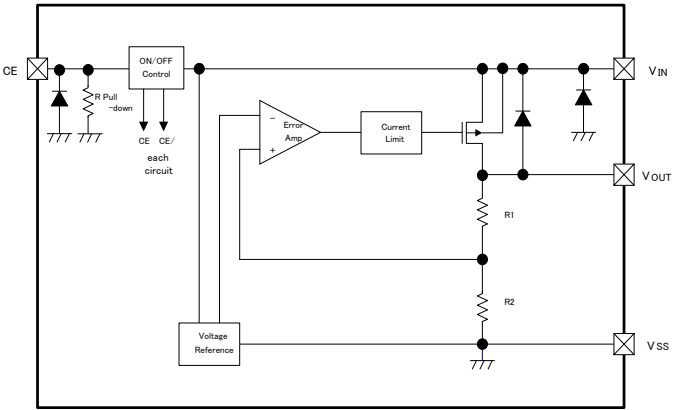
■ BLOCK DIAGRAMS



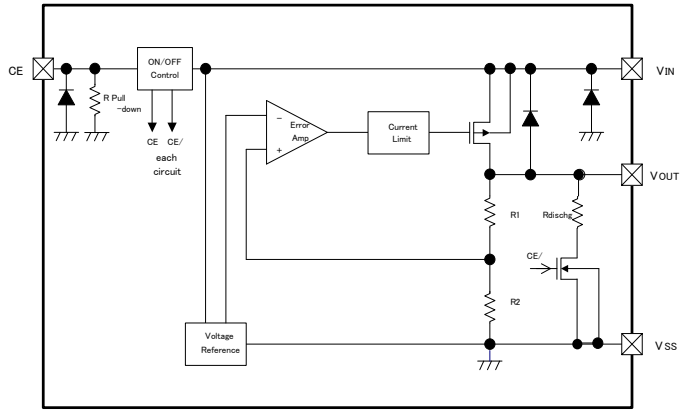
●XC6221A Series



●XC6221B Series



●XC6221C Series



●XC6221D Series

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

■ ABSOLUTE MAXIMUM RATINGS

| Ta=25°C | | | |
|-----------------------------|------------------|---|-------|
| PARAMETER | SYMBOL | RATINGS | UNITS |
| Input Voltage | V _{IN} | V _{SS} -0.3 ~ +6.5 | V |
| Output Current | I _{OUT} | 400 ^{(*)1} | mA |
| Output Voltage | V _{OUT} | V _{SS} - 0.3 ~ V _{IN} + 0.3 | V |
| CE Input Voltage | V _{CE} | V _{SS} - 0.3 ~ +6.5 | V |
| Power Dissipation | USP-4 | 120 | mW |
| | SOT-25 | 250 | |
| | SSOT-24 | 150 | |
| | USPN-4 | 100 | |
| Operating Temperature Range | T _{opr} | - 40 ~ + 85 | °C |
| Storage Temperature Range | T _{stg} | - 55 ~ +125 | °C |

*1 I_{OUT}=Less than Pd / (V_{IN}-V_{OUT})

ELECTRICAL CHARACTERISTICS

●XC6221A/BC/D series

Ta=25°C

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|--|---|--|------------------------|-------------------------------------|------------------------|--------|---------|
| Output Voltage (Standard) | V _{OUT(E)} ^(*2) | 1.5V ≤ V _{OUT(T)} , V _{CE} =V _{IN} , I _{OUT} =10mA | x 0.98 ^(*3) | V _{OUT(T)} ^(*4) | x 1.02 ^(*3) | V | ① |
| | | V _{OUT} ≤ 1.45V, V _{CE} =V _{IN} , I _{OUT} =10mA | -0.03 ^(*3) | | +0.03 ^(*3) | | |
| Output Voltage (High Accuracy) | V _{OUT(E)} ^(*2) | 2.0V ≤ V _{OUT(T)} , V _{CE} =V _{IN} , I _{OUT} =10mA | x 0.99 ^(*3) | V _{OUT(T)} ^(*4) | x 1.01 ^(*3) | V | ① |
| | | V _{OUT(T)} ≤ 1.95V, V _{CE} =V _{IN} , I _{OUT} =10mA | -0.02 ^(*3) | | +0.02 ^(*3) | | |
| Output Current | I _{OUTMAX} | V _{CE} =V _{IN} , V _{IN} =V _{OUT(T)} +1.0V, 0.8V ≤ V _{OUT(T)} ≤ 5.0V | 200 | 250 | - | mA | ① |
| Load Regulation | ΔV _{OUT} | V _{CE} =V _{IN} , 0.1mA ≤ I _{OUT} ≤ 100mA | - | 10 | 40 | mV | ① |
| Dropout Voltage ^(*5) | V _{dif} | V _{CE} =V _{IN} , I _{OUT} =100mA | E-2 | | | mV | ① |
| Supply Current | I _{SS} | V _{IN} =V _{OUT} +1.0V, I _{OUT} =0mA | - | 25 | 50 | μA | ② |
| Standby Current | I _{STBY} | V _{IN} =6.0V, V _{CE} =V _{SS} | - | 0.01 | 0.10 | μA | ② |
| Line Regulation | ΔV _{OUT} / (ΔV _{IN} ·V _{OUT}) | V _{OUT(T)} +0.5V ≤ V _{IN} ≤ 6.0V 1.1 ≤ V _{OUT(T)} , V _{CE} =V _{IN} , I _{OUT} =10mA | - | 0.01 | 0.20 | %V | ① |
| | | 1.6V ≤ V _{IN} ≤ 6.0V V _{OUT(T)} ≤ 1.05V, V _{CE} =V _{IN} , I _{OUT} =10mA | | | | | |
| 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 |
| Ripple Rejection Rate | PSRR | V _{IN} =5.75V _{DC} +0.5Vp-pAC 4.75V ≤ V _{OUT(T)} V _{CE} =V _{IN} , I _{OUT} =30mA, f=1kHz | - | 60 | - | dB | ③ |
| | | V _{IN} ={V _{OUT(T)} +1.0}V _{DC} +0.5Vp-pAC 4.05V ≤ V _{OUT(T)} ≤ 4.7V V _{CE} =V _{IN} , I _{OUT} =30mA, f=1kHz | | | | | |
| | | V _{IN} ={V _{OUT(T)} +1.0}V _{DC} +0.5Vp-pAC 0.85V ≤ V _{OUT(T)} ≤ 4.0V V _{CE} =V _{IN} , I _{OUT} =30mA, f=1kHz | | | | | |
| | | V _{IN} =1.85V _{DC} +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} | 200 | 250 | - | mA | ① |
| Short Current | I _{SHORT} | V _{CE} =V _{IN} , V _{OUT} is short-circuited at the V _{SS} level | - | 30 | - | mA | ① |
| CE High Level Voltage | V _{CEH} | | 1.2 | - | 6.0 | V | ④ |
| CE Low Level Voltage | V _{CEL} | | - | - | 0.3 | V | ④ |
| CE High Level Current | I _{CEH} | V _{CE} =V _{IN} (XC6221A/B) | -0.1 | - | 0.1 | μA | ④ |
| | | V _{CE} =6.0V (XC6221C/D) | 1.03 | - | 2.37 | | |
| CE Low Level Current | I _{CEL} | V _{CE} =V _{SS} | -0.1 | - | 0.1 | μA | ④ |
| CL Auto-Discharge Resistance ^(*8) | R _{DCHG} | V _{IN} =6.0V, V _{OUT(T)} =4.0V, V _{CE} =V _{SS} | - | 780 | - | Ω | ① |

NOTE:

- * 1: Unless otherwise stated regarding input voltage conditions, V_{IN}=V_{OUT(T)}+1.0V.
- * 2: V_{OUT(E)} = Effective output voltage (Refer to the voltage chart E-0 and E-1)
(I.e. the output voltage when HS mode and an amply stabilized "V_{OUT(T)} + 1.0V" is provided at the V_{IN} pin while maintaining a certain I_{OUT} value.)
- * 3: The relation between V_{OUT(E)} and V_{OUT(T)} is shown in the voltage chart E-0 and E-1.
- * 4: V_{OUT(T)} = Nominal output voltage
- * 5: V_{dif} = {V_{IN1}^(*7)-V_{OUT1}^(*6)}
- * 6: V_{OUT1} is the voltage equal to 98% of the normal output voltage when amply stabilized V_{OUT(T)} + 1.0V are input at the V_{IN} pin.
- * 7: V_{IN1} is the input voltage when V_{OUT1} appears at the V_{OUT} pin while input voltage is gradually decreased.
- * 8: For the XC6221B series only. The XC6221A series discharges by resistors R1 and R2 only as shown in the block diagrams.
- * 9: For operating supply current of the XC6221C/D, a current through the pull-down resistor should be considered in addition to the supply current value mentioned above.

■ OUTPUT VOLTAGE CHART

| SYMBOL | E-0 | | E-1 | | E-2 | |
|----------------------------|---------------------------------------|--------|--|--------|---------------------------|--------|
| NOMINAL OUTPUT VOLTAGE (V) | OUTPUT VOLTAGE Standard $\pm 2\%$ (V) | | OUTPUT VOLTAGE High Accuracy $\pm 1\%$ (V) | | DROPOUT VOLTAGE Vdif (mV) | |
| VOUT(T) | VOUT(E) | | VOUT(E) | | Vdif | |
| | MIN. | MAX. | MIN. | MAX. | TYP. | MAX. |
| 0.80 | 0.7700 | 0.8300 | 0.7800 | 0.8200 | 500 | 850 |
| 0.85 | 0.8200 | 0.8800 | 0.8300 | 0.8700 | | |
| 0.90 | 0.8700 | 0.9300 | 0.8800 | 0.9200 | 410 | 750 |
| 0.95 | 0.9200 | 0.9800 | 0.9300 | 0.9700 | | |
| 1.00 | 0.9700 | 1.0300 | 0.9800 | 1.0200 | 330 | 650 |
| 1.05 | 1.0200 | 1.0800 | 1.0300 | 1.0700 | | |
| 1.10 | 1.0700 | 1.1300 | 1.0800 | 1.1200 | | |
| 1.15 | 1.1200 | 1.1800 | 1.1300 | 1.1700 | | |
| 1.20 | 1.1700 | 1.2300 | 1.1800 | 1.2200 | 230 | 410 |
| 1.25 | 1.2200 | 1.2800 | 1.2300 | 1.2700 | | |
| 1.30 | 1.2700 | 1.3300 | 1.2800 | 1.3200 | | |
| 1.35 | 1.3200 | 1.3800 | 1.3300 | 1.3700 | | |
| 1.40 | 1.3700 | 1.4300 | 1.3800 | 1.4200 | 200 | 360 |
| 1.45 | 1.4200 | 1.4800 | 1.4300 | 1.4700 | | |
| 1.50 | 1.4700 | 1.5300 | 1.4800 | 1.5200 | 160 | 290 |
| 1.55 | 1.5200 | 1.5800 | 1.5300 | 1.5700 | | |
| 1.60 | 1.5700 | 1.6300 | 1.5800 | 1.6200 | 160 | 250 |
| 1.65 | 1.6200 | 1.6800 | 1.6300 | 1.6700 | | |
| 1.70 | 1.6700 | 1.7300 | 1.6800 | 1.7200 | | |
| 1.75 | 1.7200 | 1.7800 | 1.7300 | 1.7700 | | |
| 1.80 | 1.7700 | 1.8300 | 1.7800 | 1.8200 | 125 | 210 |
| 1.85 | 1.8200 | 1.8800 | 1.8300 | 1.8700 | | |
| 1.90 | 1.8700 | 1.9300 | 1.8800 | 1.9200 | | |
| 1.95 | 1.9200 | 1.9800 | 1.9300 | 1.9700 | | |
| 2.00 | 1.9600 | 2.0400 | 1.9800 | 2.0200 | 115 | 195 |
| 2.05 | 2.0090 | 2.0910 | 2.0295 | 2.0705 | | |
| 2.10 | 2.0850 | 2.1420 | 2.0790 | 2.1210 | | |
| 2.15 | 2.1070 | 2.1930 | 2.1285 | 2.1715 | | |
| 2.20 | 2.1560 | 2.2440 | 2.1780 | 2.2220 | | |
| 2.25 | 2.2050 | 2.2950 | 2.2275 | 2.2725 | | |
| 2.30 | 2.2540 | 2.3460 | 2.2770 | 2.3230 | | |
| 2.35 | 2.3030 | 2.3970 | 2.3265 | 2.3735 | | |
| 2.40 | 2.3520 | 2.4480 | 2.3760 | 2.4240 | 95 | 170 |
| 2.45 | 2.4010 | 2.4990 | 2.4255 | 2.4745 | | |
| 2.50 | 2.4500 | 2.5500 | 2.4750 | 2.5250 | | |
| 2.55 | 2.4990 | 2.6010 | 2.5245 | 2.5755 | | |
| 2.60 | 2.5480 | 2.6520 | 2.5740 | 2.6260 | | |
| 2.65 | 2.5970 | 2.7030 | 2.6235 | 2.6765 | | |
| 2.70 | 2.6460 | 2.7540 | 2.6730 | 2.7270 | | |
| 2.75 | 2.6950 | 2.8050 | 2.7225 | 2.7775 | | |
| 2.80 | 2.7440 | 2.8560 | 2.7720 | 2.8280 | 2.85 | 2.8785 |
| 2.85 | 2.7930 | 2.9070 | 2.8215 | 2.8785 | | |
| 2.90 | 2.8420 | 2.9580 | 2.8710 | 2.9290 | | |
| 2.95 | 2.8910 | 3.0090 | 2.9205 | 2.9795 | | |

■ **OUTPUT VOLTAGE CHART (Continued)**

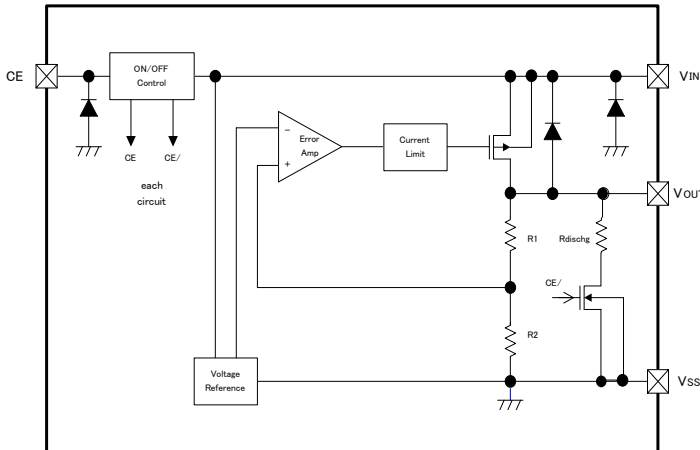
| SYMBOL | E-0 | | E-1 | | E-2 | |
|----------------------------|---------------------------------------|--------|--|--------|--------------------------------|------|
| NOMINAL OUTPUT VOLTAGE (V) | OUTPUT VOLTAGE Standard $\pm 2\%$ (V) | | OUTPUT VOLTAGE High Accuracy $\pm 1\%$ (V) | | DROPOUT VOLTAGE V_{dif} (mV) | |
| $V_{OUT(T)}$ | $V_{OUT(E)}$ | | $V_{OUT(E)}$ | | V_{dif} | |
| | MIN. | MAX. | MIN. | MAX. | TYP. | MAX. |
| 3.00 | 2.9400 | 3.0600 | 2.9700 | 3.0300 | 80 | 140 |
| 3.05 | 2.8990 | 3.1100 | 3.0195 | 3.0805 | | |
| 3.10 | 3.0380 | 3.1620 | 3.0690 | 3.1310 | | |
| 3.15 | 3.0870 | 3.2130 | 3.1185 | 3.1815 | | |
| 3.20 | 3.1360 | 3.2640 | 3.1680 | 3.2320 | | |
| 3.25 | 3.1850 | 3.3150 | 3.2175 | 3.2825 | | |
| 3.30 | 3.2340 | 3.3660 | 3.2670 | 3.3330 | | |
| 3.35 | 3.2830 | 3.4170 | 3.3165 | 3.3835 | | |
| 3.40 | 3.3320 | 3.4680 | 3.3660 | 3.4340 | | |
| 3.45 | 3.3810 | 3.5190 | 3.4155 | 3.4845 | | |
| 3.50 | 3.4300 | 3.5700 | 3.4650 | 3.5350 | | |
| 3.55 | 3.4790 | 3.6210 | 3.5145 | 3.5855 | | |
| 3.60 | 3.5280 | 3.6720 | 3.5640 | 3.6360 | | |
| 3.65 | 3.5770 | 3.7230 | 3.6135 | 3.6855 | | |
| 3.70 | 3.6260 | 3.7740 | 3.6630 | 3.7370 | | |
| 3.75 | 3.6750 | 3.8250 | 3.7125 | 3.7875 | | |
| 3.80 | 3.7240 | 3.8760 | 3.7620 | 3.8380 | | |
| 3.85 | 3.7730 | 3.9270 | 3.8115 | 3.8885 | | |
| 3.90 | 3.8220 | 3.9780 | 3.8610 | 3.9390 | | |
| 3.95 | 3.8710 | 4.0290 | 3.9105 | 3.9895 | | |
| 4.00 | 3.9200 | 4.0800 | 3.9600 | 4.0400 | | |
| 4.05 | 3.9690 | 4.1310 | 4.0095 | 4.0905 | | |
| 4.10 | 4.0180 | 4.1820 | 4.0590 | 4.1410 | | |
| 4.15 | 4.0670 | 4.2330 | 4.1085 | 4.1915 | | |
| 4.20 | 4.1160 | 4.2840 | 4.1580 | 4.2420 | | |
| 4.25 | 4.1650 | 4.3350 | 4.2075 | 4.2925 | | |
| 4.30 | 4.2140 | 4.3860 | 4.2570 | 4.3430 | | |
| 4.35 | 4.2630 | 4.4370 | 4.3065 | 4.3935 | | |
| 4.40 | 4.3120 | 4.4880 | 4.3560 | 4.4440 | | |
| 4.45 | 4.3610 | 4.5390 | 4.4055 | 4.4945 | | |
| 4.50 | 4.4100 | 4.5900 | 4.4550 | 4.5450 | | |
| 4.55 | 4.4590 | 4.6410 | 4.5045 | 4.5955 | | |
| 4.60 | 4.5080 | 4.6920 | 4.5540 | 4.6460 | | |
| 4.65 | 4.5570 | 4.7430 | 4.6035 | 4.6965 | | |
| 4.70 | 4.6060 | 4.7940 | 4.6530 | 4.7470 | | |
| 4.75 | 4.6550 | 4.8450 | 4.7025 | 4.7975 | | |
| 4.80 | 4.7040 | 4.8960 | 4.7520 | 4.8480 | | |
| 4.85 | 4.7530 | 4.9470 | 4.8015 | 4.8985 | | |
| 4.90 | 4.8020 | 4.9980 | 4.8510 | 4.9490 | | |
| 4.95 | 4.8510 | 5.0490 | 4.9005 | 4.9995 | | |
| 5.00 | 4.9000 | 5.1000 | 4.9500 | 5.0500 | | |

* For the USP-N-4 package, $0.8V \leq V_{OUT(T)} \leq 1.15V$ is under development.

OPERATIONAL EXPLANATION

<Output Voltage Control>

The voltage divided by resistors R1 & R2 is compared with the internal reference voltage by the error amplifier. The P-channel MOSFET connected to the V_{OUT} pin, is then driven by the subsequent output 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. Further, the IC's internal circuitry can be shutdown via the CE pin's signal.



<Input and Output Capacitors>

The XC6221 needs an output capacitor C_L for phase compensation. 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. For a stable power input, please connect an input capacitor C_{IN} of 1.0 μF between the V_{IN} pin and the V_{SS} pin.

●Except USPN-4

| OUTPUT VOLTAGE (V) | OUTPUT CAPACITOR VALUE |
|--------------------|-------------------------|
| 0.8V~1.15V | C _L ≥ 4.7 μF |
| 1.2V~1.35V | C _L ≥ 2.2 μF |
| 1.4V~4.0V | C _L ≥ 1.0 μF |
| 4.05V~5.0V | C _L ≥ 2.2 μF |

●USPN-4

| OUTPUT VOLTAGE (V) | OUTPUT CAPACITOR VALUE |
|--------------------|-------------------------|
| 1.2V~4.0V | C _L ≥ 2.2 μF |
| 4.05V~5.0V | C _L ≥ 4.7 μF |

<C_L Auto-Discharge Function>

XC6221B/D series can discharge the electric charge in the output capacitor (C_L), when a low signal to the CE pin, which enables the whole IC circuit to be turned off, is inputted via the N-channel transistor located between the V_{OUT} pin and the V_{SS} pin (cf. BLOCK DIAGRAM). The C_L auto-discharge resistance value is set at 780 Ω (V_{OUT}=4.0V @ V_{IN}=6.0V at typical). The discharge time of the output capacitor (C_L) is set by the C_L auto-discharge resistance (R) and the output capacitor (C_L). By setting the time constant of the C_L auto-discharge resistance value [R_{DCHG}] and the output capacitor value (C_L) as τ (τ = C × R_{DCHG}), the output voltage after discharge via the N-channel transistor is calculated by the following formula.

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

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

■ OPERATIONAL EXPLANATION (Continued)

<Current Limiter, Short-Circuit Protection>

The XC6221 series' fold-back circuit operates as an output current limiter and a short protection circuit for the output pin. When the load current reaches the current limit level, the fixed current limiter circuit operates and output voltage drops. When the output pin is short-circuited to the V_{SS} pin, the current falls and reaches about 30mA.

<CE Pin>

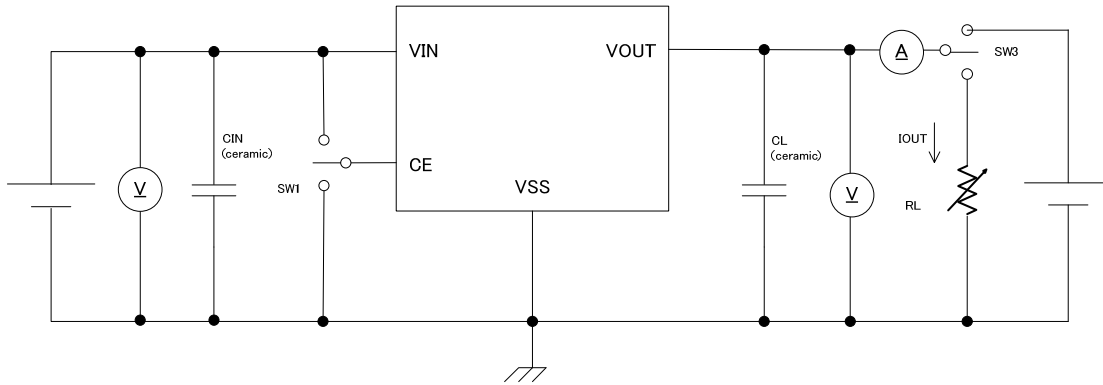
The XC6221 internal circuitry can be shutdown via the CE pin signal. In shutdown mode, output at the V_{OUT} pin will be pulled down to the V_{SS} level via R1 & R2. However, with the XC6221B/D series, the C_L auto-discharge resistor is connected in parallel to R1 and R2 while the power supply is applied to the V_{IN} pin. Therefore, time until the V_{OUT} pin reaches the V_{SS} level is shorter. For the XC6221A/B, the output voltage becomes unstable, when the CE pin is left open. For the XC6221C/D, the output voltage becomes V_{SS} level because the CE pin is short-circuited to V_{SS} via an internal pull-down resistor. However, the CE input current will be increased via a pull-down resistor when the IC operates. If this IC is used with the correct output voltage for the CE pin, the logic is fixed and the IC will operate normally. However, the supply current may increase as a result of shoot-through current in the IC's internal circuitry when a medium voltage is input.

■ NOTES ON USE

1. Please use this IC within the stated absolute maximum ratings. The IC is liable to malfunction should the ratings be exceeded.
2. Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current. Please wire the input capacitor (C_{IN}) and the output capacitor (C_L) as close to the IC as possible.

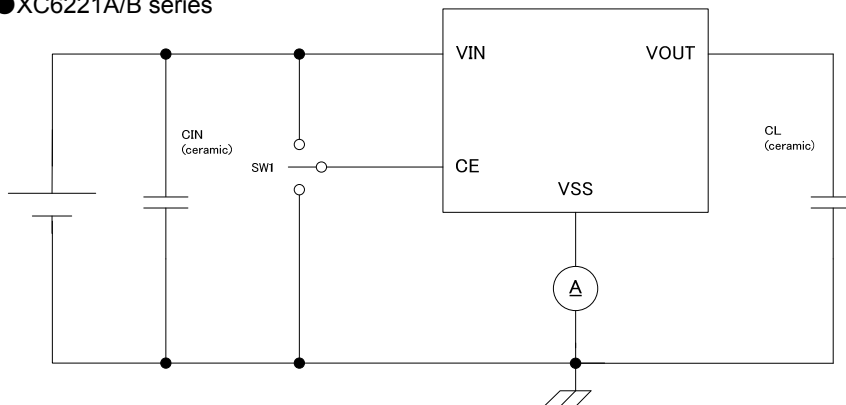
TEST CIRCUITS

Circuit 1: Output Voltage, Output Current, Dropout Voltage, Input/Operating Voltage, Line Regulation, Load Regulation, Current Limit, Short Current, CL Discharge Resistance

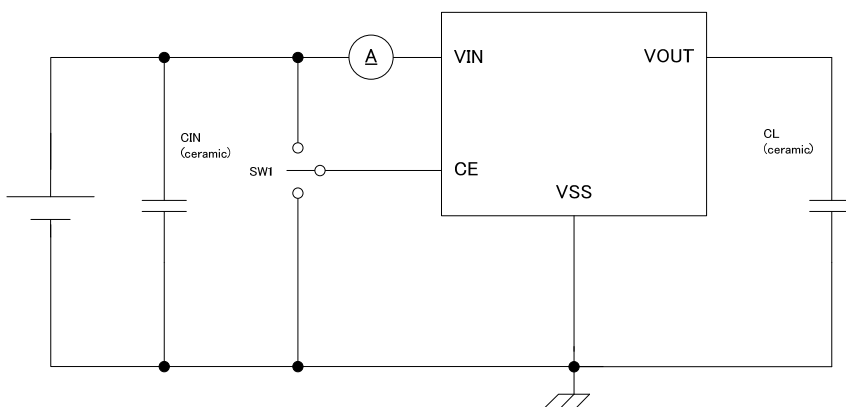


Circuit 2: Supply Current, Stand-by Current

●XC6221A/B series

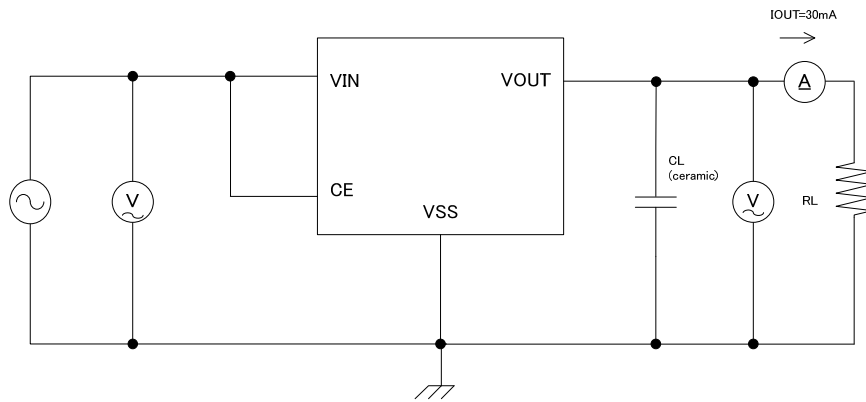


●XC6221C/D series

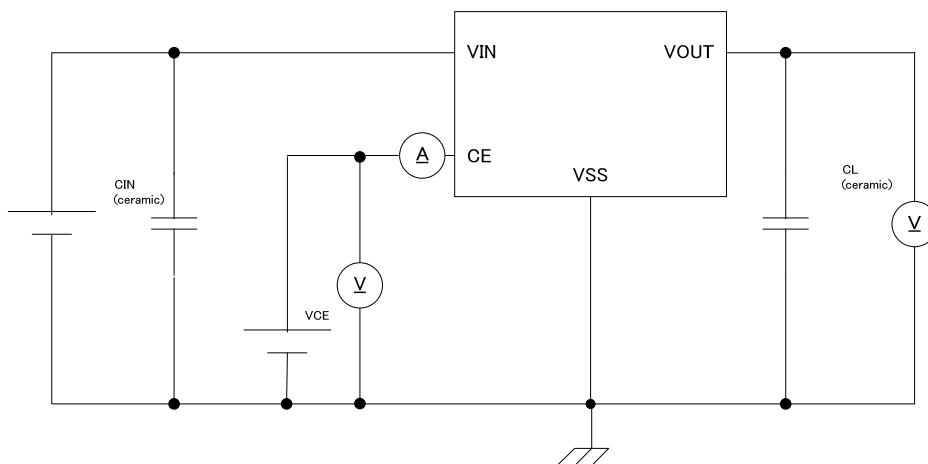


■ TEST CIRCUITS (Continued)

Circuit 3: Ripple Rejection Rate

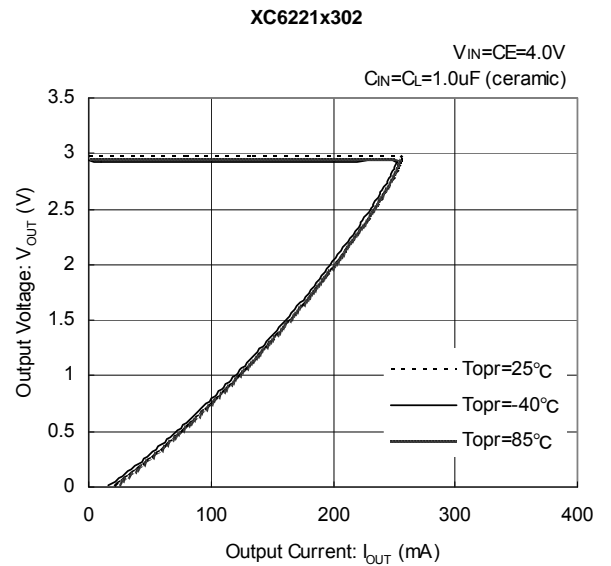
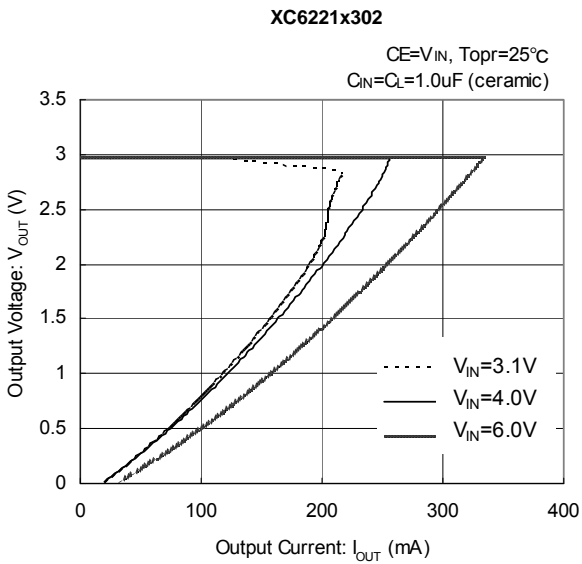
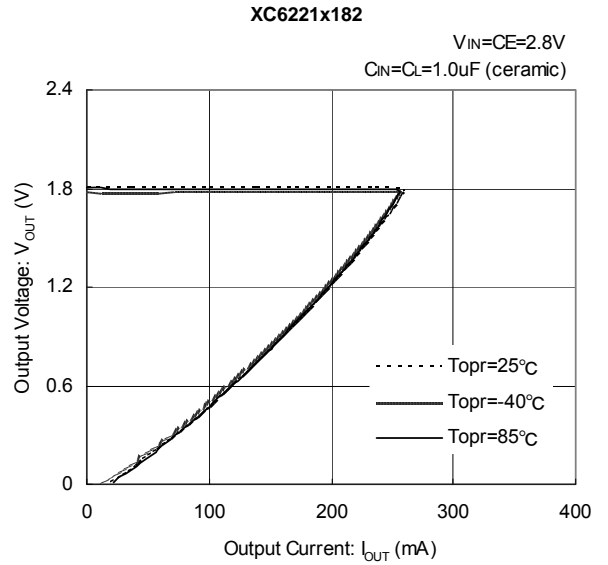
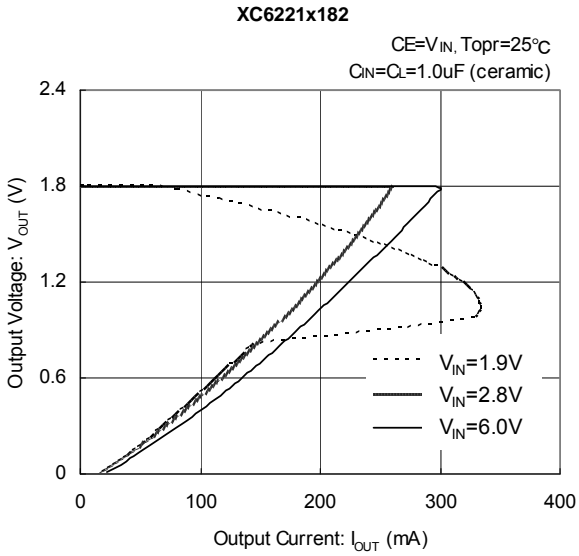


Circuit 4: CE "H" "L" Level Voltage, CE "H" "L" Level Current

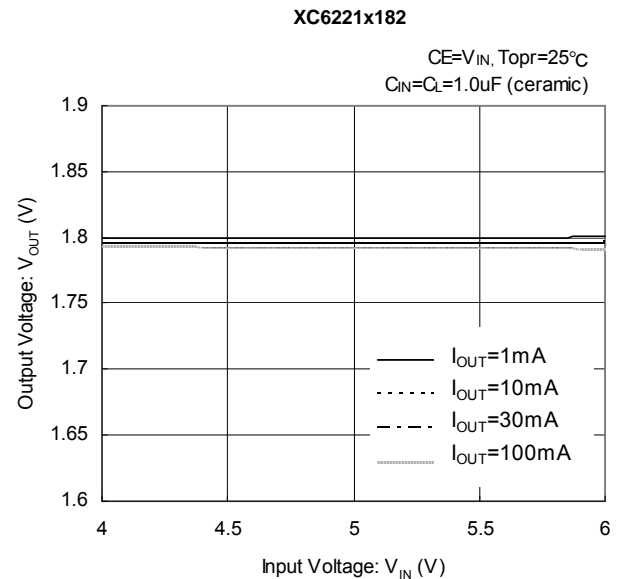
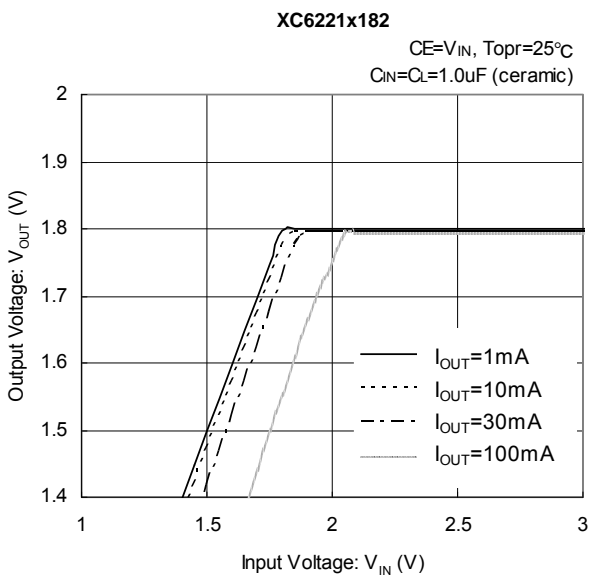


TYPICAL PERFORMANCE CHARACTERISTICS

(1) Output Voltage vs. Output Current

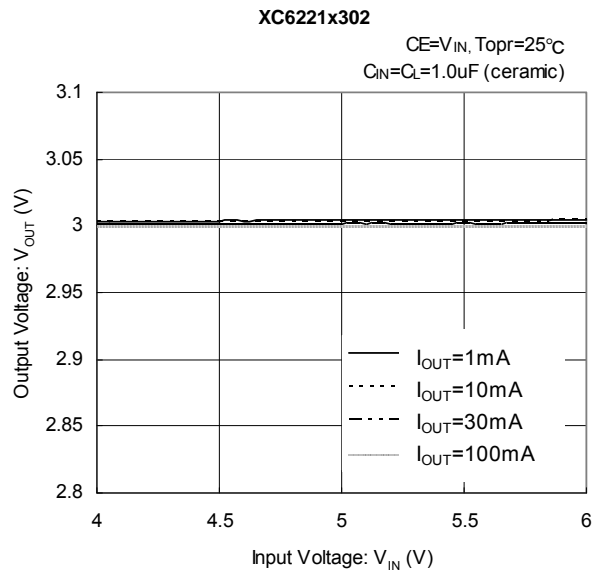
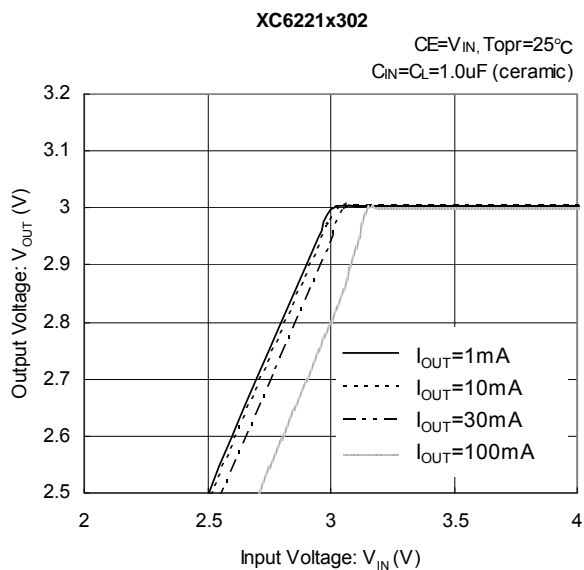


(2) Output Voltage vs. Input Voltage

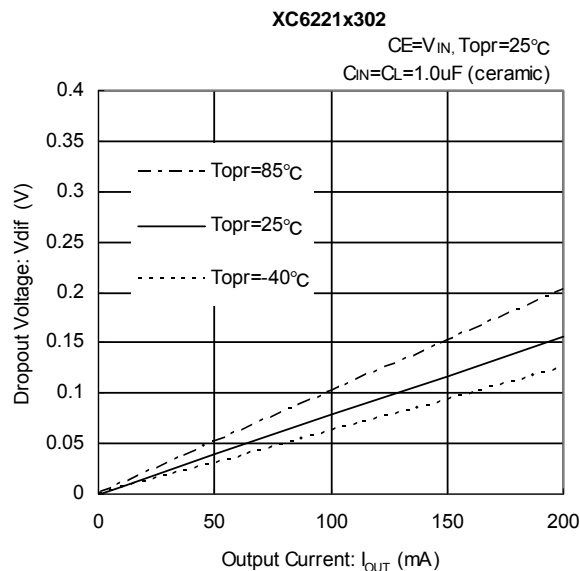
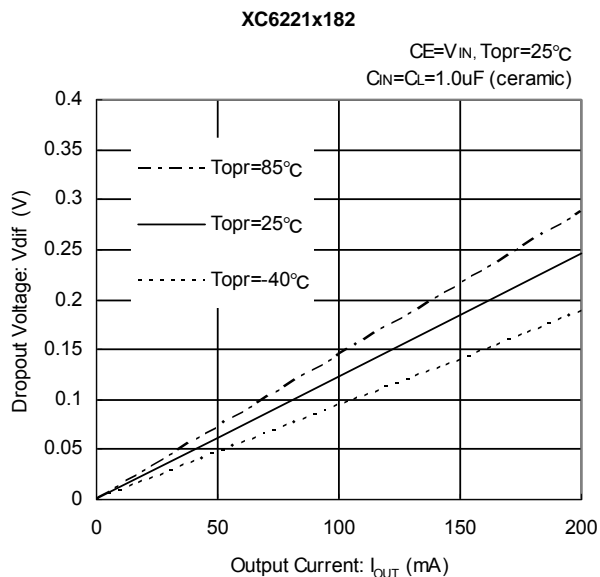


■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

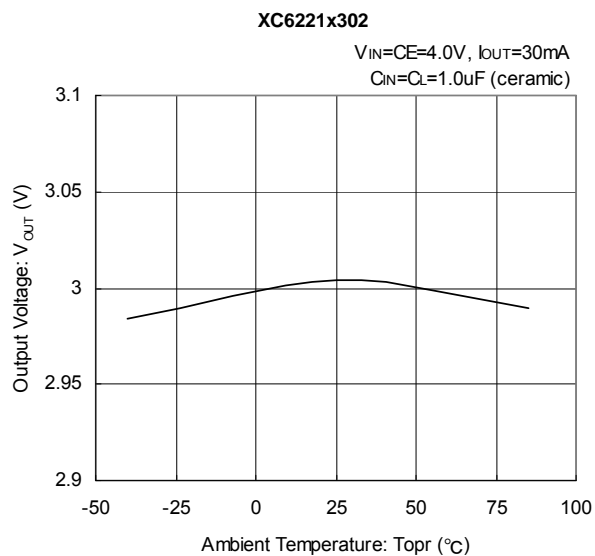
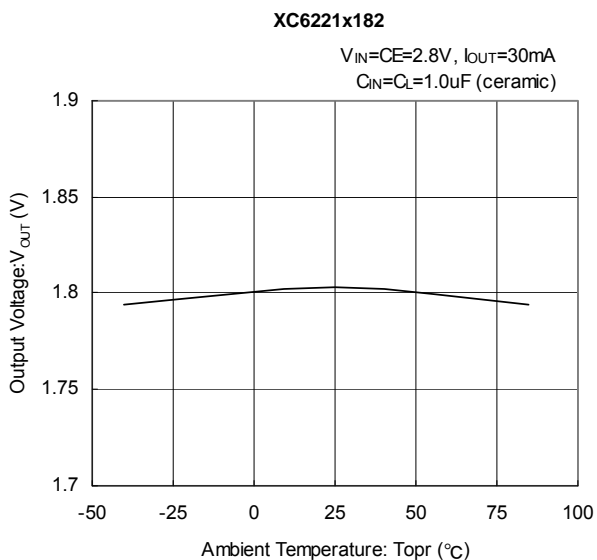
(2) Output Voltage vs. Input Voltage (Continued)



(3) Dropout Voltage vs. Output Current

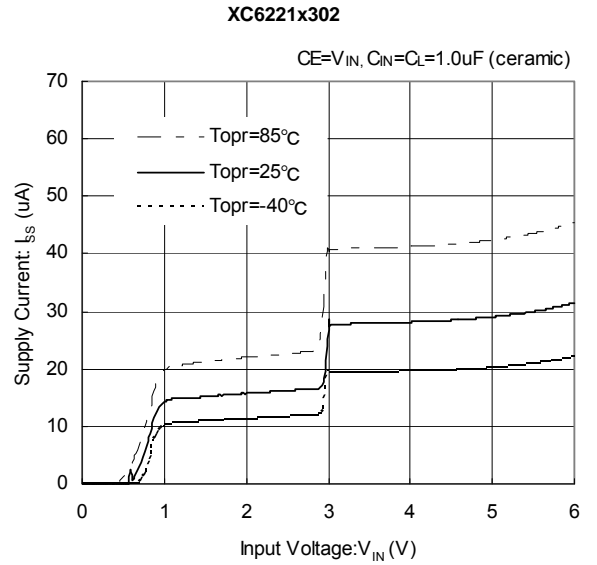
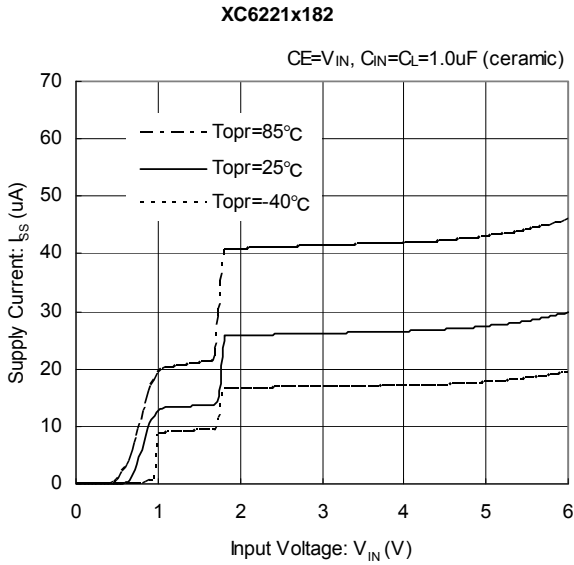


(4) Output Voltage vs. Ambient Temperature

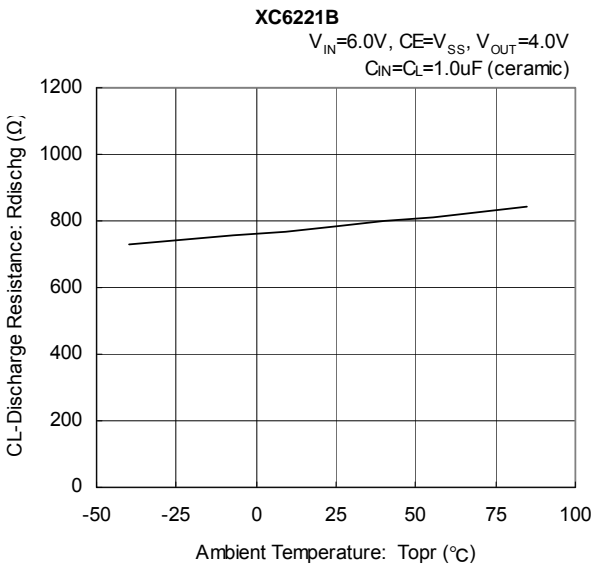


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

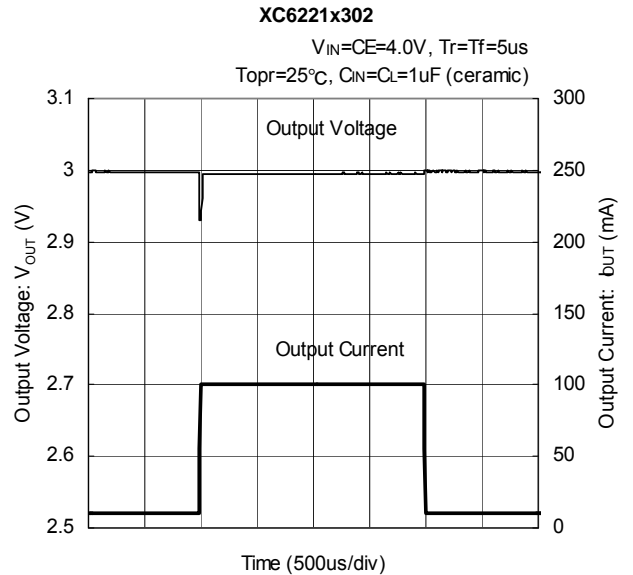
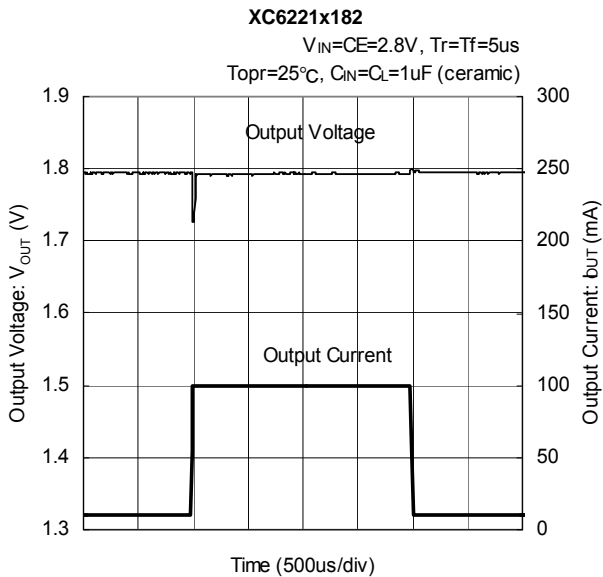
(5) Supply Current vs. Input Voltage



(6) CL-Discharge Resistance vs. Ambient Temperature



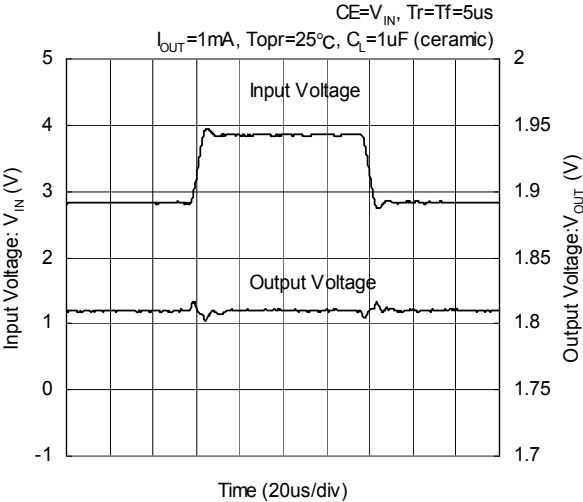
(7) Load Transient Response



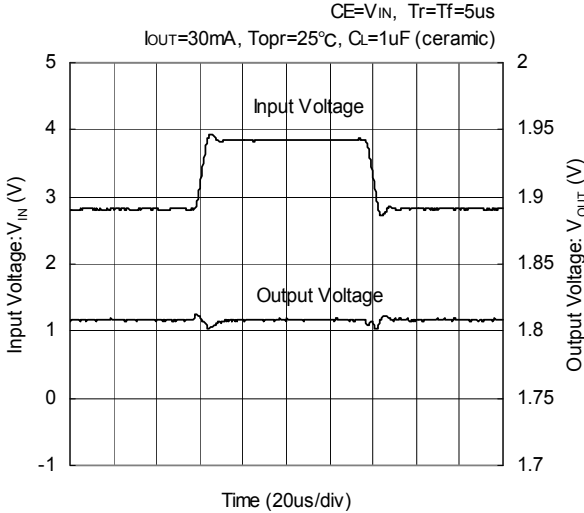
■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(8) Line Transient Response

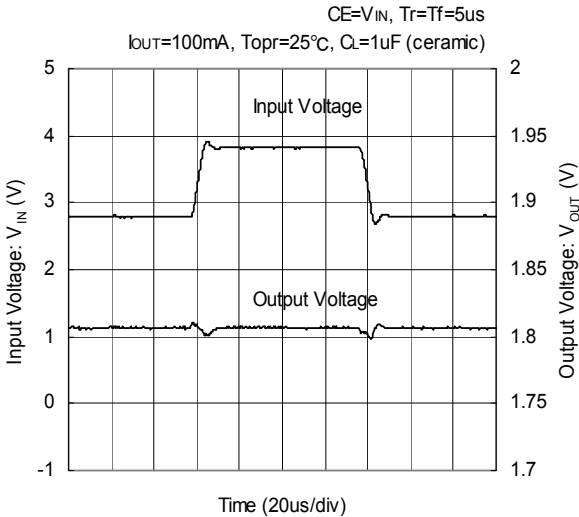
XC6221x182



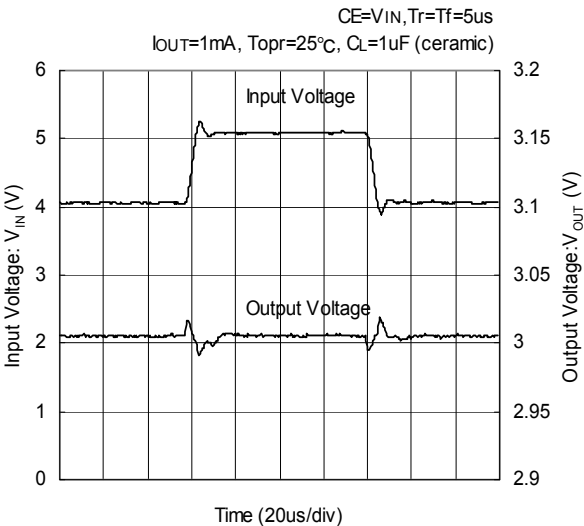
XC6221x182



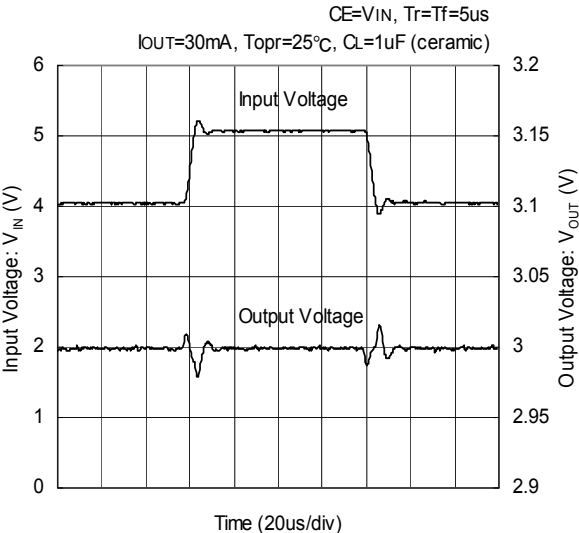
XC6221x182



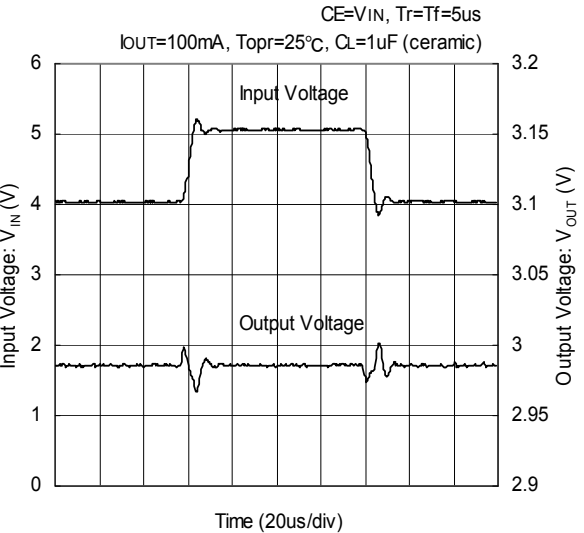
XC6221x302



XC6221x302

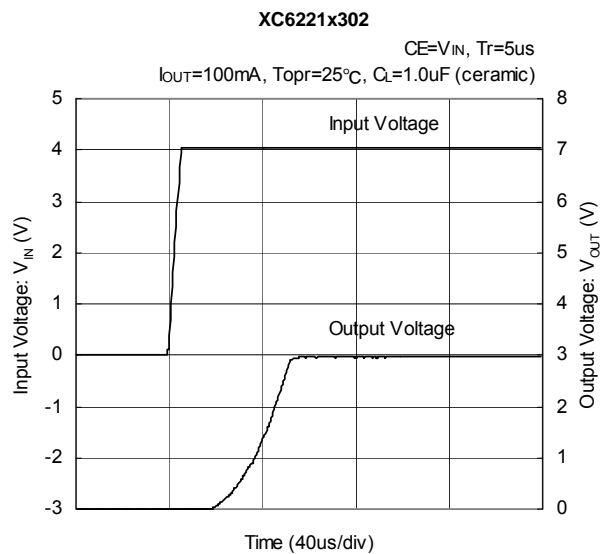
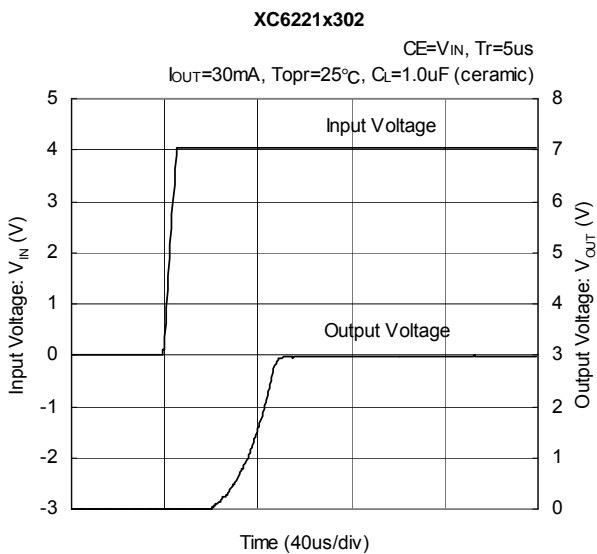
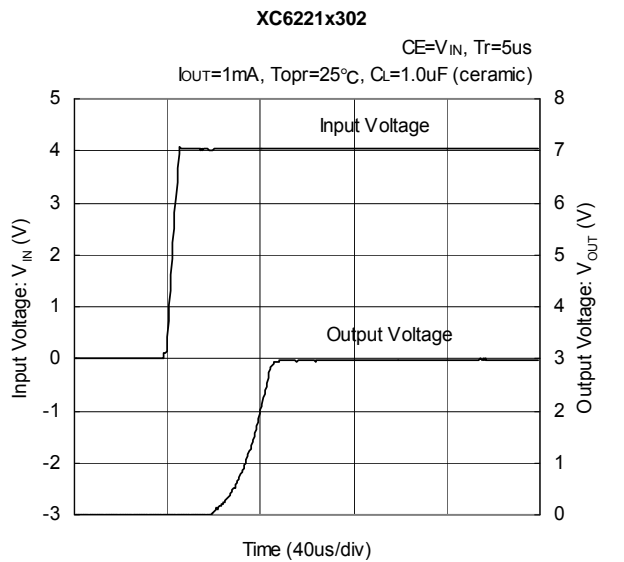
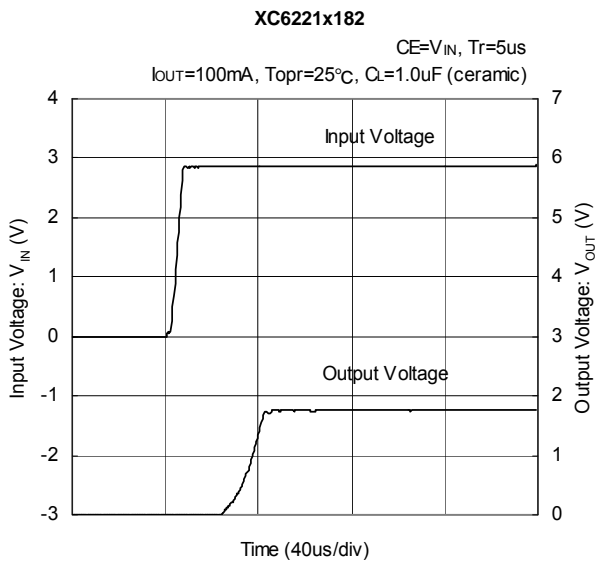
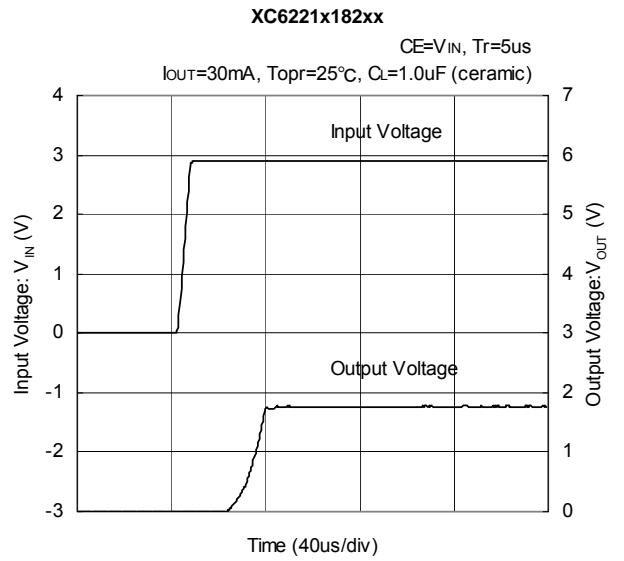
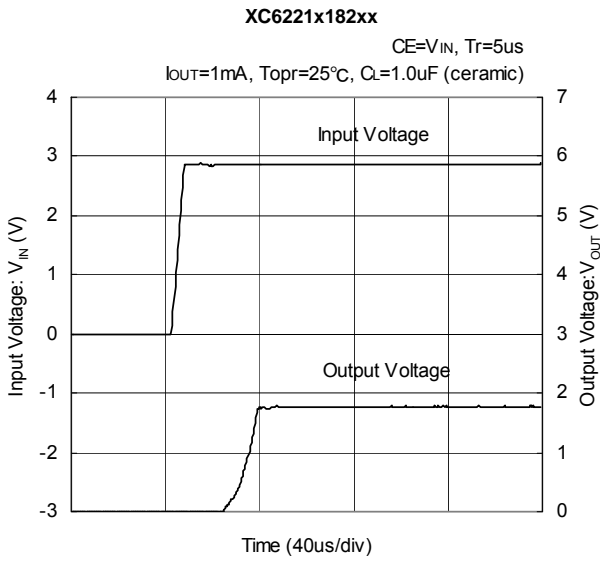


XC6221x302



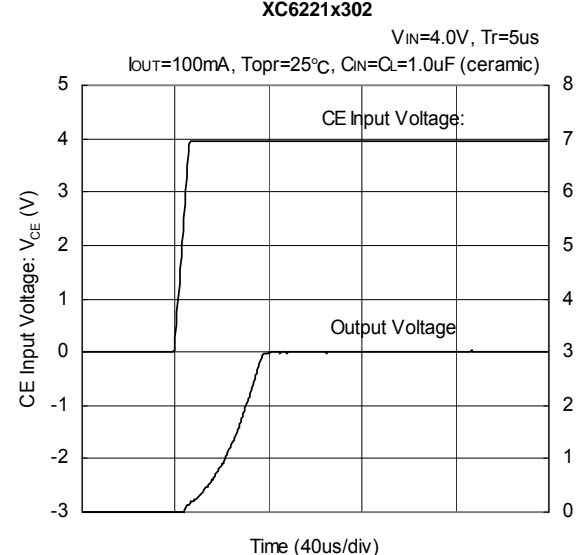
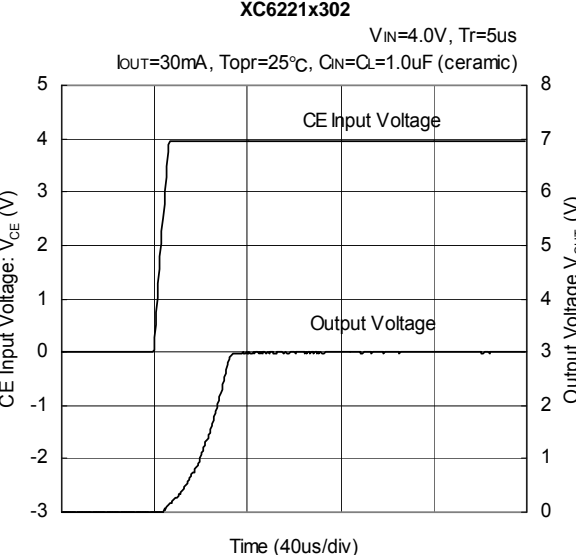
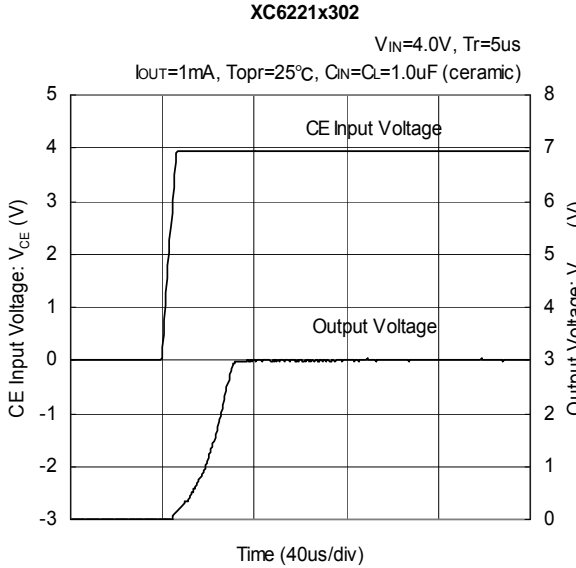
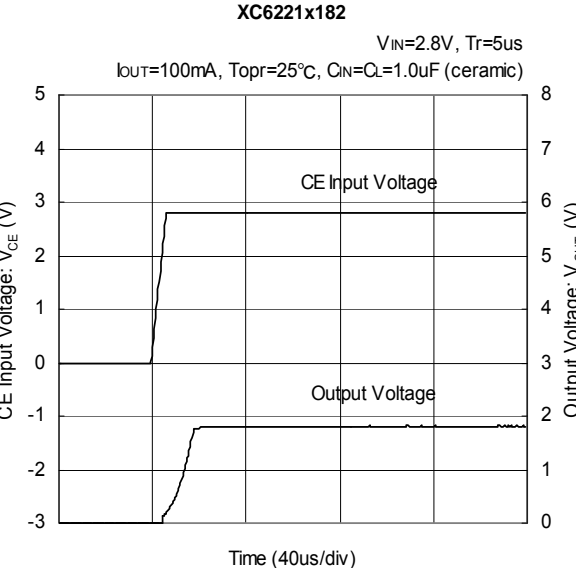
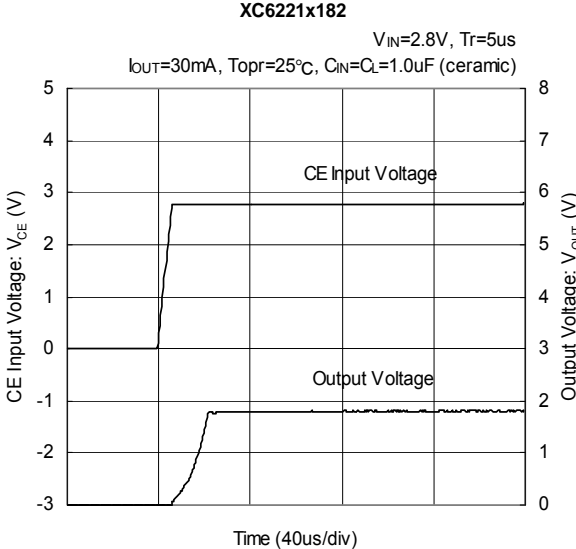
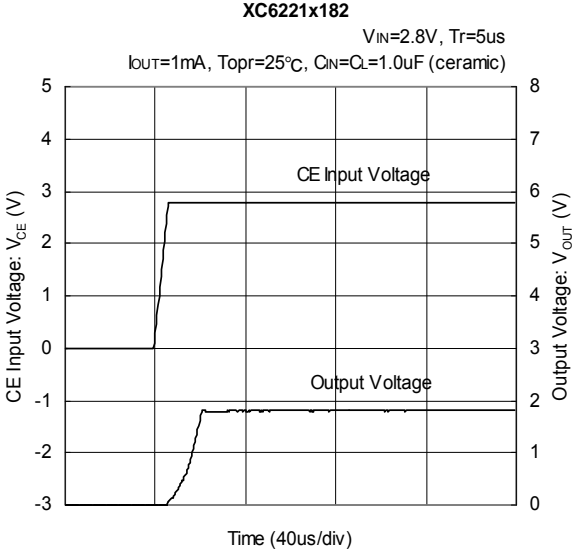
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) Input Rise Characteristics



■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(10) CE Rise Characteristics

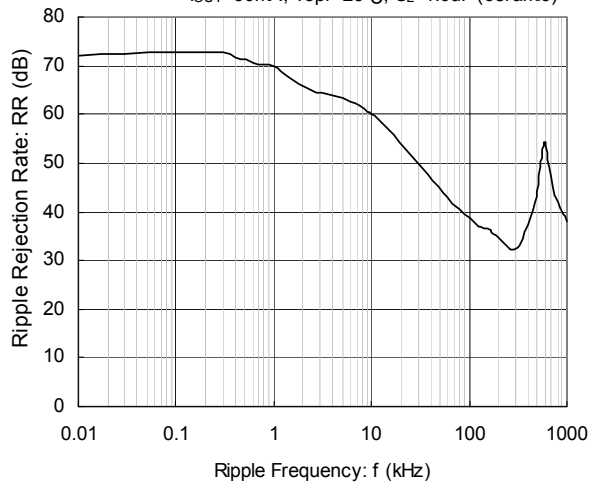


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(11) Ripple Rejection Rate

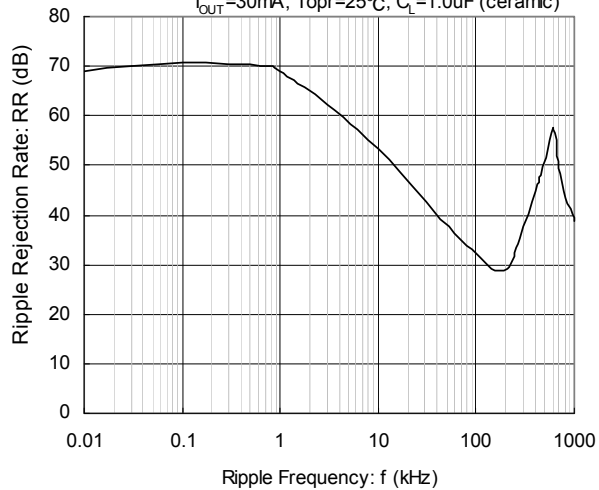
XC6221x182

$V_{IN} = CE = 2.8V_{DC} + 0.5V_{p-pAC}$,
 $I_{OUT} = 30mA$, $T_{opr} = 25^{\circ}C$, $C_L = 1.0\mu F$ (ceramic)



XC6221x302

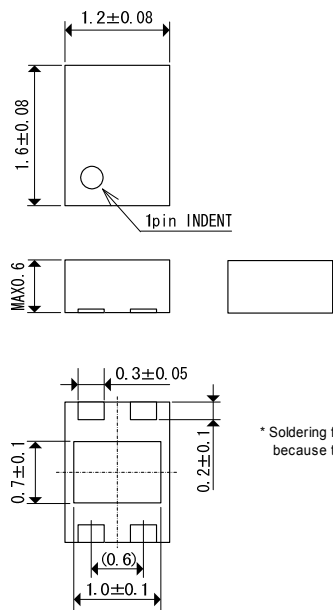
$V_{IN} = CE = 4.0V_{DC} + 0.5V_{p-pAC}$,
 $I_{OUT} = 30mA$, $T_{opr} = 25^{\circ}C$, $C_L = 1.0\mu F$ (ceramic)



PACKAGING INFORMATION

● USP-4

(unit : mm)

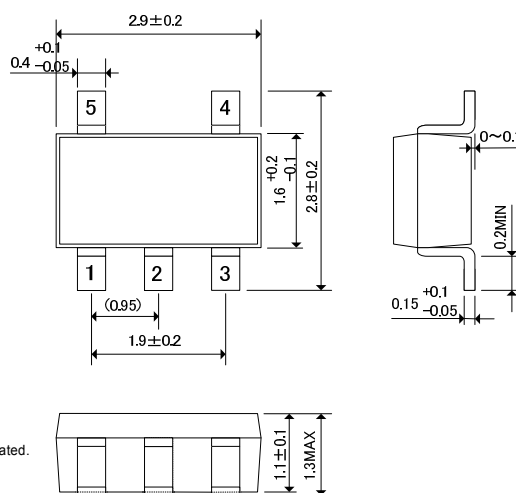


* Soldering fillet surface is not formed because the sides of the pins are plated.

USP-4 Package

● SOT-25

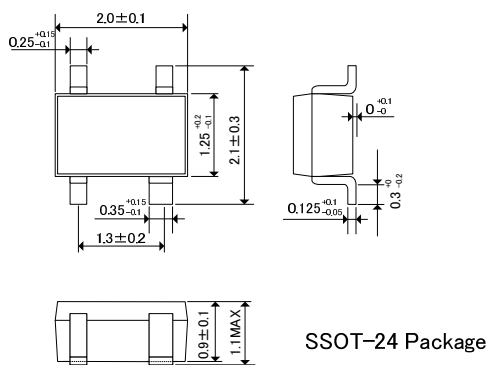
(unit : mm)



SOT-25 Package

● SSOT-24

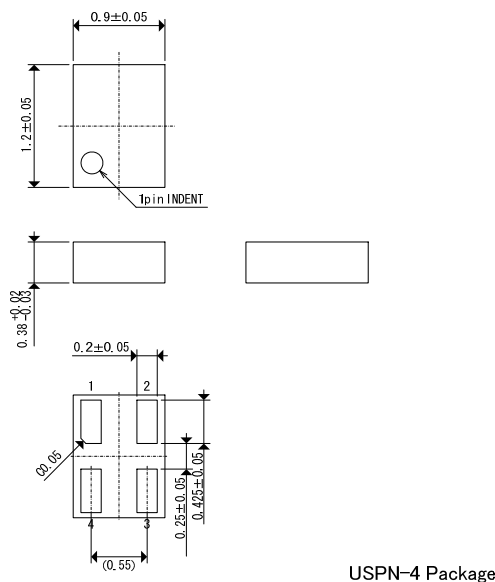
(unit : mm)



SSOT-24 Package

● USPN-4

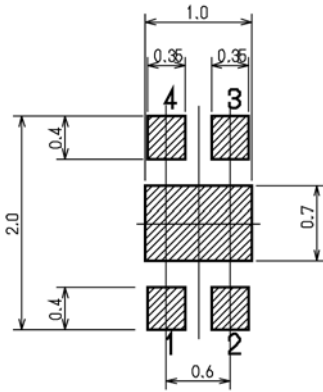
(unit : mm)



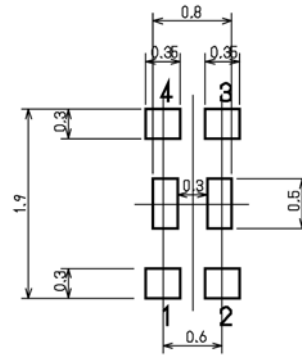
USPN-4 Package

PACKAGING INFORMATION (Continued)

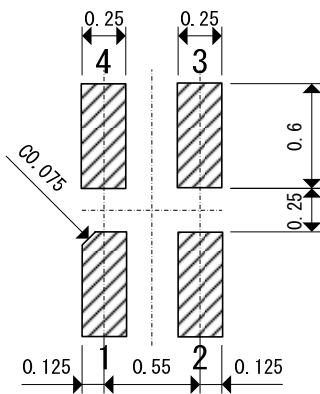
● USP-4 Reference Pattern Layout



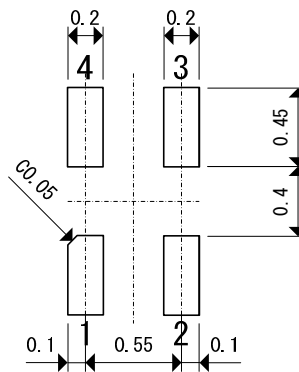
● USP-4 Reference Metal Mask Design



● USPN-4 Reference Pattern Layout

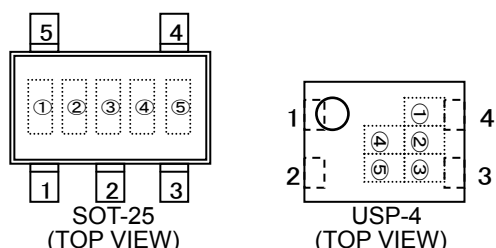


● USPN-4 Reference Metal Mask Design



MARKING RULE

●SOT-25 / USP-4



①Represents product series

| MARK | PRODUCT SERIES |
|------|----------------|
| 3 | XC6221***** |
| | XC6221S***** |

②Represents type of regulator

| MARK | | | | PRODUCT SERIES |
|--------------------------------|----------------------------|---------------------------------|------------------------------|----------------|
| OUTPUT VOLTAGE 0.1V INCREMENTS | | OUTPUT VOLTAGE 0.05V INCREMENTS | | |
| V _{OUT} =0.8~3.0V | V _{OUT} =3.1~5.0V | V _{OUT} =0.85~3.05V | V _{OUT} =3.15~4.95V | |
| V | A | E | L | XC6221A***** |
| X | B | F | M | XC6221B***** |

Custom products : Represents last 1 digits of registered serial number.

0 to 9, reverse character 0 to 9 repeated (G, I, J, O, Q, W excepted)

ex.) CUSTOM PRODUCTS

| MARK | SERIAL | PRODUCT SERIES |
|------|--------|----------------|
| 0 | 01 | XC6221S01XM* |

③Represents output voltage

| MARK | OUTPUT VOLTAGE (V) | | | | MARK | OUTPUT VOLTAGE (V) | | | |
|------|--------------------|-----|------|------|------|--------------------|-----|------|------|
| 0 | - | 3.1 | - | 3.15 | F | 1.6 | 4.6 | 1.65 | 4.65 |
| 1 | - | 3.2 | - | 3.25 | H | 1.7 | 4.7 | 1.75 | 4.75 |
| 2 | - | 3.3 | - | 3.35 | K | 1.8 | 4.8 | 1.85 | 4.85 |
| 3 | - | 3.4 | - | 3.45 | L | 1.9 | 4.9 | 1.95 | 4.95 |
| 4 | - | 3.5 | - | 3.55 | M | 2.0 | 5.0 | 2.05 | - |
| 5 | - | 3.6 | - | 3.65 | N | 2.1 | - | 2.15 | - |
| 6 | - | 3.7 | - | 3.75 | P | 2.2 | - | 2.25 | - |
| 7 | 0.8 | 3.8 | 0.85 | 3.85 | R | 2.3 | - | 2.35 | - |
| 8 | 0.9 | 3.9 | 0.95 | 3.95 | S | 2.4 | - | 2.45 | - |
| 9 | 1.0 | 4.0 | 1.05 | 4.05 | T | 2.5 | - | 2.55 | - |
| A | 1.1 | 4.1 | 1.15 | 4.15 | U | 2.6 | - | 2.65 | - |
| B | 1.2 | 4.2 | 1.25 | 4.25 | V | 2.7 | - | 2.75 | - |
| C | 1.3 | 4.3 | 1.35 | 4.35 | X | 2.8 | - | 2.85 | - |
| D | 1.4 | 4.4 | 1.45 | 4.45 | Y | 2.9 | - | 2.95 | - |
| E | 1.5 | 4.5 | 1.55 | 4.55 | Z | 3.0 | - | 3.05 | - |

Custom products : Represents last 1 digits of registered serial number.

0 to 9, reverse character 0 to 9 repeated (G, I, J, O, Q, W excepted)

ex.) CUSTOM PRODUCTS

| MARK | SERIAL | PRODUCT SERIES |
|------|--------|----------------|
| 0 | 01 | XC6221S01XM* |

④⑤Represents production lot number

01, ..., 09, 10, 11, ...,99, 0A, ...,0Z, 1A, ... 9Z, A0, ..., Z9, AA, ..., ZZ repeated.

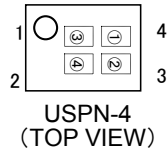
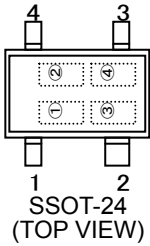
(G, I, J, O, Q, W excepted)

*No character inversion used.

MARKING RULE (Continued)

●SSOT-24

●USPN-4



①Represents product series

| MARK | | | | PRODUCT SERIES |
|--------------------------------|----------------------------|---------------------------------|------------------------------|----------------|
| OUTPUT VOLTAGE 0.1V INCREMENTS | | OUTPUT VOLTAGE 0.05V INCREMENTS | | |
| V _{OUT} =0.8~3.0V | V _{OUT} =3.1~4.0V | V _{OUT} =0.85~3.05V | V _{OUT} =3.15~3.95V | |
| 9 | D | A | E | XC6221A***** |
| B | F | C | H | XC6221B***** |

* For the USPN-4 package, $0.8V \leq V_{OUT(T)} \leq 1.15V$ is under development.

②Represents output voltage

| MARK | OUTPUT VOLTAGE (V) | | | | MARK | OUTPUT VOLTAGE (V) | | | |
|------|--------------------|-----|------|------|------|--------------------|---|------|---|
| 0 | - | 3.1 | - | 3.15 | F | 1.6 | - | 1.65 | - |
| 1 | - | 3.2 | - | 3.25 | H | 1.7 | - | 1.75 | - |
| 2 | - | 3.3 | - | 3.35 | K | 1.8 | - | 1.85 | - |
| 3 | - | 3.4 | - | 3.45 | L | 1.9 | - | 1.95 | - |
| 4 | - | 3.5 | - | 3.55 | M | 2.0 | - | 2.05 | - |
| 5 | - | 3.6 | - | 3.65 | N | 2.1 | - | 2.15 | - |
| 6 | - | 3.7 | - | 3.75 | P | 2.2 | - | 2.25 | - |
| 7 | 0.8 | 3.8 | 0.85 | 3.85 | R | 2.3 | - | 2.35 | - |
| 8 | 0.9 | 3.9 | 0.95 | 3.95 | S | 2.4 | - | 2.45 | - |
| 9 | 1.0 | 4.0 | 1.05 | - | T | 2.5 | - | 2.55 | - |
| A | 1.1 | - | 1.15 | - | U | 2.6 | - | 2.65 | - |
| B | 1.2 | - | 1.25 | - | V | 2.7 | - | 2.75 | - |
| C | 1.3 | - | 1.35 | - | X | 2.8 | - | 2.85 | - |
| D | 1.4 | - | 1.45 | - | Y | 2.9 | - | 2.95 | - |
| E | 1.5 | - | 1.55 | - | Z | 3.0 | - | 3.05 | - |

③④Represents production lot number

01, ..., 09, 10, 11, ..., 99, 0A, ..., 0Z, 1A, ..., 9Z, A0, ..., Z9, AA, ..., ZZ repeated.

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

*No character inversion used.

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