# XC6416 Series

## Dual LDO Voltage Regulator with “GreenOperation”

## ■GENERAL DESCRIPTION

☆GreenOperation Compatible

The XC6416 series is a high accurate, low noise, high ripple rejection, and low dropout CMOS Dual regulator with GreenOperation function. The series includes a reference voltage source, an error amplifier, a current limiter, and a phase compensation circuit.

GreenOperation function provides high speed operation, low power consumption and high efficiencies by automatically switching between a high speed mode (HS) and a power save mode (PS) depending on the load current level. The switching point of the GreenOperation to the output current is being fixed inside the IC, thus providing operating conditions with the most suitable level of supply current for the application. The USP-6C package has GO pin. If a high level singal is input to the GO pin, the XC6416 can be used as a high speed fixed mode regulator.

The EN function turns each output of the two regulators independently. In this state, the electric charge at the output capacitor ($C_L$) is discharged via the internal auto-discharge switch, and as a result the $V_{OUT}$ voltage quickly returns to the $V_{SS}$ level. The output stabilization capacitor ($C_L$) is also compatible with low ESR ceramic capacitors. Output voltage is selectable in 0.05V increments within a range of 0.8V ~4.0V, using laser trimming technologies. The series includes a fold-back circuit, which aids the operation of the current limiter and circuit protection.

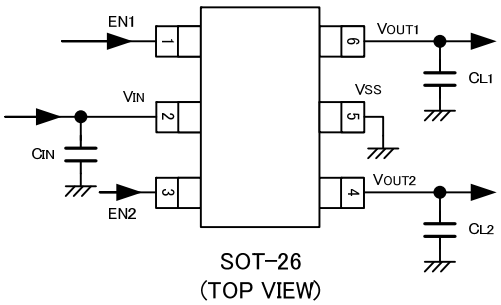
## ■APPLICATIONS

- Mobile phones
- Cordless phones, wireless communication equipment
- Portable games
- Cameras, video recorders
- Portable audio equipment
- PDAs

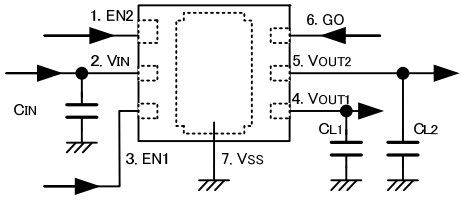
## ■ FEATURES

| | |
|---|---|
| Maximum Output Current | : 200mA (300mA limit, TYP.) |
| Dropout Voltage | : 95mV@$I_{OUT}$=100mA, $V_{OUT}$=3.0V |
| Operating Voltage Range | : 1.5V~6.0V |
| Output Voltage Range | : 0.8V~4.0V (0.05V increments) |
| High Output Accuracy | : ±1% <XC6416A/B/C/D in HS Mode><br>±0.02V @ $V_{OUT}$≦1.95V<br>±2% <XC6416E/F/G/H in HS Mode><br>±0.03V @ $V_{OUT}$≦1.45V<br>±3% <XC6416A~H in PS Mode><br>±0.06V @ $V_{OUT}$≦1.95V |
| Low Power Consumption | : 5μA/ch @ PS mode (TYP.)<br>28μA/ch @ HS mode (TYP.) |
| Stand-by Current | : Less than 0.1μA |
| Ripple Rejection Rate | : 60dB @ 1kHz |
| Operating Temperature Range | : - 40°C ~ 85°C |
| Low ESR Capacitor | : 1.0μF Ceramic Capacitor Compatible |
| Packages | : USP-6C, SOT-26 |
| Environmentally Friendly | : EU RoHS Compliant, Pb Free |

## ■TYPICAL APPLICATION CIRCUITS



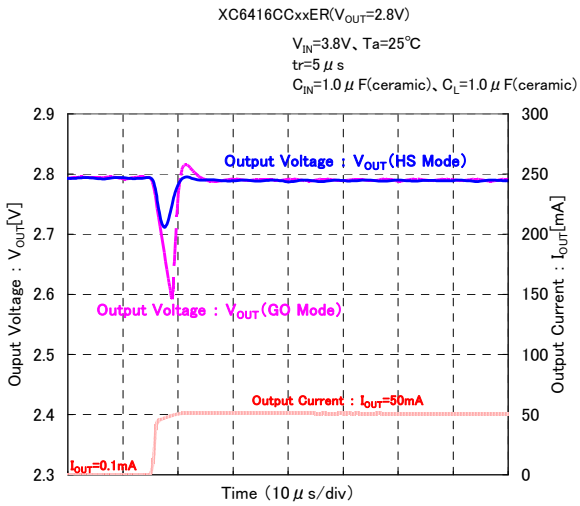

SOT-26
(TOP VIEW)



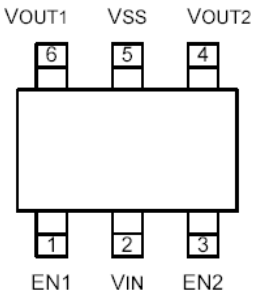

USP-6C
(TOP VIEW)

## ■TYPICAL PERFORMANCE CHARACTERISTICS

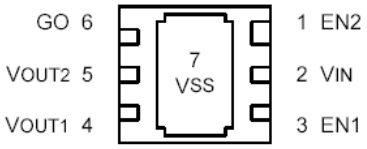
●Load Transient Response



## ■PIN CONFIGURATION




SOT-26
(TOP VIEW)




USP-6C
(BOTTOM VIEW)

## ■PIN ASSIGNMENT

| PIN NUMBER | | PIN NAME | FUNCTION |
|---|---|---|---|
| SOT-26 | USP-6C | | |
| 1 | 3 | EN1 | ON/OFF Control 1 |
| 2 | 2 | $V_{IN}$ | Power Input |
| 3 | 1 | EN2 | ON/OFF Control 2 |
| 4 | 5 | $V_{OUT2}$ | Output 2 |
| 5 | 7 | $V_{SS}$ | Ground |
| 6 | 4 | $V_{OUT1}$ | Output 1 |
| - | 6 | GO | GreenOperation Mode Switching Pin |

# ■PRODUCT CLASSIFICATION

●Ordering Information

XC6416①②③④⑤⑥-⑦(*1)

| SYMBOL | DESCRIPTION | SYMBOL | DESCRIPTION |
|---|---|---|---|
| ① | Type of Regulator EN1= High Active | A | Output accuracy 1%, SOT-26 Auto GO, No $C_L$ discharge |
| | | B | Output accuracy 1%, SOT-26 Auto GO, Auto $C_L$ discharge |
| | | C | Output accuracy 1%, USP-6C GO selection pin, No $C_L$ discharge |
| | | D | Output accuracy 1%, USP-6C GO selection pin, Auto $C_L$ discharge |
| | | E | Output accuracy 2%, SOT-26 Auto GO, No $C_L$ discharge |
| | | F | Output accuracy 2%, SOT-26 Auto GO, Auto $C_L$ discharge |
| | | G | Output accuracy 2%, USP-6C GO selection pin, No $C_L$ discharge |
| | | H | Output accuracy 2%, USP-6C GO selection pin, Auto $C_L$ discharge |
| ② | Type of Regulator EN2= High Active | A | Output accuracy 1%, SOT-26 Auto GO, No $C_L$ discharge |
| | | B | Output accuracy 1%, SOT-26 Auto GO, Auto $C_L$ discharge |
| | | C | Output accuracy 1%, USP-6C GO selection pin, No $C_L$ discharge |
| | | D | Output accuracy 1%, USP-6C GO selection pin, Auto $C_L$ discharge |
| | | E | Output accuracy 2%, SOT-26 Auto GO, No $C_L$ discharge |
| | | F | Output accuracy 2%, SOT-26 Auto GO, Auto $C_L$ discharge |
| | | G | Output accuracy 2%, USP-6C GO selection pin, No $C_L$ discharge |
| | | H | Output accuracy 2%, USP-6C GO selection pin, Auto $C_L$ discharge |
| ③④ | Two Output Voltage Combination | 01~ | Internally set sequential number (refer to the table below)<br>Regulator 1 Output Voltage Range: 0.8 ~ 4.0V (0.05V increments)<br>Regulator 2 Output Voltage Range: 0.8 ~ 4.0V (0.05V increments) |
| ⑤⑥-⑦ | Packages<br>Taping Type (*2) | MR | SOT-26 |
| | | MR-G | SOT-26 |
| | | ER | USP-6C |
| | | ER-G | USP-6C |

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

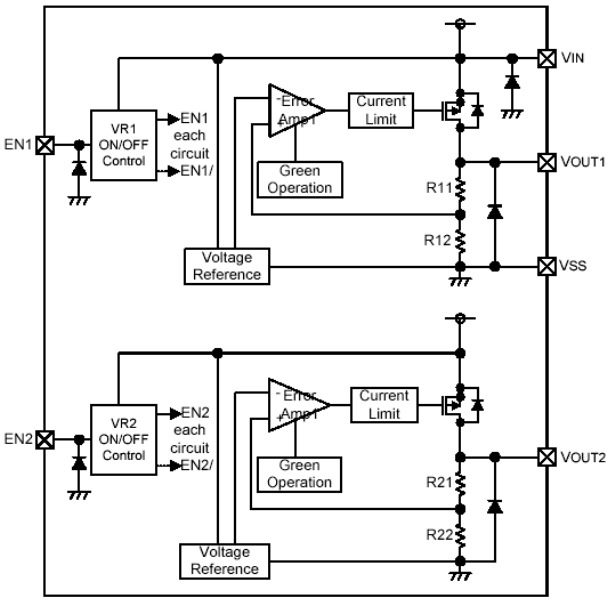
(*2) The device orientation is fixed in its embossed tape pocket. For reverse orientation, please contact your local Torex sales office or representative. (Standard orientation: ⑤R-⑦, Reverse orientation: ⑤L-⑦)

●DESIGNATOR③④

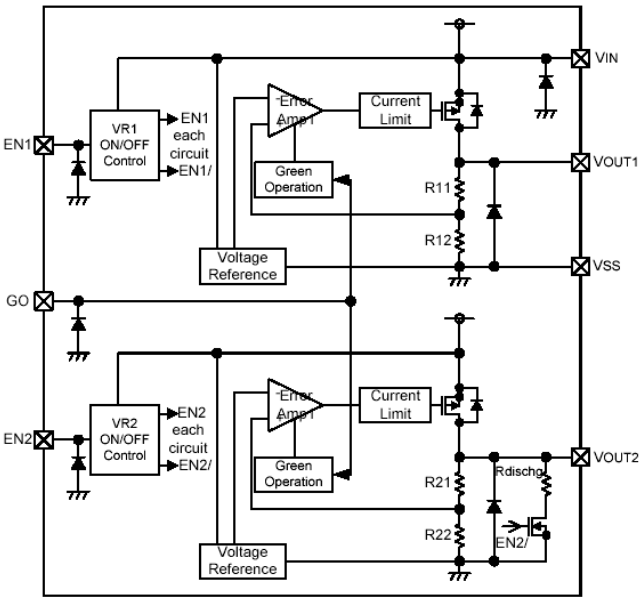
| ③④ | VR1 | VR2 | ③④ | VR1 | VR2 | ③④ | VR1 | VR2 |
|---|---|---|---|---|---|---|---|---|
| 01 | 1.80 | 2.80 | 11 | 1.30 | 1.50 | 21 | 1.50 | 2.80 |
| 02 | 1.20 | 2.90 | 12 | 2.80 | 2.80 | 22 | 1.80 | 3.00 |
| 03 | 1.80 | 1.80 | 13 | 2.50 | 3.30 | 23 | 1.85 | 2.80 |
| 04 | 1.50 | 2.70 | 14 | 3.00 | 3.30 | 24 | 1.85 | 3.30 |
| 05 | 2.85 | 2.85 | 15 | 1.20 | 1.80 | 25 | 2.60 | 2.80 |
| 06 | 1.80 | 3.30 | 16 | 2.80 | 3.30 | 26 | 1.50 | 1.50 |
| 07 | 3.00 | 3.00 | 17 | 3.30 | 3.30 | 27 | 2.00 | 3.00 |
| 08 | 2.80 | 1.80 | 18 | 3.10 | 3.10 | 28 | 3.30 | 1.80 |
| 09 | 1.20 | 1.20 | 19 | 2.80 | 1.50 | 29 | 3.30 | 1.75 |
| 10 | 1.10 | 1.30 | 20 | 1.30 | 2.80 | 31 | 1.20 | 2.80 |

*For other output voltage combinations, please consult to Torex sales offices.

## ■BLOCK DIAGRAMS




< XC6416AA Series >




< XC6416CD Series >

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

## ■ABSOLUTE MAXIMUM RATINGS

Ta=25°C

| PARAMETER | | SYMBOL | RATINGS | UNITS |
|---|---|---|---|---|
| Input Voltage | | $V_{IN}$ | - 0.3 ~ + 6.5 | V |
| Output Current | | $I_{OUT1}+I_{OUT2}$ | 500 (*1) | mA |
| Output Voltage 1 / Output Voltage 2 | | $V_{OUT1}$ /$V_{OUT2}$ | $V_{SS}$ - 0.3 $V_{IN}$ + 0.3 | V |
| EN1 / EN2 Input Voltage | | $V_{EN1}$ /$V_{EN2}$ | $V_{SS}$ - 0.3 ~ + 6.5 | V |
| Power Dissipation | USP-6C | Pd | 120 | mW |
| | | | 1000 (PCB mounted) (*2) | |
| | SOT-26 | | 250 | |
| Operating Temperature Range | | Topr | - 40 ~ + 85 | °C |
| Storage Temperature Range | | Tstg | - 55 ~ + 125 | °C |

*1) Please use within the range of Pd > { ($V_{IN}$-$V_{OUT1}$)×$I_{OUT1}$ + ($V_{IN}$-$V_{OUT2}$)×$I_{OUT2}$ }

*2) This power dissipation figure shown is PCB mounted and is for reference only. Please refer to page 29 for details.

# ■ELECTRICAL CHARACTERISTICS

●XC6416A/B/E/F Series Regulator 1, Regulator 2

Ta=25℃

| PARAMETER | SYMBOL | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUITS |
|---|---|---|---|---|---|---|---|
| Output Voltage 1 (HS*) | $V_{OUT1(E)}$ (*2) | $V_{OUT(T)}$≧2.0V, (A/B Series)<br>$V_{EN}$=$V_{IN}$, $I_{OUT}$=10mA | ×0.99 (*3) | $V_{OUT(T)}$ (*4) | ×1.01 (*3) | V | ① |
| | | $V_{OUT(T)}$≦1.95V, (A/B Series)<br>$V_{EN}$=$V_{IN}$, $I_{OUT}$=10mA | - 0.02 (*3) | | + 0.02 (*3) | | |
| | | $V_{OUT(T)}$≧1.5V（E/F Series)<br>$V_{EN}$=$V_{IN}$, $I_{OUT}$=10mA | ×0.98 (*3) | | ×1.02 (*3) | | |
| | | $V_{OUT(T)}$≦1.45V（E/F Series)<br>$V_{EN}$=$V_{IN}$, $I_{OUT}$=10mA | - 0.03 (*3) | | + 0.03 (*3) | | |
| Output Voltage 2 (PS*) | $V_{OUT2(E)}$ (*2) | $V_{OUT(T)}$≧2.0V,<br>$V_{EN}$=$V_{IN}$, $I_{OUT}$=0.1mA | ×0.97 (*3) | $V_{OUT(T)}$ (*4) | ×1.03 (*3) | V | ① |
| | | $V_{OUT}$≦1.95V,<br>$V_{EN}$=$V_{IN}$, $I_{OUT}$=0.1mA | - 0.06 (*3) | | + 0.06 (*3) | | |
| Output Current | $I_{OUTMAX}$ | | 200 | - | - | mA | ① |
| Load Regulation | $\Delta V_{OUT}$ | $V_{EN}$=$V_{IN}$, 10mA≦$I_{OUT}$≦100mA | | E-1 | | mV | ① |
| Dropout Voltage (*5) | Vdif | $I_{OUT}$=100mA, $V_{EN}$=$V_{IN}$ | | E-2 | | mV | ① |
| Supply Current 1 (HS*) | $I_{SS1}$ | $V_{IN}$=$V_{EN}$=$V_{OUT(T)}$+1.0V, | - | 28 | 60 | μA | ② |
| Supply Current 2 (PS*) | $I_{SS2}$ | $V_{IN}$=$V_{EN}$= $V_{OUT(T)}$+1.0V, | - | 5.0 | 12 | μA | ② |
| Stand-by Current | $I_{STBY}$ | $V_{IN}$=6.0V, $V_{EN}$=$V_{SS}$ | - | 0.01 | 0.1 | μA | ② |
| Line Regulation 1 (HS*) | $\Delta V_{OUT}$/<br>($\Delta V_{IN}$・$V_{OUT}$) | $V_{OUT(T)}$+0.5V≦$V_{IN}$≦6.0V<br>$V_{OUT(T)}$≧1.0V, $V_{EN}$=$V_{IN}$,<br>$I_{OUT}$=10mA | - | 0.01 | 0.2 | %/V | ① |
| | | 1.5V≦$V_{IN}$≦6.0V<br>$V_{OUT(T)}$≦0.95V, $V_{EN}$=$V_{IN}$,<br>$I_{OUT}$=10mA | | | | | |
| Input Voltage | $V_{IN}$ | | 1.5 | - | 6.0 | V | ① |
| Output Voltage Temperature Characteristics | $\Delta V_{OUT}$/<br>($\Delta$Ta・$V_{OUT}$) | $V_{EN}$=$V_{IN}$, $I_{OUT}$=30mA<br>-40℃≦Ta≦85℃ | - | ±100 | - | ppm/℃ | ① |
| Ripple Rejection Rate | PSRR | $V_{IN}$={$V_{OUT(T)}$+1.0} $V_{DC}$+0.5Vp-$p_{AC}$ | - | 60 | - | dB | ③ |
| Limit Current | $I_{LIM}$ | $V_{EN}$=$V_{IN}$ | 210 | 300 | - | mA | ① |
| Short Current | $I_{SHORT}$ | $V_{EN}$=$V_{IN}$, Short $V_{OUT}$ to $V_{SS}$ level | - | 20 | - | mA | ① |
| PS Switching Current | $I_{GOR}$ | $V_{EN}$=$V_{IN}$, $I_{OUT}$=Heavy to light load | 0.25 | 1.5 | | mA | ① |
| HS Switching Current | $I_{GO}$ | $V_{EN}$=$V_{IN}$, $I_{OUT}$=Light to heavy load | | 4 | 7.5 | mA | ① |
| Switching Current Hysteresis | $I_{GOhys}$ | $I_{GOhys}$=$I_{GO}$-$I_{GOR}$ | | 2.5 | | mA | ① |
| PS Switching Delay Time | $t_{DPS}$ | $V_{EN}$=$V_{IN}$, | | E-3 | | μs | ① |
| EN High Level Voltage | $V_{ENH}$ | | 1.2 | | 6 | V | ① |
| EN Low Level Voltage | $V_{ENL}$ | | | | 0.3 | V | ① |
| EN High Level Current | $I_{ENH}$ | $V_{EN}$=$V_{IN}$ | -0.1 | | 0.1 | μA | ① |
| EN Low Level Current | $I_{ENL}$ | $V_{EN}$=$V_{SS}$ | -0.1 | | 0.1 | μA | ① |
| $C_L$ Discharge Resistance(*8) | $R_{DCHG}$ | $V_{IN}$=6.0V, $V_{OUT}$=4.0V, $V_{EN}$=$V_{SS}$ | | 550 | | Ω | ① |

NOTE:
*HS: High Speed Mode, PS: Power Save Mode
*1: Unless otherwise stated, $V_{IN}$=$V_{OUT(T)}$ +1.0V.
*2: $V_{OUT(E)}$= Nominal output voltage (see the voltage chart)
(ie. The output voltage when "$V_{OUT(T)}$ +1.0V" is provided at the $V_{IN}$ pin while maintaining a certain $I_{OUT}$ value.
*3 : Characteristics of the effective $V_{OUT(E)}$ by nominal output voltage is shown in the voltage chart.
*4 : $V_{OUT(T)}$ : Nominal output voltage
*5: Vdif={$V_{IN1}$(*7)−$V_{OUT1}$(*6)}
*6: $V_{OUT1}$: A voltage equal to 98% of the $V_{OUT(T)}$ when an amply stabilized $V_{OUT(T)}$ +1.0V is input.
*7: $V_{IN1}$: The input voltage when the $V_{OUT1}$ voltage appears at the $V_{OUT}$ pin during decreasing input voltage gradually.
*8: For XC6416xB/Bx/xF/Fx series only.
XC6416xA/Ax/xE/Ex series discharge with only Rx1 and Rx2 resistors as shown in the BLOCK DIAGRAMS.
*9: When each channel is measured, the other channel is turned off ($V_{EN}$=$V_{SS}$).

## ■ELECTRICAL CHARACTERISITCS (Continued)

Ta=25℃

●XC6416C/D/G/H Series Regulator 1, Regulator 2

| PARAMETER | SYMBO | CONDITIONS | MIN. | TYP. | MAX. | UNITS | CIRCUIT |
|---|---|---|---|---|---|---|---|
| Output Voltage 1(HS*) | $V_{OUT1(E)}$ (*2) | $V_{OUT(T)} \geqq 2.0V$, (C/D Series)<br>$V_{EN}=V_{IN}$, $I_{OUT}=10mA$ | ×0.99 (*3) | $V_{OUT(T)}$ (*4) | ×1.01 (*3) | V | ① |
| | | $V_{OUT} \leqq 1.95V$, (C/D Series)<br>$V_{EN}=V_{IN}$, $I_{OU}T=10mA$ | -0.02 (*3) | | +0.02 (*3) | | |
| | | $V_{OUT(T)} \geqq 1.5V$ （G/H Series)<br>$V_{EN}=V_{IN}$, $I_{OUT}=10mA$ | ×0.98 (*3) | | ×1.02 (*3) | | |
| | | $V_{OUT} \leqq 1.45V$ （G/H Series)<br>$V_{EN}=V_{IN}$, $I_{OUT}=10mA$ | -0.03 (*3) | | +0.03 (*3) | | |
| Output Voltage 2 (PS*) | $V_{OUT2(E)}$ (*2) | $V_{OUT(T)} \geqq 2.0V$,$V_{EN}=V_{IN}$, $I_{OUT}=0.1mA$ | ×0.97 (*3) | $V_{OUT(T)}$ (*4) | ×1.03 (*3) | V | ① |
| | | $V_{OUT} \leqq 1.95V$,$V_{EN}=V_{IN}$, $I_{OUT}=0.1mA$ | -0.06 (*3) | | +0.06 (*3) | | |
| Output Current | $I_{OUTMAX}$ | | 200 | - | - | mA | ① |
| Load Regulation | $\Delta V_{OUT}$ | $V_{EN}=V_{GO}=V_{IN}$, | E-1 | | | mV | ① |
| Dropout Voltage (*5) | Vdif | $I_{OUT}=100mA$, $V_{EN}=V_{GO}=V_{IN}$ | E-2 | | | mV | ① |
| Supply Current 1 (HS*) | $I_{SS1}$ | $V_{IN}=V_{EN}=V_{GO}=V_{OUT(T)}+1.0V$, | - | 28 | 60 | μA | ② |
| Supply Current 2 (PS*) | $I_{SS2}$ | $V_{IN}=V_{EN}=V_{OUT(T)}+1.0V$, | - | 5.0 | 12 | μA | ② |
| Stand-by Current | $I_{STBY}$ | $V_{IN}=6.0V$, $V_{EN}=V_{SS}$ | - | 0.01 | 0.1 | μA | ② |
| Line Regulation 1 (HS*) | $\Delta V_{OUT}$/<br>($\Delta V_{IN} \cdot V_{OUT}$) | $V_{OUT(T)}+0.5V \leqq V_{IN} \leqq 6.0V$<br>$V_{OUT(T)} \geqq 1.0V$, $V_{EN}=V_{GO}=V_{IN}$,<br>$I_{OUT}=10mA$ | - | 0.01 | 0.2 | %/V | ① |
| | | $1.5V \leqq V_{IN} \leqq 6.0V$<br>$V_{OUT(T)} \leqq 0.95V$, $V_{EN}=V_{GO}=V_{IN}$,<br>$_{OUT}=10mA$ | | | | | |
| Input Voltage | $V_{IN}$ | | 1.5 | - | 6.0 | V | ① |
| Output Voltage Temperature Characteristics | $\Delta V_{OUT}$/<br>($\Delta Ta \cdot V_{OUT}$) | $V_{EN}=V_{GO}=V_{IN}$, $I_{OUT}=30mA$,<br>$-40℃ \leqq Ta \leqq +85℃$ | - | ±100 | - | ppm/℃ | ① |
| Ripple Rejection Rate | PSRR | $V_{IN}=\{V_{OUT(T)}+1.0\}V_{DC}+0.5Vp\text{-}p_{AC}$ | - | 60 | - | dB | ③ |
| Limit Current | $I_{LIM}$ | $V_{EN}=V_{GO}=V_{IN}$ | 210 | 300 | - | mA | ① |
| Short Circuit Current | $I_{SHORT}$ | $V_{EN}=V_{GO}=V_{IN}$, | - | 20 | - | mA | ① |
| PS Switching Current | $I_{GOR}$ | $V_{EN}=V_{IN}$, $V_{GO}=V_{SS}$ | 0.25 | 1.5 | - | mA | ① |
| HS Switching Current | $I_{GO}$ | $V_{EN}=V_{IN}$, $V_{GO}=V_{SS}$ | - | 4 | 7.5 | mA | ① |
| Switching Current Hysteresis | $I_{GOhys}$ | $I_{GOhys}=I_{GO}-I_{GOR}$ | - | 2.5 | - | mA | ① |
| PS Switching Delay Time | $t_{DPS}$ | $V_{EN}=V_{IN}$, $V_{GO}=V_{SS}$ | E-3 | | | μs | ① |
| EN High Level Voltage | $V_{ENH}$ | | 1.2 | - | 6 | V | ① |
| EN Low Level Voltage | $V_{ENL}$ | | - | - | 0.3 | V | ① |
| EN High Level Current | $I_{ENH}$ | $V_{EN}=V_{GO}=V_{IN}=6.0V$ | -0.1 | - | 0.1 | μA | ① |
| EN Low Level Current | $I_{ENL}$ | $V_{IN}=6.0V$, $V_{EN}=V_{GO}=V_{SS}$ | -0.1 | - | 0.1 | μA | ① |
| GO High Level Voltage | $V_{GOH}$ | $V_{EN}=V_{IN}$, $I_{OUT}=0mA$ | 1.2 | - | 6 | V | ① |
| GO Low Level Voltage | $V_{GOL}$ | $V_{EN}=V_{IN}$, $I_{OUT}=0mA$ | - | - | 0.3 | V | ① |
| GO High Level Current | $I_{GOH}$ | $V_{EN}=V_{GO}=V_{IN}=6.0V$ | -0.1 | - | 0.1 | μA | ① |
| GO Low Level Current | $I_{GOL}$ | $V_{IN}=6.0V$, $V_{EN}=V_{GO}=V_{SS}$ | -0.1 | - | 0.1 | μA | ① |
| $C_L$ Discharge Resistor (*8) | $R_{DCHG}$ | $V_{IN}=6.0V$, $V_{OUT}=4.0V$, $V_{EN}=V_{SS}$ | - | 550 | - | Ω | ① |

NOTE:
*HS: High Speed Mode, PS: Power Save Mode
*1: Unless otherwise stated, $V_{IN}=V_{OUT(T)}+1.0V$.
*2: $V_{OUT(E)}$= Nominal output voltage (see the voltage chart)
(ie. The output voltage when "$V_{OUT(T)}+1.0V$" is provided at the $V_{IN}$ pin while maintaining a certain $I_{OUT}$ value.
*3 : Characteristics of the effective $V_{OUT(E)}$ by nominal output voltage is shown in the voltage chart.
*4 : $V_{OUT(T)}$ : Nominal output voltage
*5: Vdif={$V_{IN1}$(*7)−$V_{OUT1}$(*6)}
*6: $V_{OUT1}$: A voltage equal to 98% of the $V_{OUT(T)}$ when an amply stabilized $V_{OUT(T)}+1.0V$ is input.
*7: $V_{IN1}$: The input voltage when the $V_{OUT1}$ voltage appears at the $V_{OUT}$ pin during deceasing input voltage gradually.
*8: For XC6416xD/Dx/xH/Hx series only.
XC6416xC/Cx/xG/Gx series discharge with only Rx1 and Rx2 resistors as shown in the BLOCK DIAGRAMS.
*9: When each channel is measured, the other channel is turned off ($V_{EN}=V_{SS}$).

# ■ELECTRICAL CHARACTERISTICS (Continued)

●Output Voltage Table

| NOMINAL OUTPUT VOLTAGE (V) | OUTPUT VOLTAGE 1% IN HS MODE (V) | | OUTPUT VOLTAGE 2% IN PS MODE (V) | | OUTPUT VOLTAGE 3% IN PS MODE (V) | | LOAD REGULATION E-1 (mV) | | DROPOUT VOLTAGE E-2 (mV) | | PS SWITCHING DELEAY TIME E-3 ( $\mu$ s) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OUT(T)}$ | $V_{OUT1(E)}$ | | $V_{OUT1(E)}$ | | $V_{OUT2(E)}$ | | $\Delta V_{OUT}$ | | $V_{dif}$ | | $t_{DPS}$ | |
| | MIN. | MAX. | MIN. | MIN. | MIN. | MAX. | TYP. | MAX. | TYP. | MAX. | TYP. | MAX. |
| 0.80 | 0.7800 | 0.8200 | 0.7700 | 0.8300 | 0.7400 | 0.8600 | 10 | 30 | 500 | 850 | 250 | 850 |
| 0.85 | 0.8300 | 0.8700 | 0.8200 | 0.8800 | 0.7900 | 0.9100 | 10 | 30 | 500 | 850 | 250 | 850 |
| 0.90 | 0.8800 | 0.9200 | 0.8700 | 0.9300 | 0.8400 | 0.9600 | 10 | 30 | 410 | 750 | 250 | 850 |
| 0.95 | 0.9300 | 0.9700 | 0.9200 | 0.9800 | 0.8900 | 1.0100 | 10 | 30 | 410 | 750 | 250 | 850 |
| 1.00 | 0.9800 | 1.0200 | 0.9700 | 1.0300 | 0.9400 | 1.0600 | 10 | 30 | 360 | 600 | 250 | 850 |
| 1.05 | 1.0300 | 1.0700 | 1.0200 | 1.0800 | 0.9900 | 1.1100 | 10 | 30 | 360 | 600 | 250 | 850 |
| 1.10 | 1.0800 | 1.1200 | 1.0700 | 1.1300 | 1.0400 | 1.1600 | 10 | 30 | 330 | 500 | 250 | 850 |
| 1.15 | 1.1300 | 1.1700 | 1.1200 | 1.1800 | 1.0900 | 1.2100 | 10 | 30 | 330 | 500 | 250 | 850 |
| 1.20 | 1.1800 | 1.2200 | 1.1700 | 1.2300 | 1.1400 | 1.2600 | 10 | 30 | 280 | 420 | 250 | 850 |
| 1.25 | 1.2300 | 1.2700 | 1.2200 | 1.2800 | 1.1900 | 1.3100 | 10 | 30 | 280 | 420 | 250 | 850 |
| 1.30 | 1.2800 | 1.3200 | 1.2700 | 1.3300 | 1.2400 | 1.3600 | 10 | 30 | 240 | 360 | 250 | 850 |
| 1.35 | 1.3300 | 1.3700 | 1.3200 | 1.3800 | 1.2900 | 1.4100 | 10 | 30 | 240 | 360 | 250 | 850 |
| 1.40 | 1.3800 | 1.4200 | 1.3700 | 1.4300 | 1.3400 | 1.4600 | 10 | 30 | 200 | 300 | 250 | 850 |
| 1.45 | 1.4300 | 1.4700 | 1.4200 | 1.4800 | 1.3900 | 1.5100 | 10 | 30 | 200 | 300 | 250 | 850 |
| 1.50 | 1.4800 | 1.5200 | 1.4700 | 1.5300 | 1.4400 | 1.5600 | 10 | 30 | 180 | 260 | 250 | 850 |
| 1.55 | 1.5300 | 1.5700 | 1.5190 | 1.5810 | 1.4900 | 1.6100 | 10 | 30 | 180 | 260 | 250 | 850 |
| 1.60 | 1.5800 | 1.6200 | 1.5680 | 1.6320 | 1.5400 | 1.6600 | 10 | 30 | 170 | 240 | 250 | 850 |
| 1.65 | 1.6300 | 1.6700 | 1.6170 | 1.6830 | 1.5900 | 1.7100 | 10 | 30 | 170 | 240 | 250 | 850 |
| 1.70 | 1.6800 | 1.7200 | 1.6660 | 1.7340 | 1.6400 | 1.7600 | 10 | 30 | 170 | 240 | 250 | 850 |
| 1.75 | 1.7300 | 1.7700 | 1.7150 | 1.7850 | 1.6900 | 1.8100 | 10 | 30 | 170 | 240 | 250 | 850 |
| 1.80 | 1.7800 | 1.8200 | 1.7640 | 1.8360 | 1.7400 | 1.8600 | 10 | 30 | 150 | 200 | 250 | 850 |
| 1.85 | 1.8300 | 1.8700 | 1.8130 | 1.8870 | 1.7900 | 1.9100 | 10 | 30 | 150 | 200 | 250 | 850 |
| 1.90 | 1.8800 | 1.9200 | 1.8620 | 1.9380 | 1.8400 | 1.9600 | 10 | 30 | 150 | 200 | 250 | 850 |
| 1.95 | 1.9300 | 1.9700 | 1.9110 | 1.9890 | 1.8900 | 2.0100 | 10 | 30 | 150 | 200 | 250 | 850 |
| 2.00 | 1.9800 | 2.0200 | 1.9600 | 2.0400 | 1.9400 | 2.0600 | 20 | 50 | 150 | 200 | 400 | 1500 |
| 2.05 | 2.0295 | 2.0705 | 2.0090 | 2.0910 | 1.9885 | 2.1115 | 20 | 50 | 150 | 200 | 400 | 1500 |
| 2.10 | 2.0790 | 2.1210 | 2.0580 | 2.1420 | 2.0370 | 2.1630 | 20 | 50 | 150 | 200 | 400 | 1500 |
| 2.15 | 2.1285 | 2.1715 | 2.1070 | 2.1930 | 2.0855 | 2.2145 | 20 | 50 | 150 | 200 | 400 | 1500 |
| 2.20 | 2.1780 | 2.2220 | 2.1560 | 2.2440 | 2.1340 | 2.2660 | 20 | 50 | 120 | 180 | 400 | 1500 |
| 2.25 | 2.2275 | 2.2725 | 2.2050 | 2.2950 | 2.1825 | 2.3175 | 20 | 50 | 120 | 180 | 400 | 1500 |
| 2.30 | 2.2770 | 2.3230 | 2.2540 | 2.3460 | 2.2310 | 2.3690 | 20 | 50 | 120 | 180 | 400 | 1500 |
| 2.35 | 2.3265 | 2.3735 | 2.3030 | 2.3970 | 2.2795 | 2.4205 | 20 | 50 | 120 | 180 | 400 | 1500 |
| 2.40 | 2.3760 | 2.4240 | 2.3520 | 2.4480 | 2.3280 | 2.4720 | 20 | 50 | 120 | 180 | 400 | 1500 |
| 2.45 | 2.4255 | 2.4745 | 2.4010 | 2.4990 | 2.3765 | 2.5235 | 20 | 50 | 120 | 180 | 400 | 1500 |
| 2.50 | 2.4750 | 2.5250 | 2.4500 | 2.5500 | 2.4250 | 2.5750 | 20 | 50 | 110 | 180 | 400 | 1500 |
| 2.55 | 2.5245 | 2.5755 | 2.4990 | 2.6010 | 2.4735 | 2.6265 | 20 | 50 | 110 | 180 | 400 | 1500 |
| 2.60 | 2.5740 | 2.6260 | 2.5480 | 2.6520 | 2.5220 | 2.6780 | 20 | 50 | 110 | 180 | 400 | 1500 |
| 2.65 | 2.6235 | 2.6765 | 2.5970 | 2.7030 | 2.5705 | 2.7295 | 20 | 50 | 110 | 180 | 400 | 1500 |
| 2.70 | 2.6730 | 2.7270 | 2.6460 | 2.7540 | 2.6190 | 2.7810 | 20 | 50 | 110 | 180 | 400 | 1500 |
| 2.75 | 2.7225 | 2.7775 | 2.6950 | 2.8050 | 2.6675 | 2.8325 | 20 | 50 | 110 | 180 | 400 | 1500 |
| 2.80 | 2.7720 | 2.8280 | 2.7440 | 2.8560 | 2.7160 | 2.8840 | 20 | 50 | 95 | 150 | 400 | 1500 |
| 2.85 | 2.8215 | 2.8785 | 2.7930 | 2.9070 | 2.7645 | 2.9355 | 20 | 50 | 95 | 150 | 400 | 1500 |
| 2.90 | 2.8710 | 2.9290 | 2.8420 | 2.9580 | 2.8130 | 2.9870 | 20 | 50 | 95 | 150 | 400 | 1500 |
| 2.95 | 2.9205 | 2.9795 | 2.8910 | 3.0090 | 2.8615 | 3.0385 | 20 | 50 | 95 | 150 | 400 | 1500 |

## ■ELECTRICAL CHARACTERISTICS (Continued)

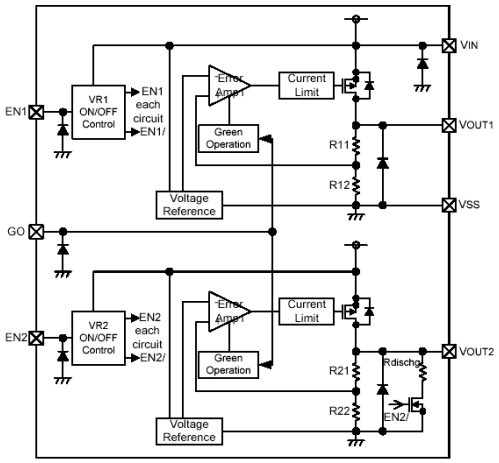
●Output Voltage Table (Continued)

| NOMINAL OUTPUT VOLTAGE (V) | OUTPUT VOLTAGE 1% IN HS MODE (V) | | OUTPUT VOLTAGE 2% IN PS MODE (V) | | OUTPUT VOLTAGE 3% IN PS MODE (V) | | LOAD REGULATION E-1 (mV) | | DROPOUT VOLTAGE E-2 (mV) | | PS SWITCHING DELEAY TIME E-3 ( $\mu$ s) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OUT}$(T) | $V_{OUT1(E)}$ | | $V_{OUT1(E)}$ | | $V_{OUT2(E)}$ | | $\Delta V_{OUT}$ | | $V_{dif}$ | | $t_{DPS}$ | |
| | MIN. | MAX. | MIN. | MIN. | MIN. | MAX. | MIN. | MAX. | MIN. | MIN. | MIN. | MAX. |
| 3.00 | 2.9700 | 3.0300 | 2.9400 | 3.0600 | 2.9100 | 3.0900 | 20 | 50 | 95 | 150 | 400 | 1500 |
| 3.05 | 3.0195 | 3.0805 | 2.9890 | 3.1110 | 2.9585 | 3.1415 | 20 | 50 | 95 | 150 | 400 | 1500 |
| 3.10 | 3.0690 | 3.1310 | 3.0380 | 3.1620 | 3.0070 | 3.1930 | 20 | 50 | 95 | 150 | 400 | 1500 |
| 3.15 | 3.1185 | 3.1815 | 3.0870 | 3.2130 | 3.0555 | 3.2445 | 20 | 50 | 95 | 150 | 400 | 1500 |
| 3.20 | 3.1680 | 3.2320 | 3.1360 | 3.2640 | 3.1040 | 3.2960 | 20 | 50 | 95 | 150 | 400 | 1500 |
| 3.25 | 3.2175 | 3.2825 | 3.1850 | 3.3150 | 3.1525 | 3.3475 | 20 | 50 | 95 | 150 | 400 | 1500 |
| 3.30 | 3.2670 | 3.3330 | 3.2340 | 3.3660 | 3.2010 | 3.3990 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.35 | 3.3165 | 3.3835 | 3.2830 | 3.4170 | 3.2495 | 3.4505 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.40 | 3.3660 | 3.4340 | 3.3320 | 3.4680 | 3.2980 | 3.5020 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.45 | 3.4155 | 3.4845 | 3.3810 | 3.5190 | 3.3465 | 3.5535 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.50 | 3.4650 | 3.5350 | 3.4300 | 3.5700 | 3.3950 | 3.6050 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.55 | 3.5145 | 3.5855 | 3.4790 | 3.6210 | 3.4435 | 3.6565 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.60 | 3.5640 | 3.6360 | 3.5280 | 3.6720 | 3.4920 | 3.7080 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.65 | 3.6135 | 3.6865 | 3.5770 | 3.7230 | 3.5405 | 3.7595 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.70 | 3.6630 | 3.7370 | 3.6260 | 3.7740 | 3.5890 | 3.8110 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.75 | 3.7125 | 3.7875 | 3.6750 | 3.8250 | 3.6375 | 3.8625 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.80 | 3.7620 | 3.8380 | 3.7240 | 3.8760 | 3.6860 | 3.9140 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.85 | 3.8115 | 3.8885 | 3.7730 | 3.9270 | 3.7345 | 3.9655 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.90 | 3.8610 | 3.9390 | 3.8220 | 3.9780 | 3.7830 | 4.0170 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 3.95 | 3.9105 | 3.9895 | 3.8710 | 4.0290 | 3.8315 | 4.0685 | 20 | 50 | 80 | 150 | 400 | 1500 |
| 4.00 | 3.9600 | 4.0400 | 3.9200 | 4.0800 | 3.8800 | 4.1200 | 30 | 60 | 80 | 120 | 400 | 1500 |

# ■OPERATIONAL DESCRIPTION

<Output Voltage Control>

The voltage divided by resistors Rx1 & Rx2 is compared with the internal reference voltage by the error amplifier. The P-channel MOSFET connected to the VOUT pin is then driven by the subsequent output signal. The output voltage at the VOUT 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 EN pin's signal.




< XC6416CD Series >

<GreenOperation>

XC6416C/D/G/H series can be set as a fixed high-speed (HS) mode or a green operation (GO) mode via a signal to the green operation (GO) pin. The IC operates in the GO mode when the GO pin becomes low level and the IC operates in the fixed high-speed mode when the GO pin becomes high level. The XC6416A/B/E/F series normally operates in GO mode because the GO signal is fixed to the $V_{SS}$ level inside the IC. The GO mode enables the IC to switch automatically the supply current to the high speed (HS) mode and the power save (PS) mode according to the level of output current. While having both high-speed operation and low supply current state, the series can acquire high efficiency. At the HS/PS automatic switching mode (GO mode), the switching point of the HS mode and the PS mode is being fixed inside the IC. When the output current becomes IGOR 1.5mA (TYP.) or below, the mode changes automatically to the PS mode after the delay time of hundreds $\mu$s (TYP.), and it can reduce supply current in light load. Also when the output current becomes IGO 4mA (TYP.) or more, the mode changes automatically to the HS mode and the IC becomes high speed operation.

<Input and Output Capacitor>

The XC6416 needs an output capacitor for phase compensation. The requested capacitance values are described in the table below. The device may go into unstable operation when the output capacitance reduction happens as a result of bias or temperature drift. Please choose a capacitor with less influence from temperature and bias. Also, please place 1.0$\mu$F input capacitor $C_L$ between $V_{IN}$ and $V_{SS}$ pins for stabilizing input supply voltage.

Output Capacitor Table

| OUTPUT VOLTAGE | OUTPUT CAPACITOR |
|---|---|
| 0.8V～2.35V | $C_L \geqq 2.2\mu F$ |
| 2.4V～4.0V | $C_L \geqq 1.0\mu F$ |

## ■OPERATIONAL DESCRIPTION (Continued)

<CL Auto-Discharge Function>

XC6416B/D/F/H series can quickly discharge the electric charge at the output capacitor ($C_L$), when a low signal to the EN pin, which enables a whole IC circuit put into OFF state, is inputted via the N-channel transistor located between the $V_{OUT}$ pin and the $V_{SS}$ pin (cf. BLOCK DIAGRAM). The $C_L$ discharge resistance is set to 550Ω when $V_{IN}$ is 6.0V (TYP.) and $V_{OUT}$ is 4.0V (TYP.). Moreover, 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 time constant of a $C_L$ auto-discharge resistance value [R] and an output capacitor value ($C_L$) as $\tau$ ($\tau$ =C x R), the output voltage after discharge via the N channel transistor is calculated by the following formulas.

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

V : Output voltage after discharge, $V_{OUT(E)}$ : Output voltage, t: Discharge time,
$\tau$ : $C_L$ auto-discharge resistance R × Output capacitor ($C_L$) value C

$C_L$ high-speed discharge function can be set by each regulator.

<Current Limiter, Short-Circuit Protection>

The XC6416 series includes a fold-back circuit, which aid the operations 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 20mA (TYP.) flows.

<EN Pin>

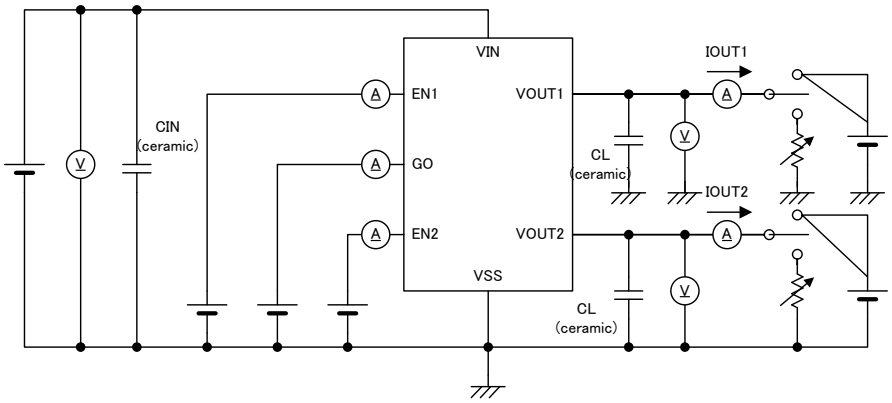
The IC's internal circuitry can be shutdown via the signal from the EN pin with the XC6416 series. In shutdown mode, output at the $V_{OUT}$ pin will be pulled down to the $V_{SS}$ level via Rx1 & Rx2. However, as for the XC6416B/D/F/H series, the $C_L$ auto-discharge resistor is connected in parallel to Rx1 and Rx2 while the power supply is applied to the $V_{IN}$ pin. Therefore, time until the $V_{OUT}$ pin reaches the $V_{SS}$ level becomes short. The output voltage becomes unstable, when the EN pin is open. If this IC is used with the correct output voltage for the EN pin, the logic is fixed and the IC will operate normally. However, supply current may increase as a result of through current in the IC's internal circuitry when medium voltage is input.

## ■NOTES ON USE

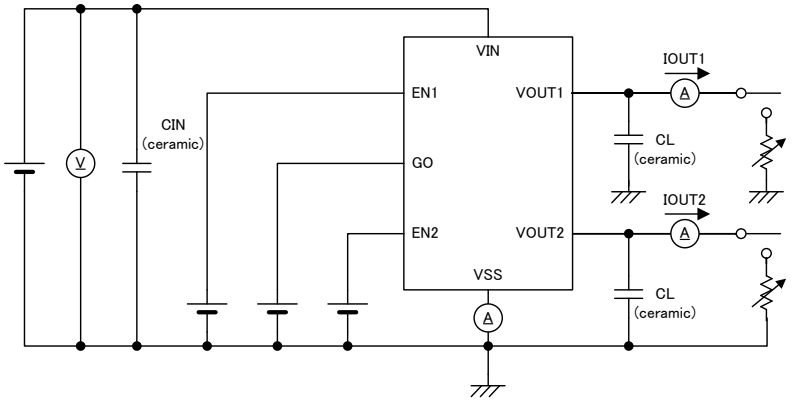
1. Please use this IC within the stated absolute maximum ratings. The IC is liable to malfunction should the ratings be exceeded.
2. Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current. Please wire the input capacitor ($C_{IN}$) and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

# ■TEST CIRCUITS

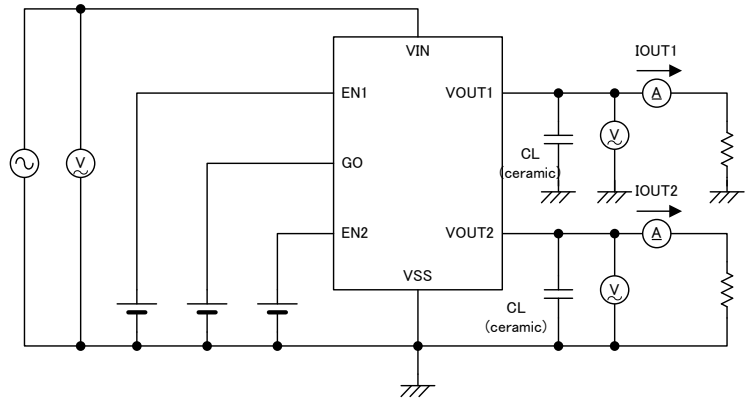
●Circuit ①




●Circuit ②




●Circuit ③



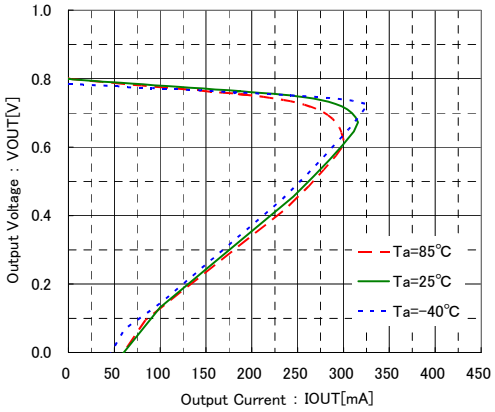

*XC6416Ax/xA/Bx/xB/Ex/xE/Fx/xF do not have GO pin so that the test circuits ①～③ are different from the figures in this page.

# ■TYPICAL PERFORMANCE CHARACTERISTICS

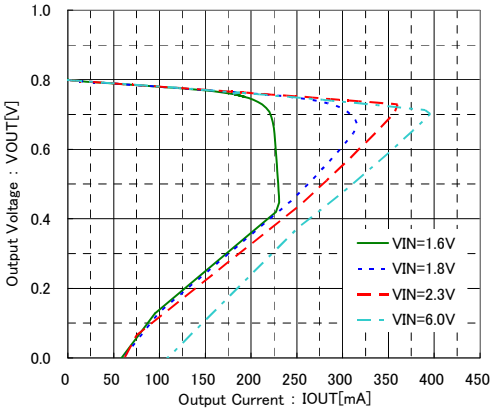
* EN and GO Voltage condition: Unless otherwise stated, $V_{EN}=V_{GO}=V_{IN}$ while the other channel is turned off（$V_{EN}=V_{SS}$）.

(1) Output Voltage vs. Output Current

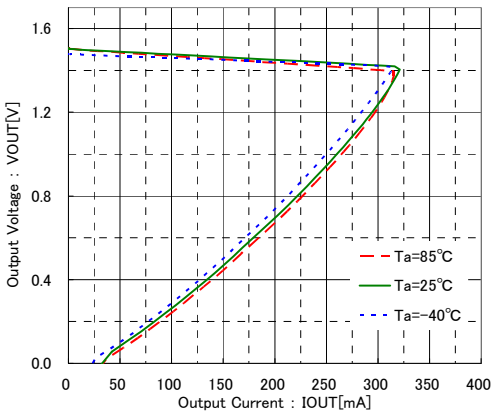
XC6416(VOUT=0.8V)
VIN=1.8V
CIN=1.0μF(ceramic)、CL=2.2μF(ceramic)



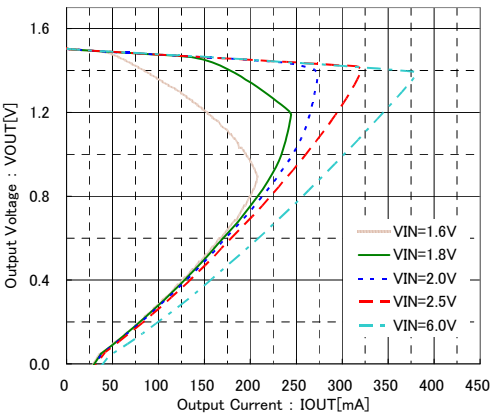

XC6416(VOUT=0.8V)
Ta=25℃
CIN=1.0μF(ceramic)、CL=2.2μF(ceramic)



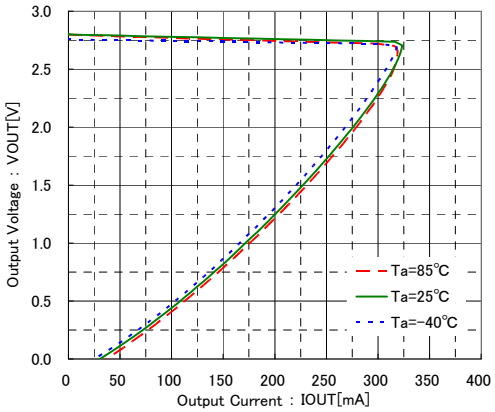

XC6416($V_{OUT}$=1.5V)
$V_{IN}$=2.5V
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)



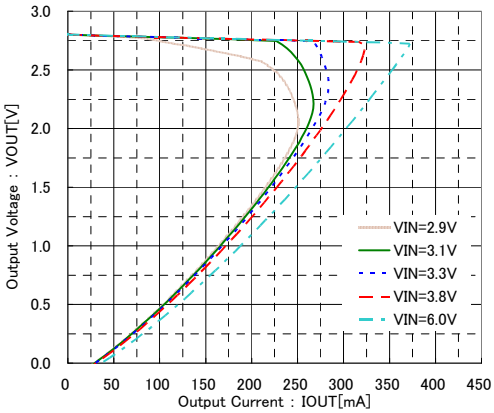

XC6416($V_{OUT}$=1.5V)
Ta=25℃
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)




XC6416($V_{OUT}$=2.8V)
$V_{IN}$=3.8V
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)

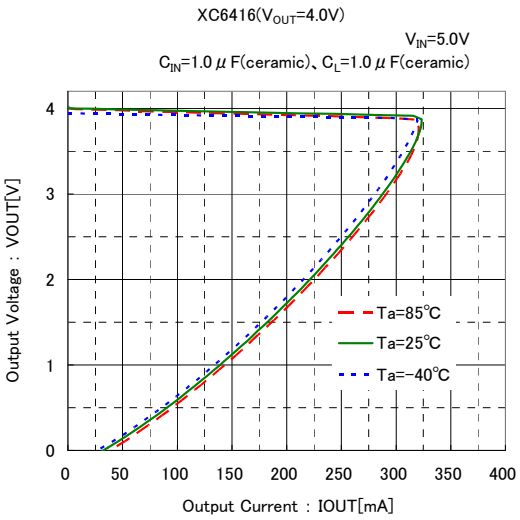


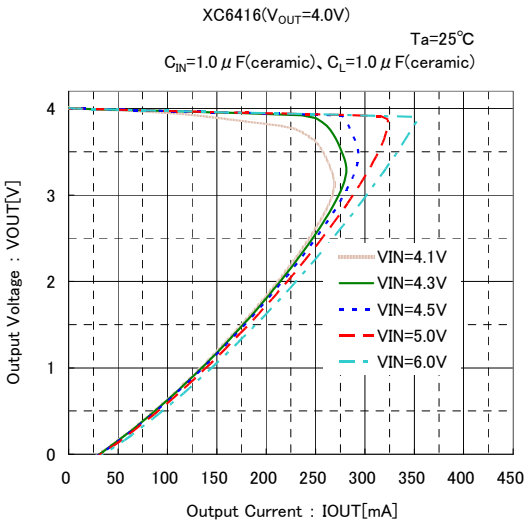

XC6416($V_{OUT}$=2.8V)
Ta=25℃
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)



# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

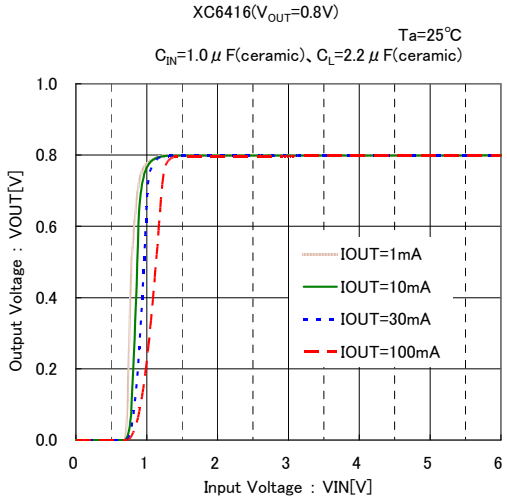
## (1) Output Voltage vs. Output Current (Continued)

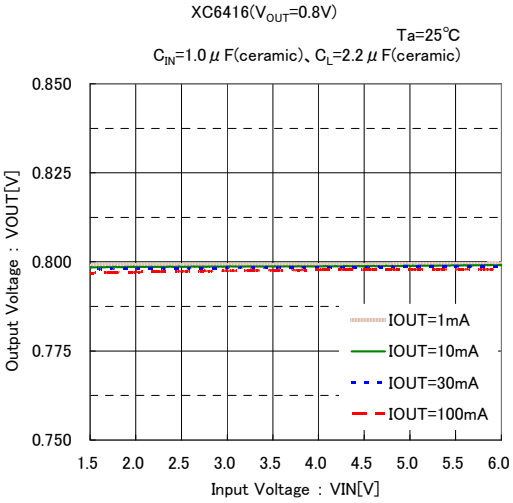


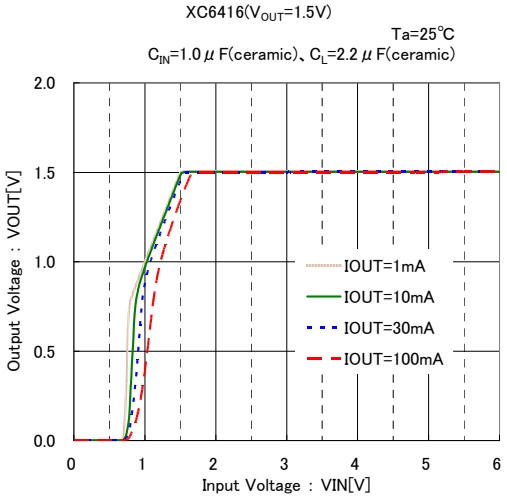



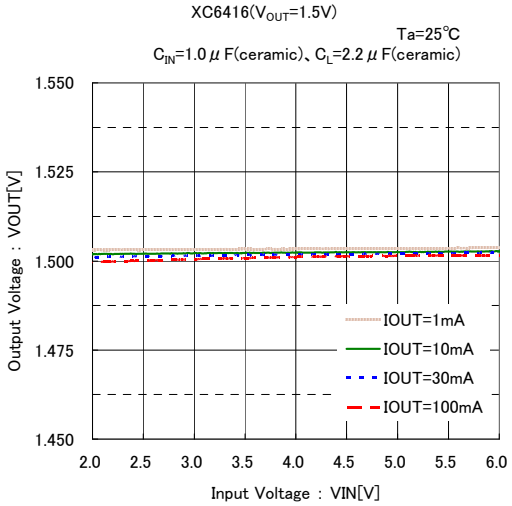

## (2) Output Voltage vs. Input Voltage

■HS mode(VGO=VIN)



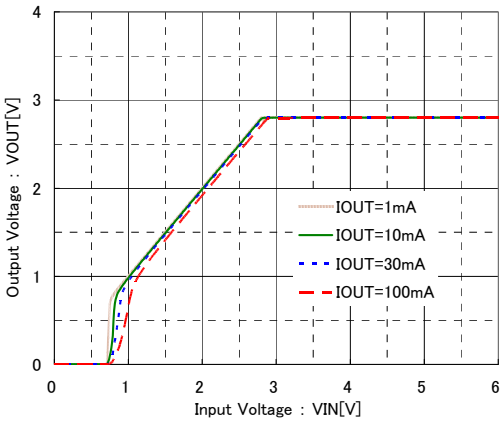



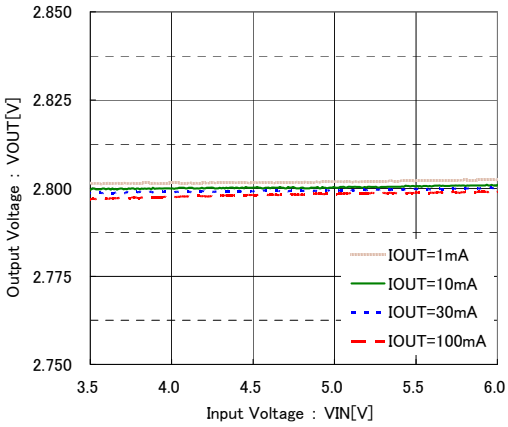
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

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

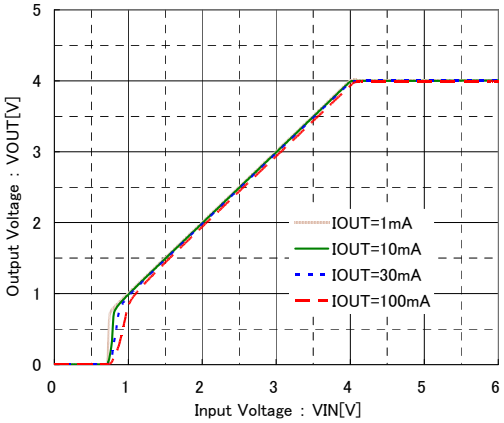
XC6416($V_{OUT}$=2.8V)
Ta=25℃
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)



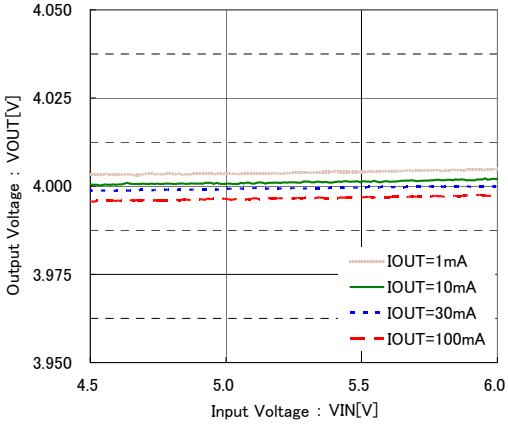

XC6416($V_{OUT}$=2.8V)
Ta=25℃
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)




XC6416($V_{OUT}$=4.0V)
Ta=25℃
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)

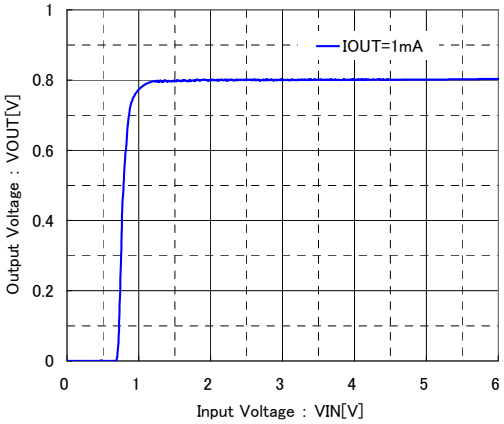



XC6416($V_{OUT}$=4.0V)
Ta=25℃
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)

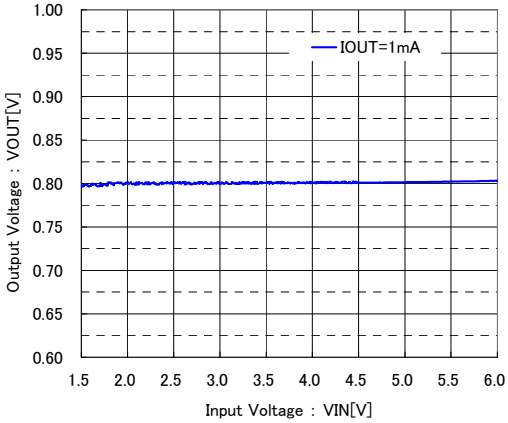



■GreenOperation mode ($V_{GO}$=$V_{SS}$)

XC6416($V_{OUT}$=0.8V)
Ta=25℃
$V_{GO}$=$V_{SS}$
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)



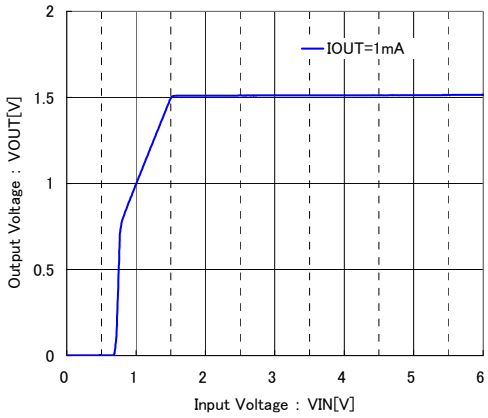

XC6416($V_{OUT}$=0.8V)
Ta=25℃
$V_{GO}$=$V_{SS}$
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)



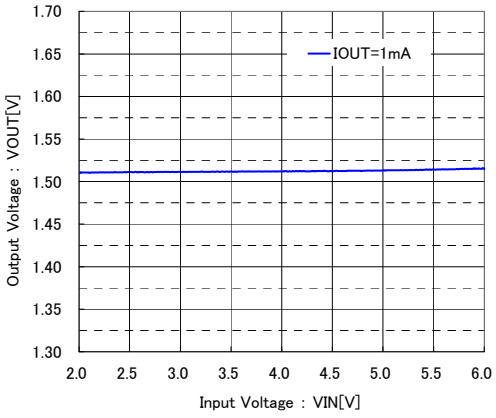
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

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

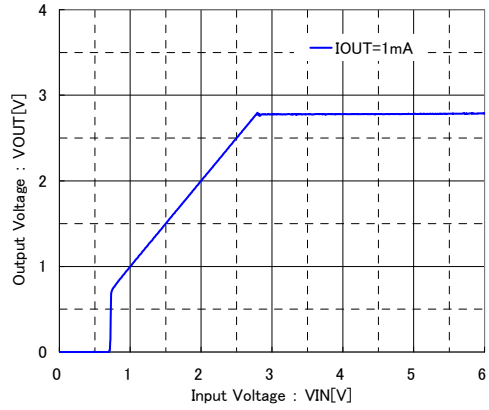
XC6416($V_{OUT}$=1.5V)
Ta=25℃
$V_{GO}$=$V_{SS}$
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)



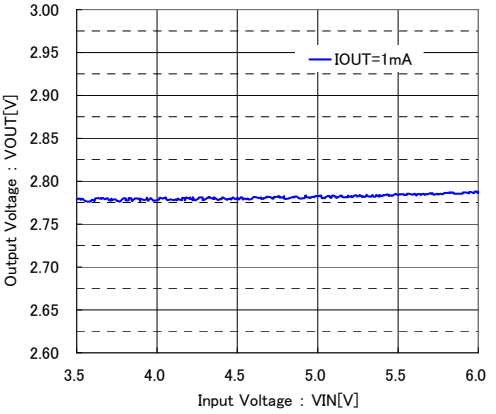

XC6416($V_{OUT}$=1.5V)
Ta=25℃
$V_{GO}$=$V_{SS}$
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)



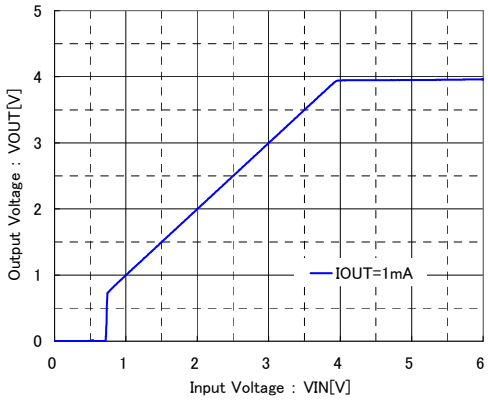

XC6416($V_{OUT}$=2.8V)
Ta=25℃
$V_{GO}$=$V_{SS}$
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)



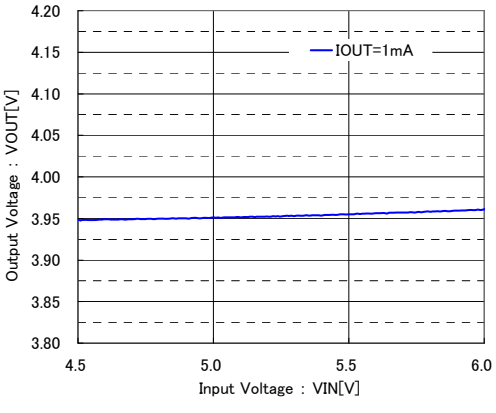

XC6416($V_{OUT}$=2.8V)
Ta=25℃
$V_{GO}$=$V_{SS}$
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)




XC6416($V_{OUT}$=4.0V)
Ta=25℃
$V_{GO}$=$V_{SS}$
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)




XC6416($V_{OUT}$=4.0V)
Ta=25℃
$V_{GO}$=$V_{SS}$
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)

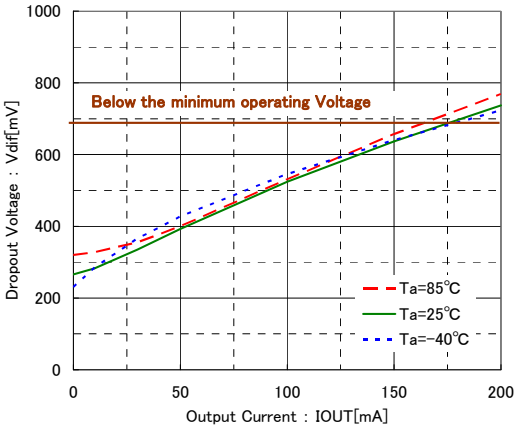


## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(3) Dropout Voltage vs. Output Current

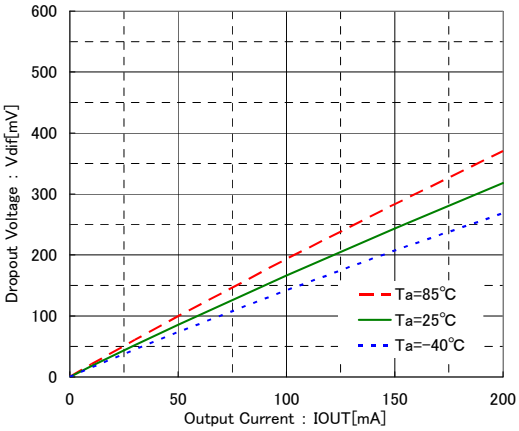
XC6416($V_{OUT}$=0.8V)

$C_{IN}$=1.0μF(ceramic), $C_L$=2.2μF(ceramic)



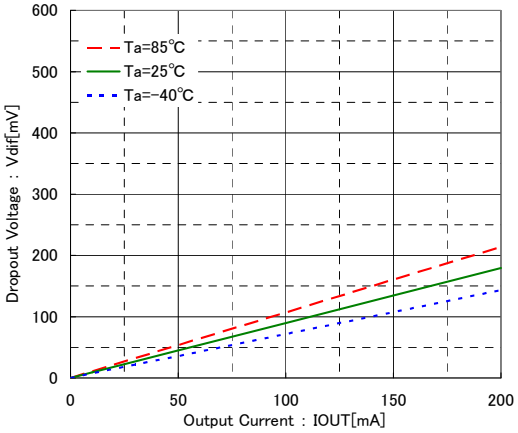

XC6416($V_{OUT}$=1.5V)

$C_{IN}$=1.0μF(ceramic), $C_L$=2.2μF(ceramic)



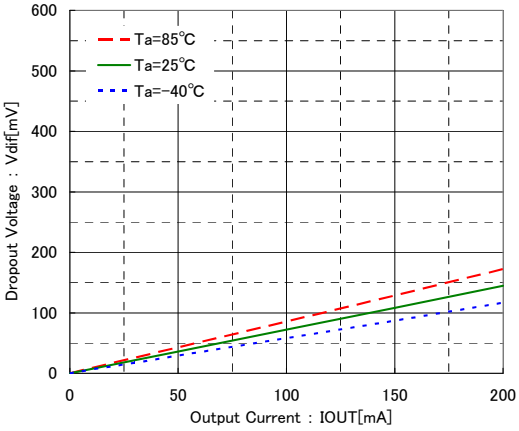

XC6416($V_{OUT}$=2.8V)

$C_{IN}$=1.0μF(ceramic), $C_L$=1.0μF(ceramic)




XC6416($V_{OUT}$=4.0V)

$C_{IN}$=1.0μF(ceramic), $C_L$=1.0μF(ceramic)

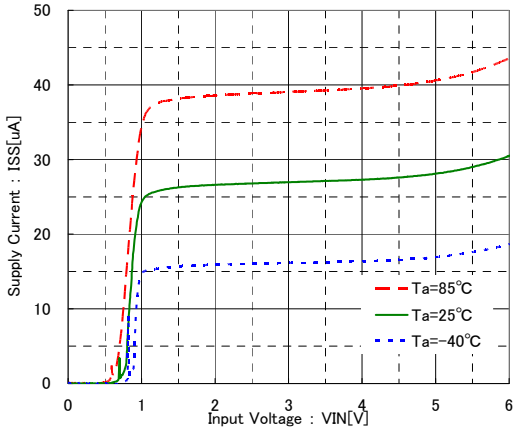



(4) Supply Current vs. Input Voltage

■HS mode ($V_{GO}$=$V_{IN}$)

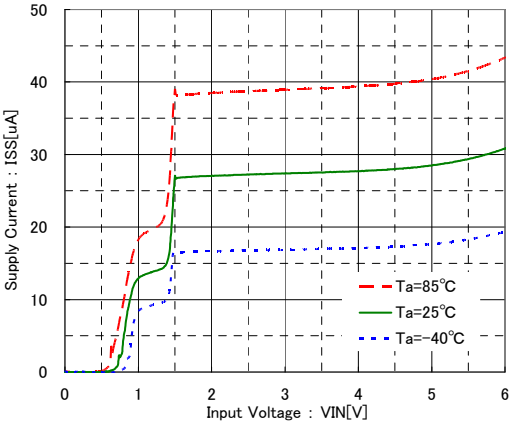
XC6416($V_{OUT}$=0.8V)

$I_{OUT}$=0mA




XC6416($V_{OUT}$=1.5V)

$I_{OUT}$=0mA

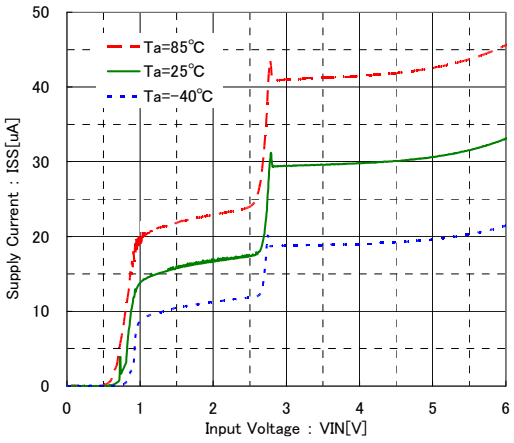


# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(4) Supply Current vs. Input Voltage (Continued)

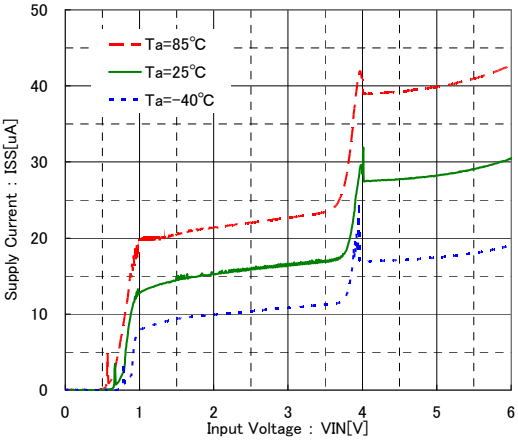
XC6416($V_{OUT}$=2.8V)

$I_{OUT}$=0mA




XC6416($V_{OUT}$=4.0V)

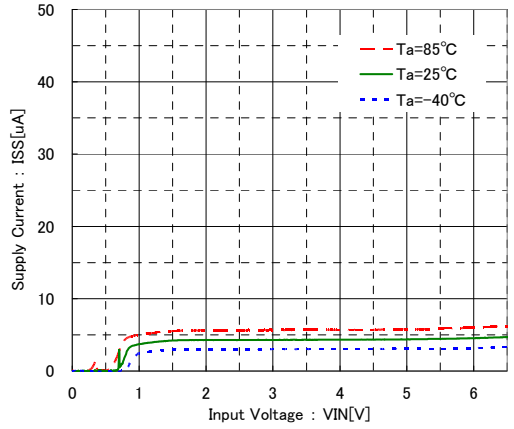
$I_{OUT}$=0mA




■GreenOperation mode ($V_{GO}$=$V_{SS}$)

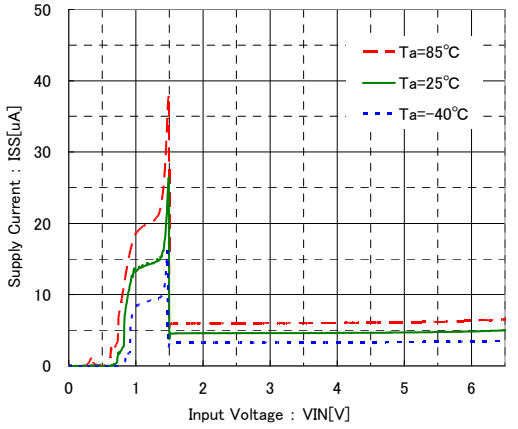
XC6416($V_{OUT}$=0.8V)

$V_{GO}$=$V_{SS}$
$I_{OUT}$=0mA



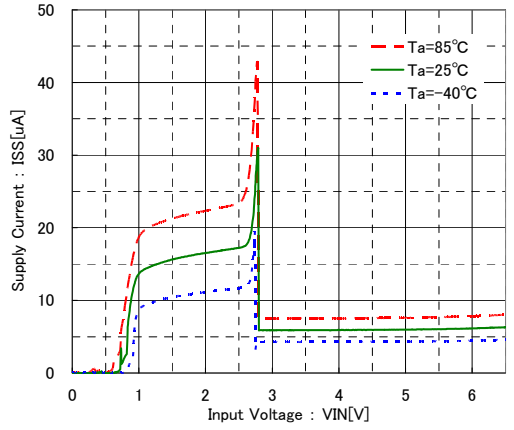

XC6416($V_{OUT}$=1.5V)

$V_{GO}$=$V_{SS}$
$I_{OUT}$=0mA



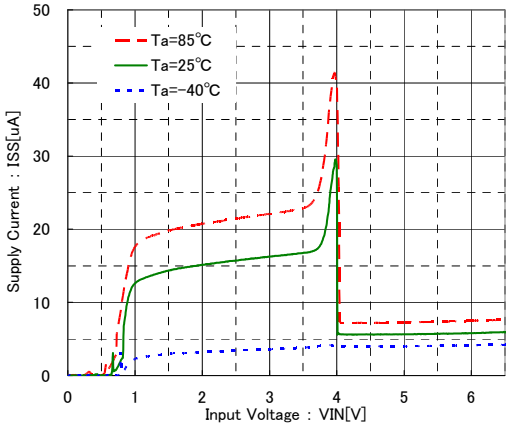

XC6416($V_{OUT}$=2.8V)

$V_{GO}$=$V_{SS}$
$I_{OUT}$=0mA




XC6416($V_{OUT}$=4.0V)

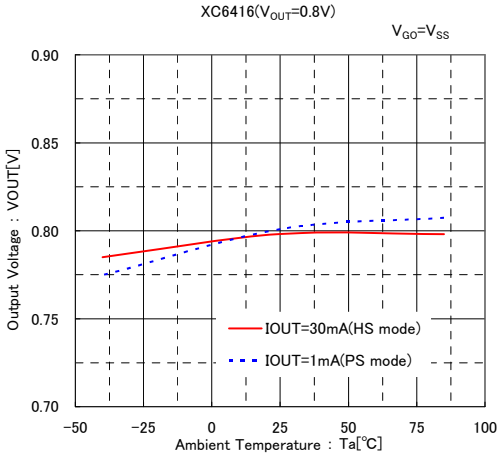
$V_{GO}$=$V_{SS}$
$I_{OUT}$=0mA

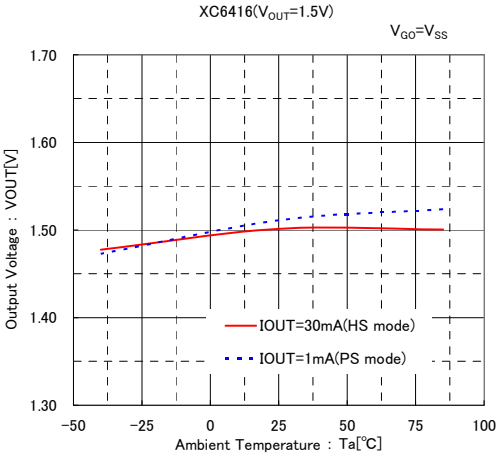


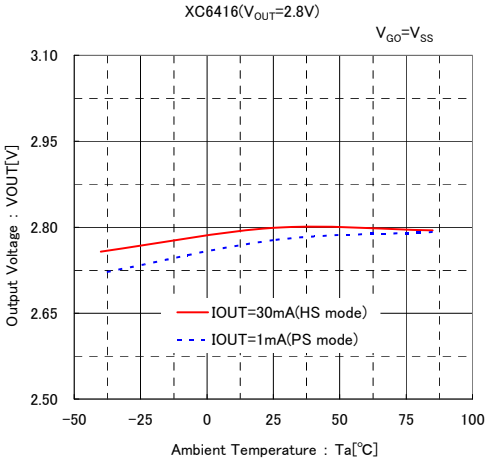
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

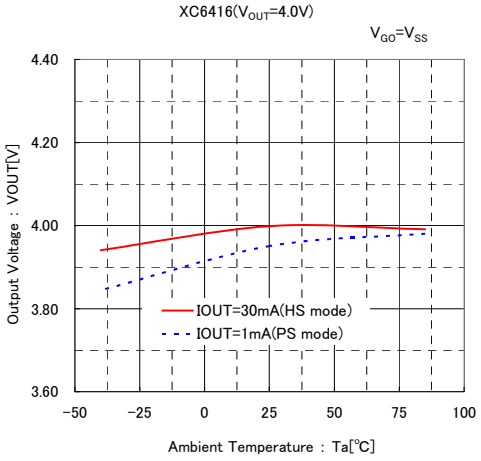
(5) Output Voltage vs. Ambient Temperature

■GreenOperation mode ($V_{GO}$=$V_{SS}$)

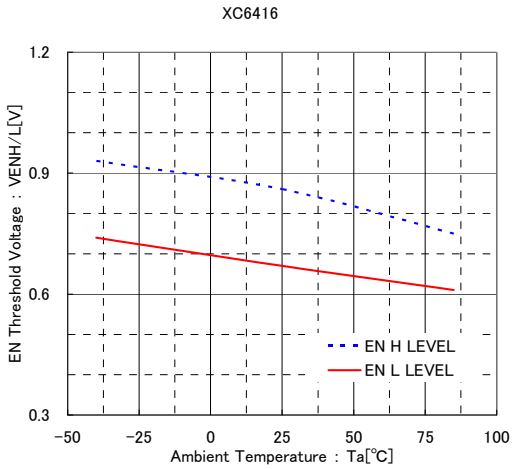


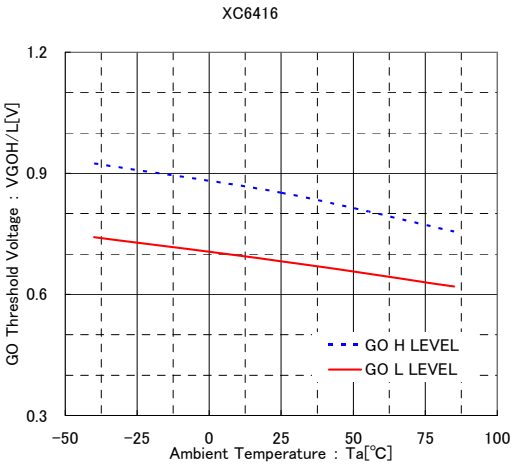




(6) EN Threshold Voltage vs. Ambient Temperature




(7) GO Threshold Voltage vs. Ambient Temperature

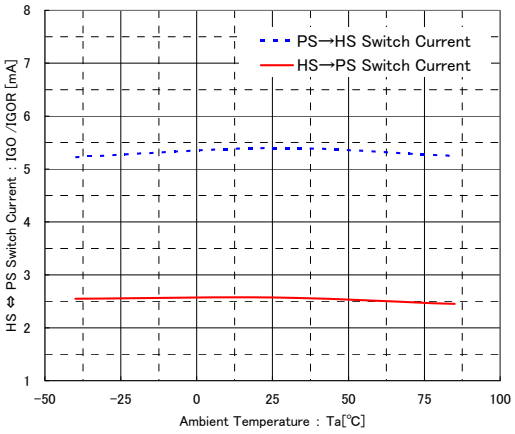


# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

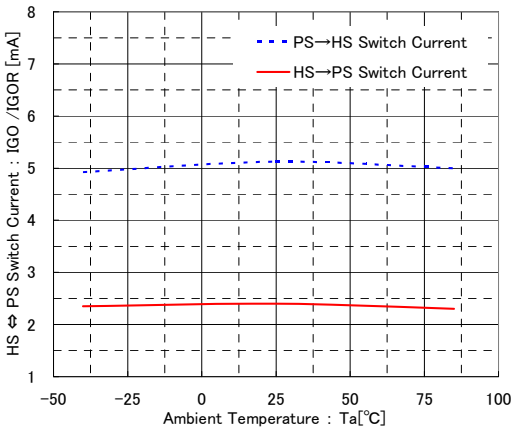
(8) PS/HS Switch Current vs. Ambient Temperature

■GreenOperation mode ($V_{GO}$=$V_{SS}$)

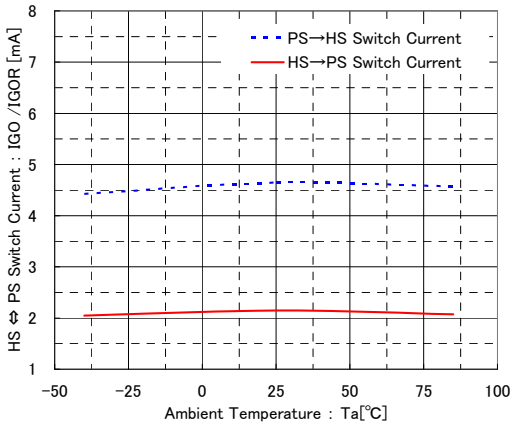
XC6416($V_{OUT}$=0.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=6.0V
$V_{GO}$=$V_{SS}$



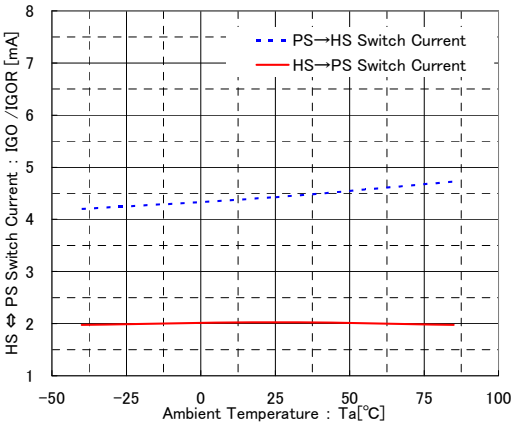

XC6416($V_{OUT}$=1.5V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=6.0V
$V_{GO}$=$V_{SS}$




XC6416($V_{OUT}$=2.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=6.0V
$V_{GO}$=$V_{SS}$




XC6416($V_{OUT}$=4.0V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=6.0V
$V_{GO}$=$V_{SS}$

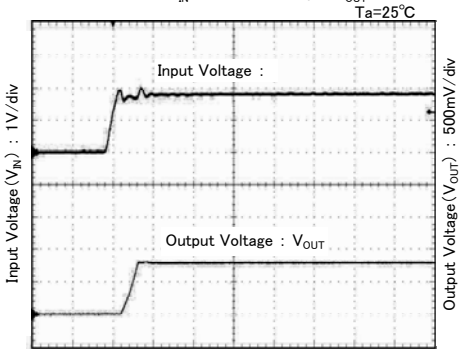


# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) Rising Response Time

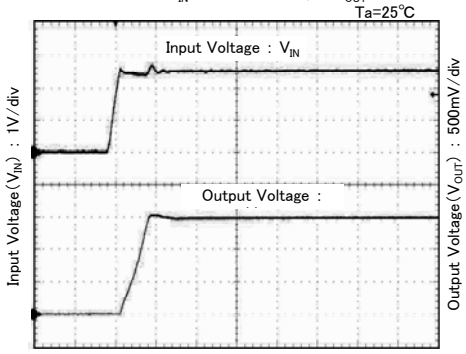
■HS mode ($V_{GO}$=$V_{IN}$)

XC6416($V_{OUT}$=0.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=0V→1.8V、tr=5μs、$I_{OUT}$=30mA
Ta=25℃



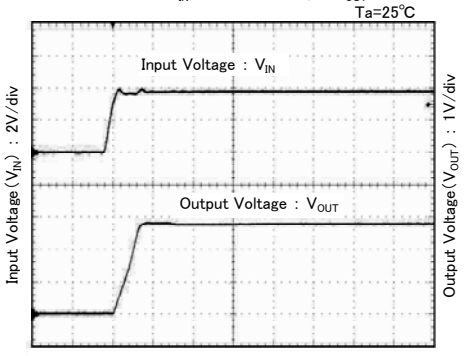

Time : 20μs/div

XC6416($V_{OUT}$=1.5V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=0V→2.5V、tr=5μs、$I_{OUT}$=30mA
Ta=25℃



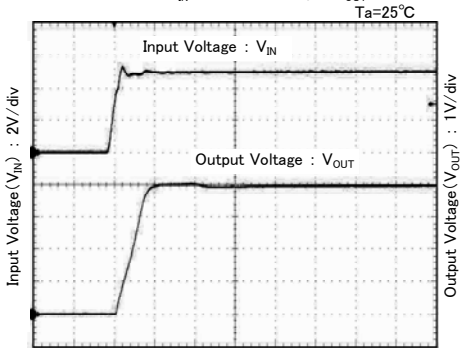

Time : 20μs/div

XC6416($V_{OUT}$=2.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=0V→3.8V、tr=5μs、$I_{OUT}$=30mA
Ta=25℃




Time : 20μs/div

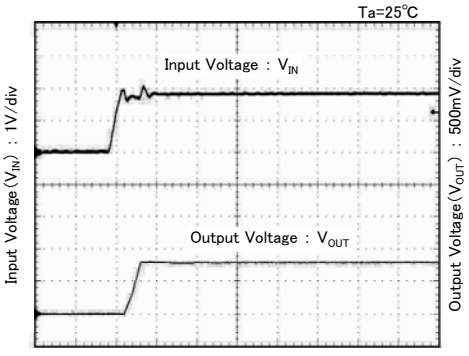
XC6416($V_{OUT}$=4.0V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=0V→5.0V、tr=5μs、$I_{OUT}$=30mA
Ta=25℃




Time : 20μs/div

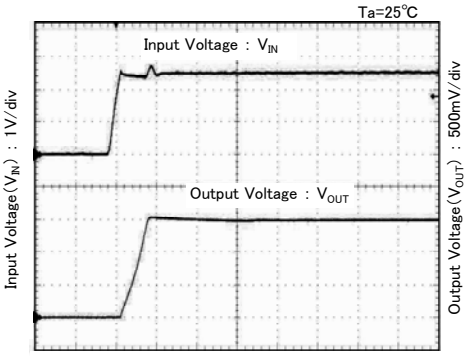
■GreenOperation mode ($V_{GO}$=$V_{SS}$)

XC6416($V_{OUT}$=0.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=0V→1.8V、tr=5μs、$I_{OUT}$=1.0mA
$V_{GO}$=$V_{SS}$
Ta=25℃




Time : 20μs/div

XC6416($V_{OUT}$=1.5V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=0V→2.5V、tr=5μs、$I_{OUT}$=1.0mA
$V_{GO}$=$V_{SS}$
Ta=25℃

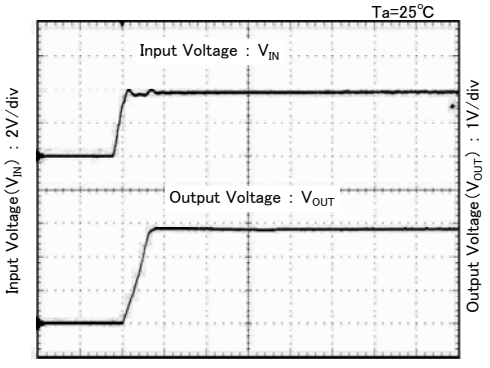



Time : 20μs/div

# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

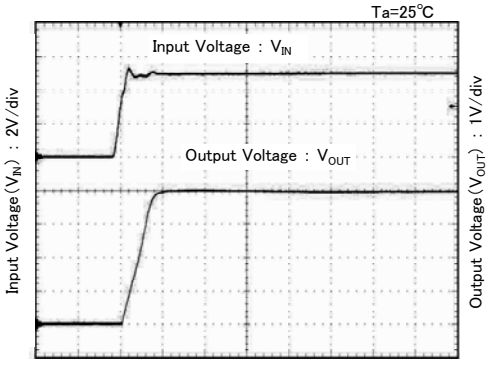
(9) Rising Response Time (Continued)

XC6416($V_{OUT}$=2.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=0V→3.8V、tr=5μs、$I_{OUT}$=1.0mA
$V_{GO}$=$V_{SS}$
Ta=25℃




Time : 20μs/div

XC6416($V_{OUT}$=4.0V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=0V→5.0V、tr=5μs、$I_{OUT}$=1.0mA
$V_{GO}$=$V_{SS}$
Ta=25℃

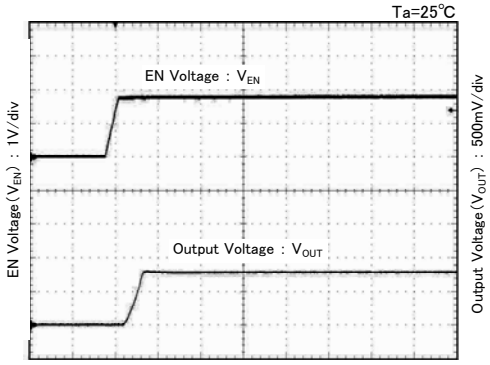



Time : 20μs/div

(10) EN Rising Response Time

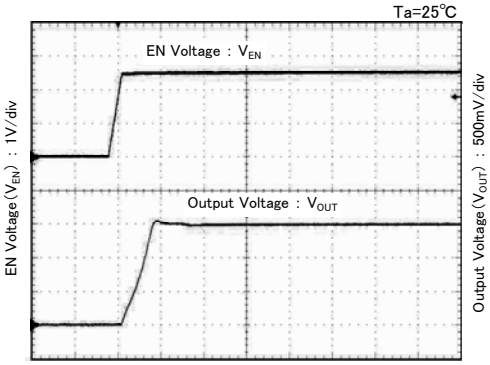
■HS mode ($V_{GO}$=$V_{IN}$)

XC6416($V_{OUT}$=0.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=1.8V、$V_{EN}$=0V→1.8V、tr=5μs
$I_{OUT}$=30mA
Ta=25℃



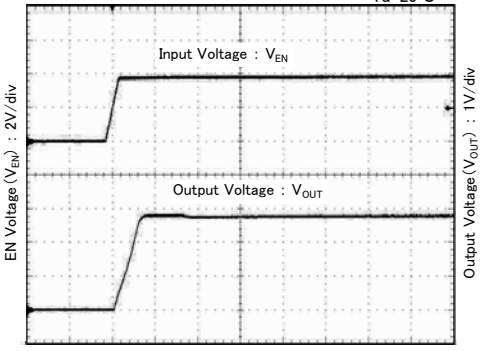

Time : 20μs/div

XC6416($V_{OUT}$=1.5V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=2.5V、$V_{EN}$=0V→2.5V、tr=5μs
$I_{OUT}$=30mA
Ta=25℃



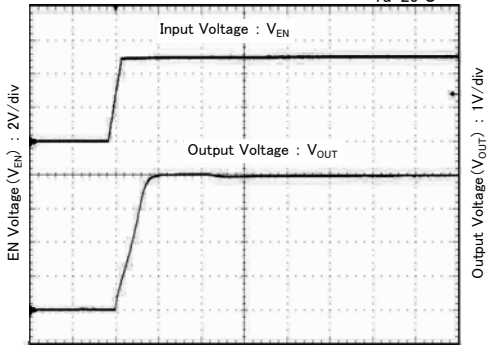

Time : 20μs/div

XC6416($V_{OUT}$=2.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=3.8V、$V_{EN}$=0V→3.8V、tr=5μs
$I_{OUT}$=30mA
Ta=25℃




Time : 20μs/div

XC6416($V_{OUT}$=4.0V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=5.0V、$V_{EN}$=0V→5.0V、tr=5μs
$I_{OUT}$=30mA
Ta=25℃



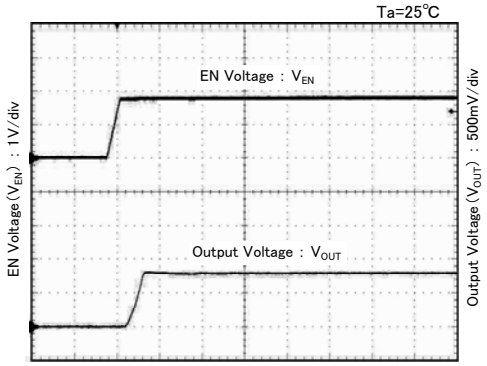

Time : 20μs/div

# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(10) EN Rising Response Time (Continued)

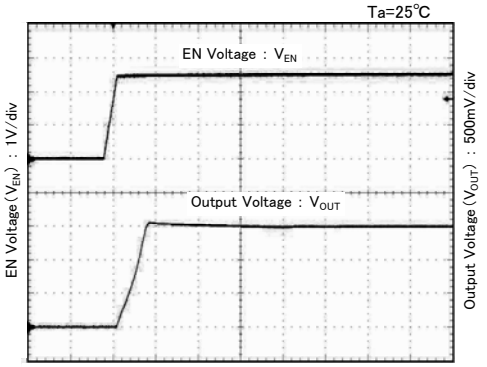
■GreenOperation mode ($V_{GO}$=$V_{SS}$)

XC6416($V_{OUT}$=0.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=1.8V、$V_{EN}$=0V→1.8V、tr=5μs
$I_{OUT}$=1.0mA
$V_{GO}$=$V_{SS}$
Ta=25℃



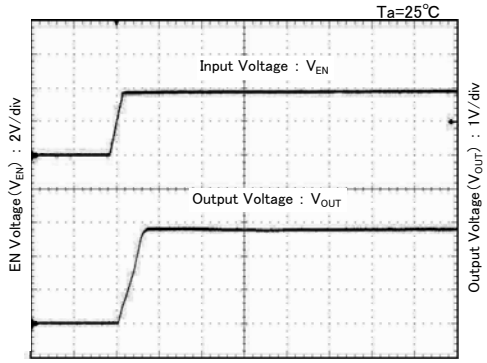

Time : 20μs/div

XC6416($V_{OUT}$=1.5V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{IN}$=2.5V、$V_{EN}$=0V→2.5V、tr=5μs
$I_{OUT}$=1.0mA
$V_{GO}$=$V_{SS}$
Ta=25℃



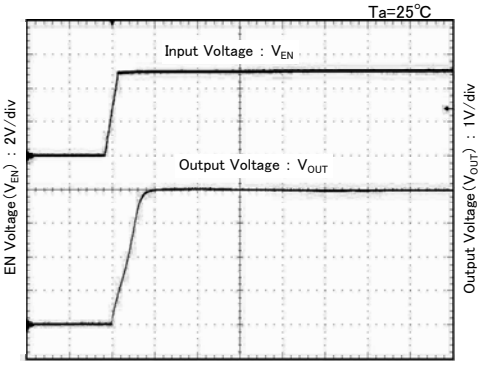

Time : 20μs/div

XC6416($V_{OUT}$=2.8V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=3.8V、$V_{EN}$=0V→3.8V、tr=5μs
$I_{OUT}$=1.0mA
$V_{GO}$=$V_{SS}$
Ta=25℃




Time : 20μs/div

XC6416($V_{OUT}$=4.0V)
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{IN}$=5.0V、$V_{EN}$=0V→5.0V、tr=5μs
$I_{OUT}$=1.0mA
$V_{GO}$=$V_{SS}$
Ta=25℃

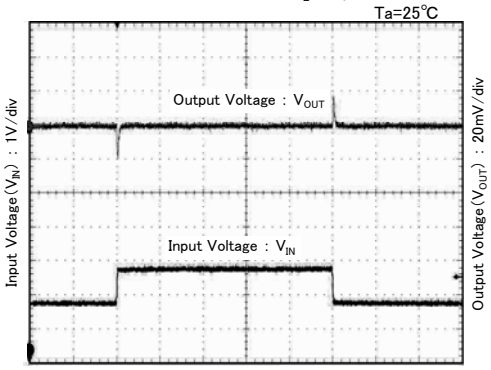



Time : 20μs/div

(11) Input Transient Response

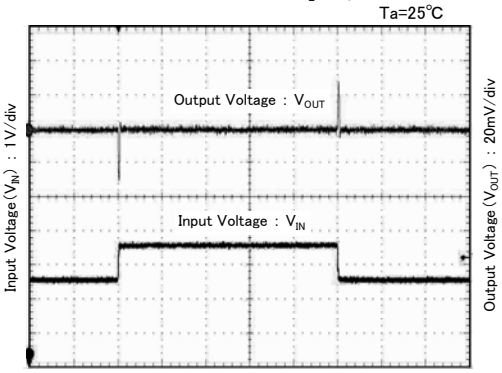
■HS mode ($V_{GO}$=$V_{IN}$)

XC6416($V_{OUT}$=0.8V)
$V_{IN}$=1.8V→2.8V、tr=tf=5μs、$I_{OUT}$=30mA
$C_L$=2.2μF(ceramic)
Ta=25℃




Time : 200μs/div

XC6416($V_{OUT}$=1.5V)
$V_{IN}$=2.5V→3.5V、tr=tf=5μs、$I_{OUT}$=30mA
$C_L$=2.2μF(ceramic)
Ta=25℃

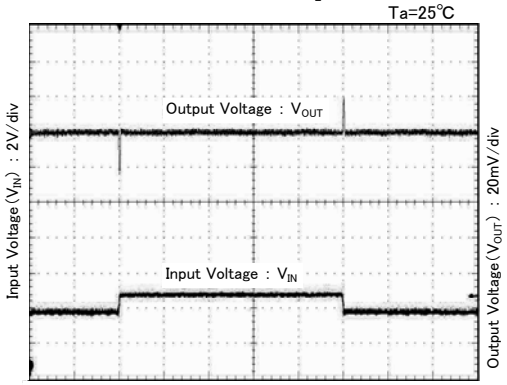



Time : 200μs/div

# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

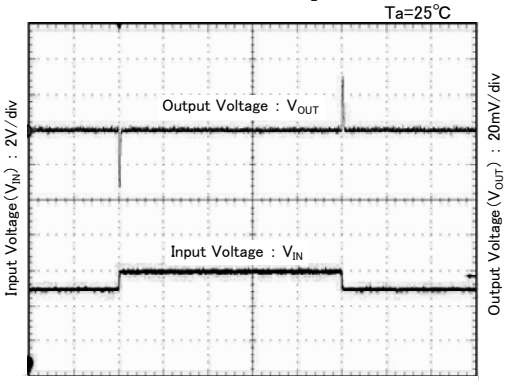
(11) Input Transient Response (Continued)

XC6416($V_{OUT}$=2.8V)
$V_{IN}$=3.8V→4.8V、tr=tf=5μs、$I_{OUT}$=30mA
$C_L$=1.0μF(ceramic)
Ta=25℃




Time : 200μs/div

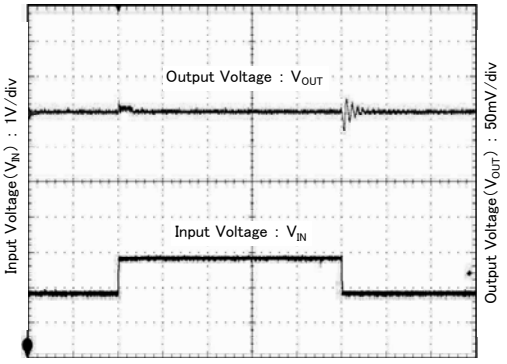
XC6416($V_{OUT}$=4.0V)
$V_{IN}$=5.0V→6.0V、tr=tf=5μs、$I_{OUT}$=30mA
$C_L$=1.0μF(ceramic)
Ta=25℃




Time : 200μs/div

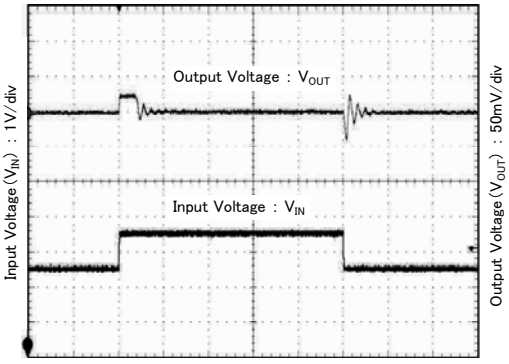
■GreenOperation mode ($V_{GO}$=$V_{SS}$)

XC6416($V_{OUT}$=0.8V)
$V_{IN}$=1.8V→2.8V、tr=tf=5μs、$I_{OUT}$=1.0mA
$C_L$=2.2μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃



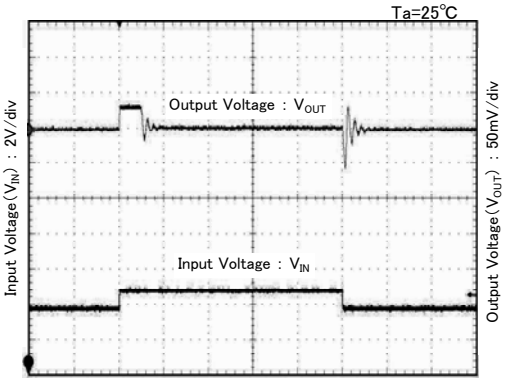

Time: 1ms / div

XC6416($V_{OUT}$=1.5V)
$V_{IN}$=2.5V→3.5V、tr=tf=5μs、$I_{OUT}$=1.0mA
$C_L$=2.2μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃



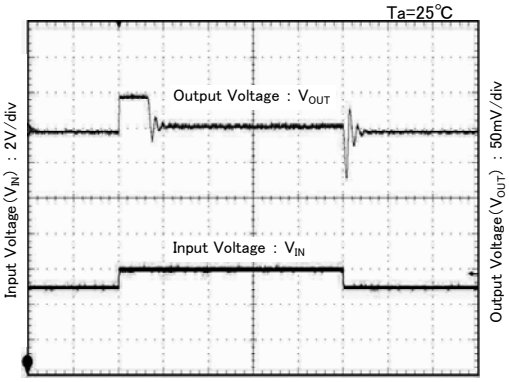

Time: 1ms / div

XC6416($V_{OUT}$=2.8V)
$V_{IN}$=3.8V→4.8V、tr=tf=5μs、$I_{OUT}$=30mA
$C_L$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃




Time: 1ms / div

XC6416($V_{OUT}$=4.0V)
$V_{IN}$=5.0V→6.0V、tr=tf=5μs、$I_{OUT}$=30mA
$C_L$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃



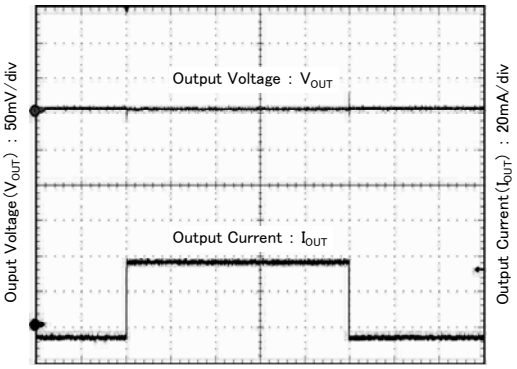

Time: 1ms / div

## ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(12) Load Transient Response

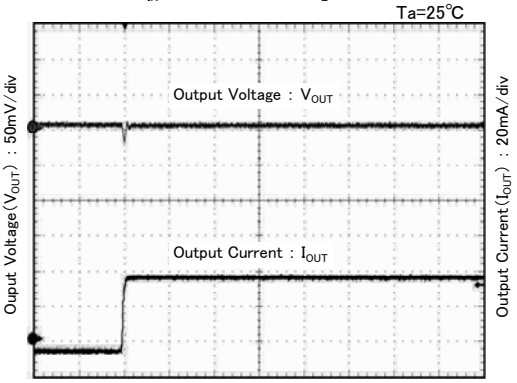
■HS mode ($V_{GO}$=$V_{IN}$)

XC6416($V_{OUT}$=0.8V)
$V_{IN}$=1.8V、$I_{OUT}$=10mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
Ta=25℃



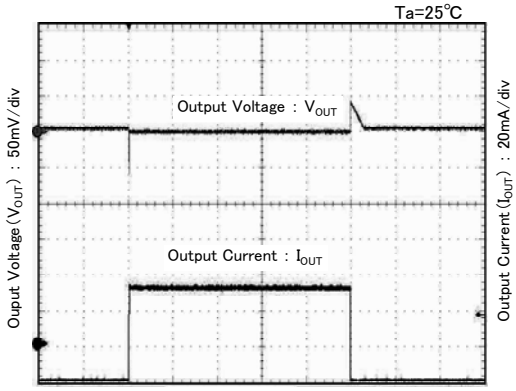

Time : 1ms/div

XC6416($V_{OUT}$=0.8V)
$V_{IN}$=1.8V、$I_{OUT}$=10mA⇔50mA、tr=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
Ta=25℃



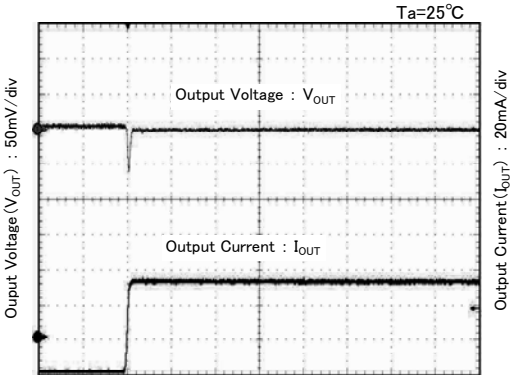

Time : 50μs/div

XC6416($V_{OUT}$=1.5V)
$V_{IN}$=2.5V、$I_{OUT}$=10mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
Ta=25℃



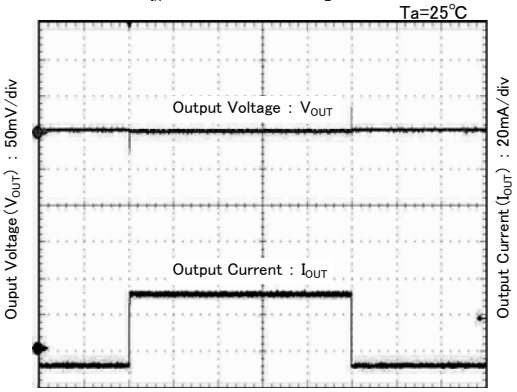

Time : 1ms/div

XC6416($V_{OUT}$=1.5V)
$V_{IN}$=2.5V、$I_{OUT}$=10mA⇔50mA、tr=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
Ta=25℃



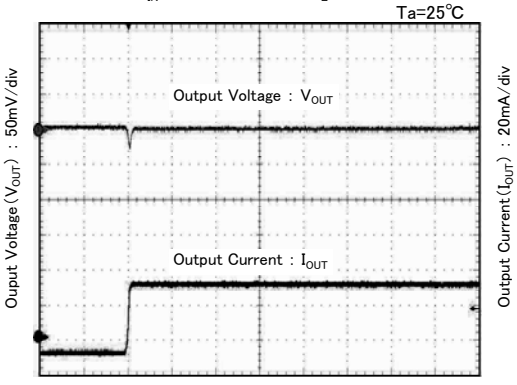

Time : 50μs/div

XC6416($V_{OUT}$=2.8V)
$V_{IN}$=3.8V、$I_{OUT}$=10mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
Ta=25℃




Time : 1ms/div

XC6416($V_{OUT}$=2.8V)
$V_{IN}$=3.8V、$I_{OUT}$=10mA⇔50mA、tr=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
Ta=25℃

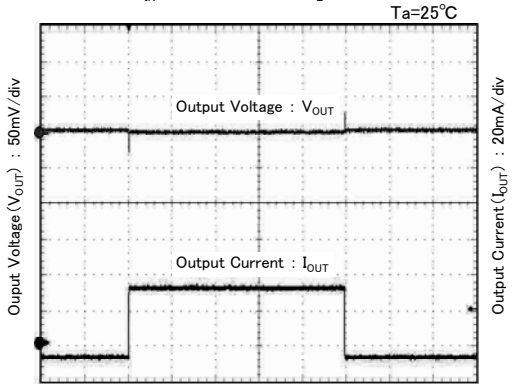



Time : 50μs/div

# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

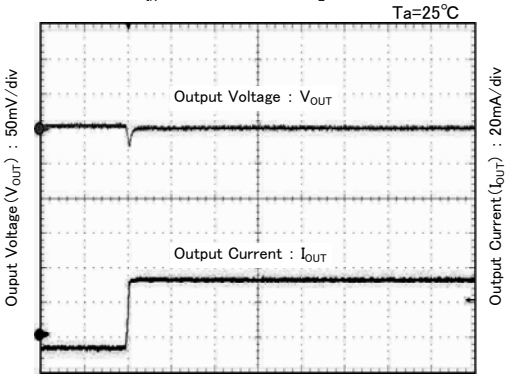
(12) Load Transient Response (Continued)

XC6416($V_{OUT}$=4.0V)
$V_{IN}$=5.0V、$I_{OUT}$=10mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
Ta=25℃




Time : 1ms/div

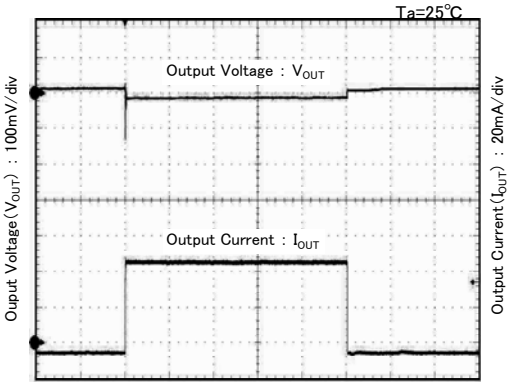
XC6416($V_{OUT}$=4.0V)
$V_{IN}$=5.0V、$I_{OUT}$=10mA⇔50mA、tr=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
Ta=25℃




Time : 50μs/div

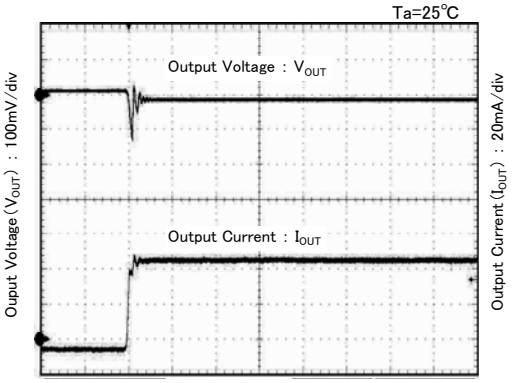
■GO mode($V_{GO}$=$V_{SS}$)

XC6416($V_{OUT}$=0.8V)
$V_{IN}$=1.8V、$I_{OUT}$=0.1mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃



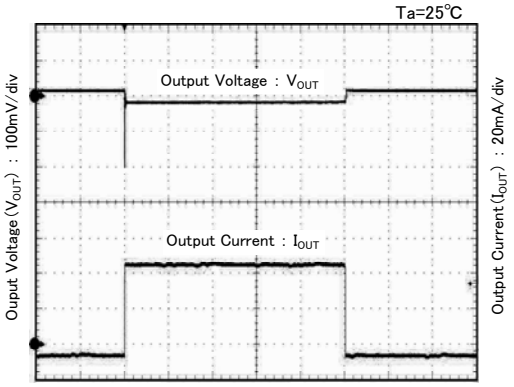

Time : 1ms/div

XC6416($V_{OUT}$=0.8V)
$V_{IN}$=1.8V、$I_{OUT}$=0.1mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃



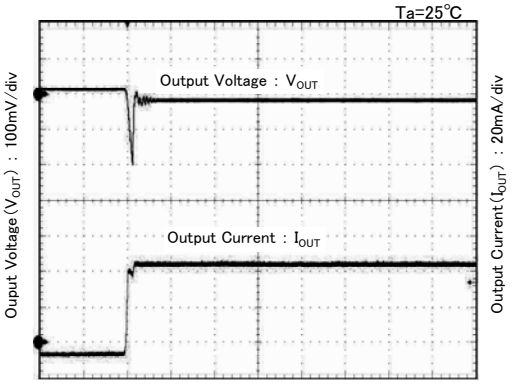

Time : 50μs/div

XC6416($V_{OUT}$=1.5V)
$V_{IN}$=2.5V、$I_{OUT}$=0.1mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃




Time : 1ms/div

XC6416($V_{OUT}$=1.5V)
$V_{IN}$=2.5V、$I_{OUT}$=0.1mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=2.2μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃

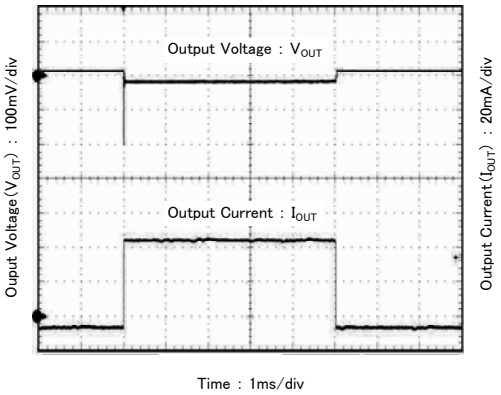



Time : 50μs/div

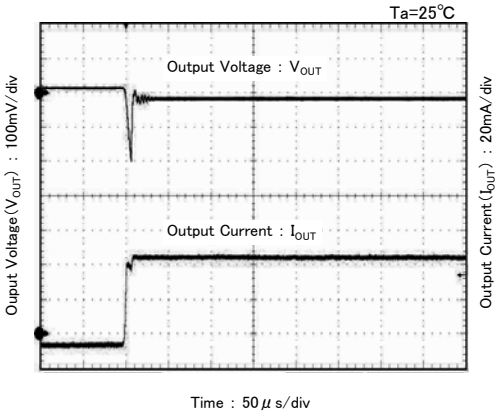
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(12) Load Transient Response (Continued)

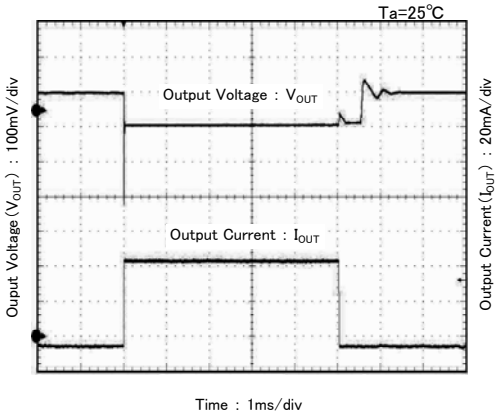
XC6416($V_{OUT}$=2.8V)
$V_{IN}$=3.8V、$I_{OUT}$=0.1mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃



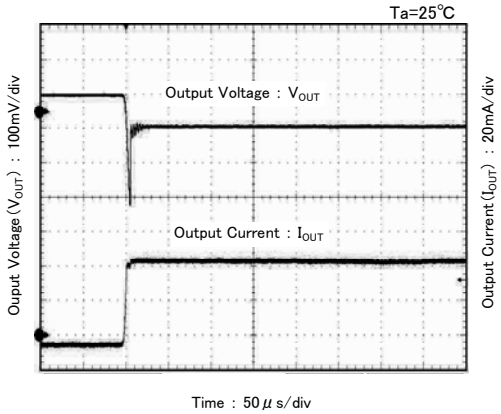

XC6416($V_{OUT}$=2.8V)
$V_{IN}$=3.8V、$I_{OUT}$=0.1mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃




XC6416($V_{OUT}$=4.0V)
$V_{IN}$=5.0V、$I_{OUT}$=0.1mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃

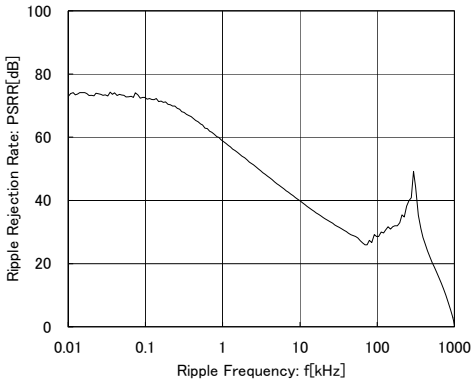



XC6416($V_{OUT}$=4.0V)
$V_{IN}$=5.0V、$I_{OUT}$=0.1mA⇔50mA、tr=tf=5μs
$C_{IN}$=1.0μF(ceramic)、$C_L$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃

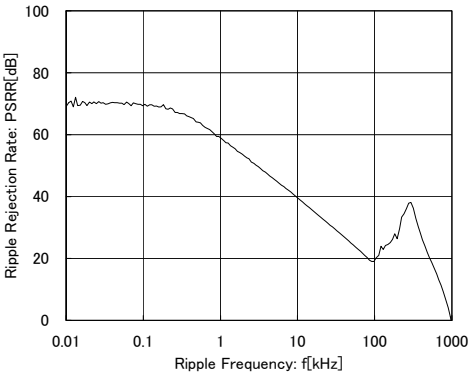



(13) Ripple Rejection Rate

XC6416($V_{OUT}$=0.8V)
$V_{IN}$=1.8V+0.5Vp-p $_{AC}$、$I_{OUT}$=30mA
$C_L$=2.2μF(ceramic)
Ta=25℃



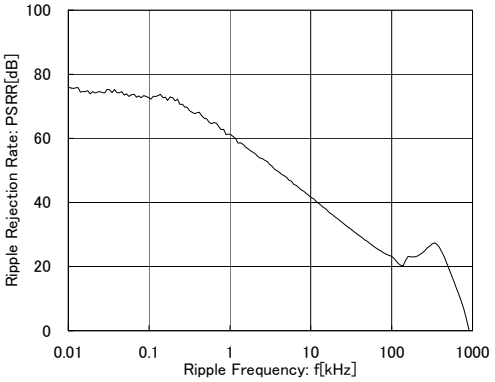

XC6416($V_{OUT}$=1.5V)
$V_{IN}$=2.5V+0.5Vp-p $_{AC}$、$I_{OUT}$=30mA
$C_L$=2.2μF(ceramic)
Ta=25℃



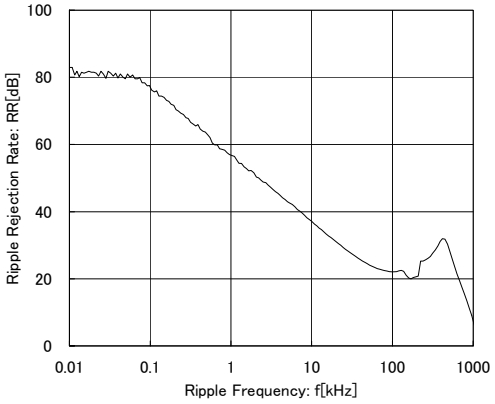
# ■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(13) Ripple Rejection Rate (Continued)

XC6416($V_{OUT}$=2.8V)
$V_{IN}$=3.8V+0.5Vp-p $_{AC}$、$I_{OUT}$=30mA
$C_L$=1.0μF(ceramic)
Ta=25℃

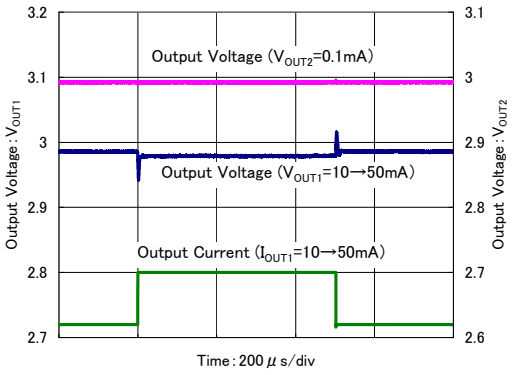



XC6416($V_{OUT}$=4.0V)
$V_{IN}$=5.0V+0.5Vp-p $_{AC}$、$I_{OUT}$=30mA
$C_L$=1.0μF(ceramic)
Ta=25℃

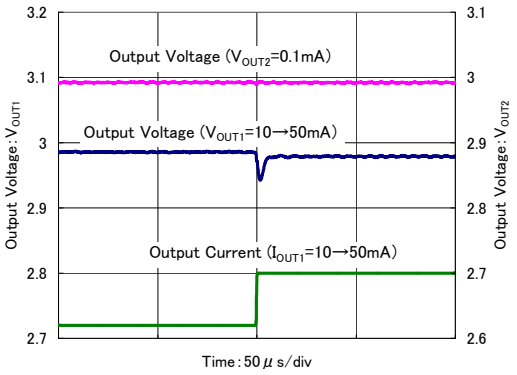



(14) Cross Talk

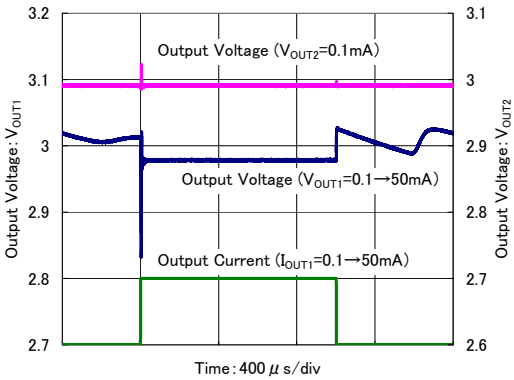
XC6416BB07MR($V_{OUT1}$=3.0V、$V_{OUT2}$=3.0V)
$V_{IN}$=4.0V、$I_{OUT1}$=10mA⇔50mA、tr=tf=5μs
$C_{IN}$=$C_{L1}$=$C_{L2}$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃



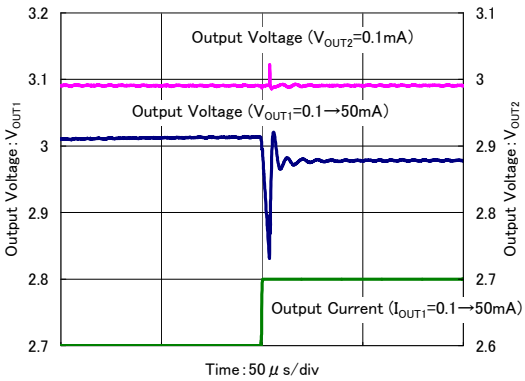

XC6416BB07MR($V_{OUT1}$=3.0V、$V_{OUT2}$=3.0V)
$V_{IN}$=4.0V、$I_{OUT1}$=10mA→50mA、tr=5μs
$C_{IN}$=$C_{L1}$=$C_{L2}$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃




XC6416BB07MR($V_{OUT1}$=3.0V、$V_{OUT2}$=3.0V)
$V_{IN}$=4.0V、$I_{OUT1}$=0.1mA⇔50mA、tr=tf=5μs
$C_{IN}$=$C_{L1}$=$C_{L2}$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃

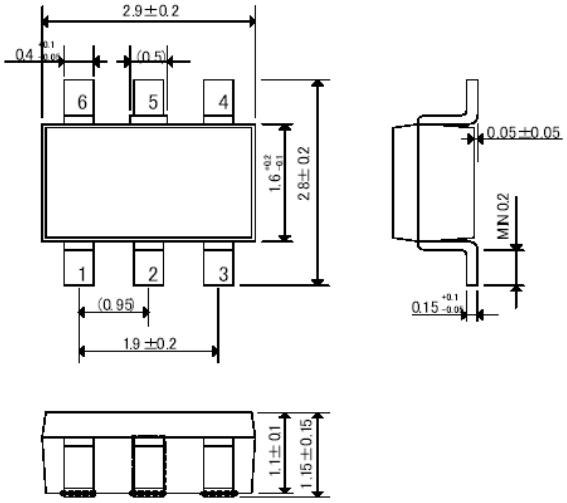



XC6416BB07MR($V_{OUT1}$=3.0V、$V_{OUT2}$=3.0V)
$V_{IN}$=4.0V、$I_{OUT1}$=0.1mA→50mA、tr=5μs
$C_{IN}$=$C_{L1}$=$C_{L2}$=1.0μF(ceramic)
$V_{GO}$=$V_{SS}$
Ta=25℃

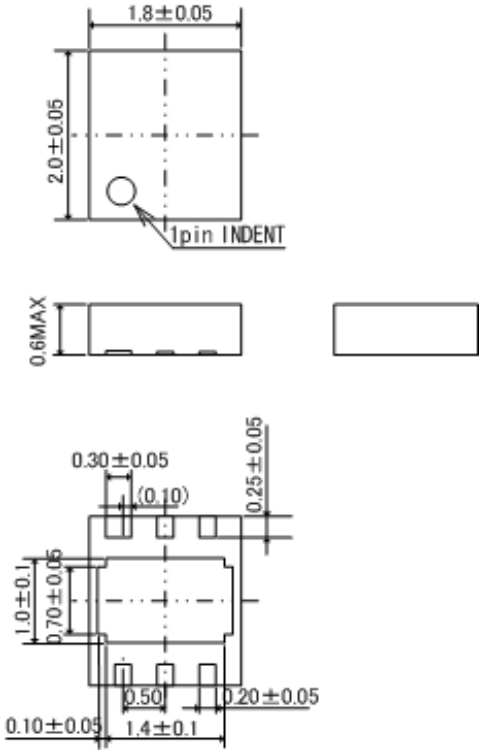


# ■PACKAGING INFORMATION

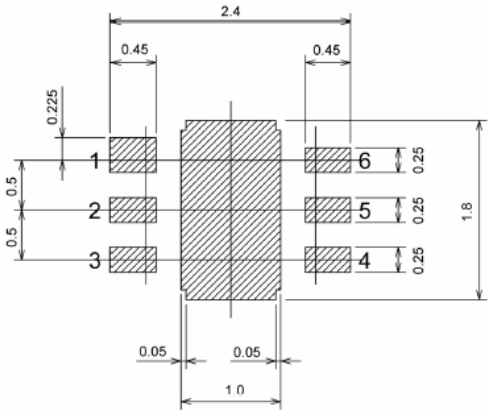
●SOT-26 Unit mm



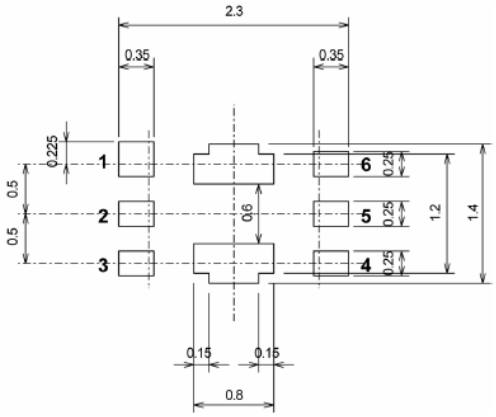

●USP-6C Unit mm




●USP-6C Reference Pattern Layout




●USP-6C Reference Metal Mask Design

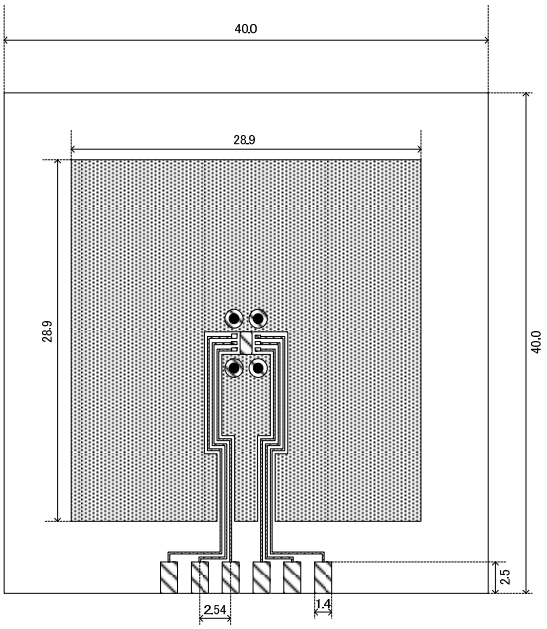


# ■PACKAGING INFORMATION (Continued)

● USP-6C Power Dissipation

Power dissipation data for the USP-6C is shown in this page.
The value of power dissipation varies with the mount board conditions.
Please use this data as one of reference data taken in the described condition.

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

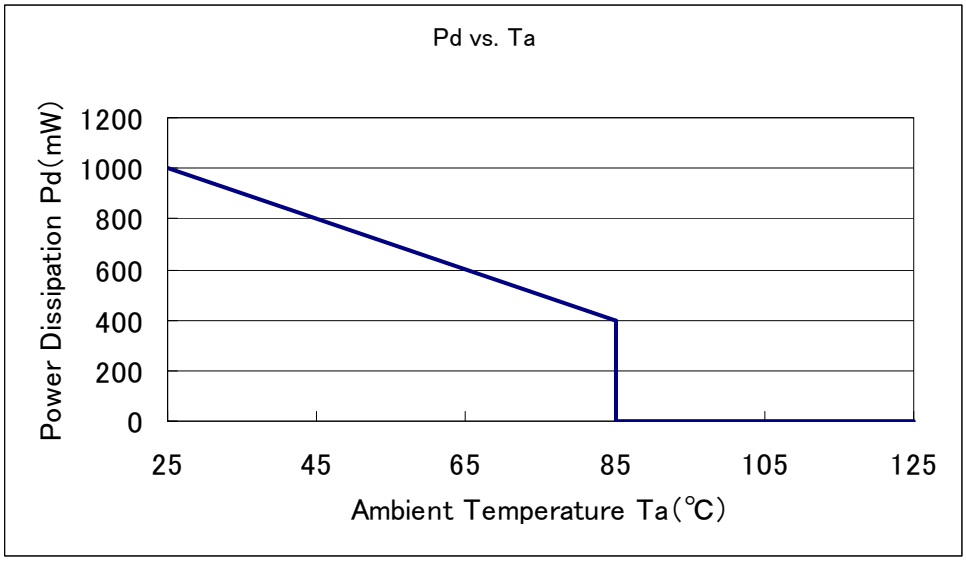


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient Temperature

Board Mount (Tj max = 125℃)

| Ambient Temperature (℃) | Power Dissipation Pd (mW) | Thermal Resistance (℃/W) |
|---|---|---|
| 25 | 1000 | 100 |
| 85 | 400 | |



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