XC6405 Series

ETR1003_006

High Current, High Speed LDO Regulators, Voltage Detector Function

■GENERAL DESCRIPTION

The XC6405 series are precise, low noise, high speed, high current, positive voltage low dropout regulators with built-in voltage detector. They are fabricated using Torex's CMOS process. Performance features of the series includes high ripple rejection and low dropout voltage, and the series features a voltage reference, an error amplifier, a current limiter and a phase compensation circuit plus a driver transistor.

Detect voltage is selectable in 100mV increments within the range of 0.9V to 5.5V and the LDO output voltage is selectable within a range of 0.9V to 5.1V, also in 100mV increments.

The series is also compatible with low ESR ceramic capacitors which give added output stability. This stability can be maintained even during load fluctuations due to the excellent transient response of the series. The current limiter's foldback circuit also operates as a short circuit protection for the output current limiter and the output pin. The series provides options to the user to select from a variety of circuit features, such as detector monitoring, detector output logic, CE and EN pin input logic, internal pull-up / down resistance, and power ready. The IC's internal regulator circuit can be placed in stand-by mode via the EN function (XC6405 A to C series). The whole IC can be put in to stand-by mode via the CE function with the XC6405D series (semi-custom). In the stand-by mode, power consumption is greatly reduced. The XC6405 A and B series features the toggle operation function. The regulator output can be OFF when the XC6405B series detects voltage (semi-custom). The XC6405E series can monitor another power source by using the V_{SEN} pin (semi-custom).

The XC6405F series can delay the detector output: the delay time can be controlled by the use of an external capacitor (semi-custom).

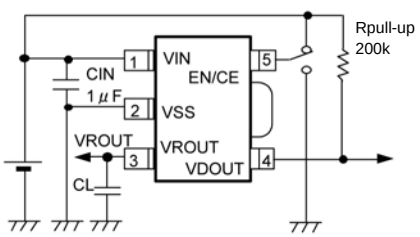
■APPLICATIONS

- ●Optical disk drive
- ●Magnetic disk drive
- ●Digital still cameras / Camcorders
- ●Digital audio equipments
- ●Multi-function power supplies

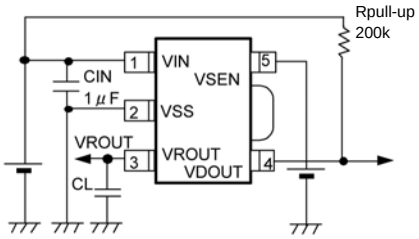
■FEATURES

Maximum Output Current	: More than 500mA (600mA limit) ($2.5V \leqq V_{ROUT} \leqq 4.9V$)
Dropout Voltage	: 200mV @ 100mA 400mV @ 200mA
Operating Voltage Range	: 2.0V ~ 6.0V
VR Setting Output Voltage	: 0.9V~ 5.1V (±2%)
Detect Voltage Setting Range	: 0.9V ~ 5.5V (±2%) More than 2.0V (V_{IN} sensing)
VR.VD Temperature Coefficient	: ±100ppm/℃ (TYP.)
Low Power Consumption	: 90μA (TYP.)
High Ripple Rejection	: 65dB (@10kHz)
Operational Temperature	: - 40 ~ 85℃
Low ESR Capacitor Compatible	
Highly Accurate	: ±2%
Ultra Small Packages	: SOT-25 (SOT-23-5) : SOT-89-5
Environmentally Friendly	: EU RoHS Compliant, Pb Free

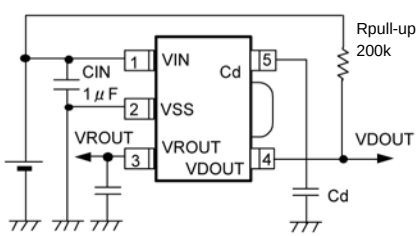
■TYPICAL APPLICATION CIRCUITS



XC6405A ~ D Series

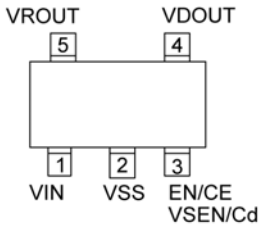


XC6405E Series

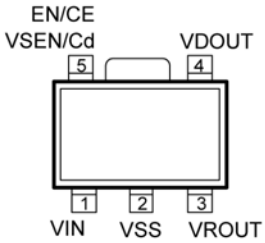


XC6405F Series

■PIN CONFIGURATION



SOT-25 (TOP VIEW)



SOT-89-5 (TOP VIEW)

■PRODUCT CLASSIFICATION

PIN NUMBER		PIN NAME	FUNCTION
SOT-25	SOT-89-5		
1	1	V_{IN}	Power Input
2	2	V_{SS}	Ground
3	5	EN	VR ON / OFF Control
3	5	CE	ON / OFF Control
3	5	V_{SEN}	VD Monitoring
3	5	Cd	Delay Capacitor Connection
4	4	V_{DOUT}	VD Output
5	3	V_{ROUT}	VR Output

■PRODUCT CLASSIFICATION

●Selection Guide

1. TOGGLE FUNCTION, VD SELF-SATURATION AS OPTION

SERIES	TOGGLE FUNCTION (BUILT-IN)
XC6405A	VD with Toggle Function
XC6405B	VD with Toggle Function and
XC6405C ~ F	VD with No Toggle Function

2. STAND-BY MODE FUNCTION AS OPTION

SERIES	STAND-BY MODE FUNCTION
XC6405A ~ C	VR with Stand-By Mode Function
XC6405D	Chip Stand-By Mode Function
XC6405E,F	No Stand-By Mode Function

3. CE / EN INPUT LOGIC INTERNAL PULL-UP/DOWN AS OPTION (* A ~ D Series)

SERIES	CE INPUT LOGIC
XC6405 * A ~ D	High Active with Pull Down
XC6405 * E ~ K	High Active with No Pull Down
XC6405 * L ~ P	Low Active with Pull Up
XC6405 * R ~ U	Low Active with No Pull Up

4. VD SENSE AS OPTION (*A ~ D and F Series)

SERIES	VD SENSE PIN
XC6405 * A, B, E, F, L, M, R, S, V,	V_{IN}
XC6405 * C, D, H, K, N, P, T, U, Y,	V_{OUT}
XC6405 EV ~ Z	V_{SEN}

5. VD OUTPUT LOGIC AS OPTION

SERIES	VD OUTPUT LOGIC FUNCTION
XC6405A ~ F	Detect L or Detect H

6. VD DELAY FUNCTION AS OPTION

SERIES	VD OUTPUT LOGIC FUNCTION
XC6405A ~ E	No Delay
XC6405F	Delay Time Adjustable by Connecting

■PRODUCT CLASSIFICATION (Continued)

●Ordering Information

XC6405①②③④⑤⑥-⑦(*1)

DESIGNATOR	DESCRIPTION	SYMBOL	DESCRIPTION
①	Operational Function	A	: Toggle and EN function (preliminary)
		B	: Toggle, EN function, VD signal/VR OFF function (preliminary)
		C	: EN function (preliminary)
		D	: CE function (preliminary)
		E	: VSEN Pin (preliminary)
		F	: Cd pin
②	Type of Regulator	-	: As in the chart below.
③ ④	Output Voltage & Detect Voltage	-	: Internally set sequential number relating to output voltage and detect voltage (refer to the chart below) VR setting output voltage range: 0.9V~5.1V Detect voltage setting range: 0.9V ~5.5V 100mV increments are available
⑤⑥-⑦	Packages Taping Type (*2)	MR	: SOT-25
		MR-G	: SOT-25 (Halogen & Antimony free)
		PR	: SOT-89-5
		PR-G	: SOT-89-5 (Halogen & Antimony free)

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

●PIN NUMBER : ② Types

②	EN / CE FUNCTION	EN / CE LOGIC	PULL UP/DOWN RESISTANCE	VD SENSE PIN	VD OUTPUT LOGIC	PIN NUMBER ①
A	Function	High Active	Pull-Down Function	VIN	Detect L	A ~ D Series
B	Function	High Active	Pull-Down Function	VIN	Detect H	
C	Function	High Active	Pull-Down Function	VROUT	Detect L	
D	Function	High Active	Pull-Down Function	VROUT	Detect H	
E	Function	High Active	Nonfunctional	VIN	Detect L	
F	Function	High Active	Nonfunctional	VIN	Detect H	
H	Function	High Active	Nonfunctional	VROUT	Detect L	
K	Function	High Active	Nonfunctional	VROUT	Detect H	
L	Function	Low Active	Pull-Up Function	VIN	Detect L	
M	Function	Low Active	Pull-Up Function	VIN	Detect H	
N	Function	Low Active	Pull-Up Function	VROUT	Detect L	
P	Function	Low Active	Pull-Up Function	VROUT	Detect H	
R	Function	Low Active	Nonfunctional	VIN	Detect L	
S	Function	Low Active	Nonfunctional	VIN	Detect H	
T	Function	Low Active	Nonfunctional	VROUT	Detect L	
U	Function	Low Active	Nonfunctional	VROUT	Detect H	
V	Nonfunctional	-	-	VIN / VSEN	Detect L	E & F Series
X	Nonfunctional	-	-	VIN / VSEN	Detect H	
Y	Nonfunctional	-	-	VROUT	Detect L	F Series
Z	Nonfunctional	-	-	VROUT	Detect H	

* The XC6405A, XC6405B, XC6405C, XC6405D, XC6405E series are under development.
For further detail, please ask your sales contacts.

■PRODUCT CLASSIFICATION (Continued)

●PIN NUMBER : ③, ④ Types (80 ~ 99 : Standard voltage products)

③④	VROUT	VDOUT	③④	VROUT	VDOUT	③④	VROUT	VDOUT	③④	VROUT	VDOUT
01	2.20	1.80	21						80	1.80	1.60
02	3.30	3.80	22						81	2.80	3.10
03	3.30	4.20	23						82	1.80	2.00
04	3.00	2.60	24						83	2.50	2.80
05	3.30	4.00	25						84	2.85	3.20
06	3.30	3.60	26						85	3.00	3.30
07	1.80	2.30	27						86	3.50	3.80
08	3.30	3.10	28						87	3.00	4.20
09	3.30	3.00	29						88	3.30	4.00
10	3.30	2.80	30						89		
11	2.60	3.90	31						90		
12	3.30	3.70	32						91		
13	1.80	3.60	33						92		
14			34						93		
15			35						94		
16			36						95		
17			37						96		
18			38						97		
19			39						98		
20			40						99		

For the other voltages, please ask your sales contacts.

●Ordering Example (Standard Products)

PRODUCT NAME	PRODUCT DESCRIPTION	VOLTAGE	
		VROUT	VDOUT
XC6405CH80MR	EN Function, High Active, VROUT Sense, Detect L	1.80	1.60
XC6405CE81MR	EN Function, High Active, VIN Sense, Detect L	2.80	3.10
XC6405DE82MR	CE Function, High Active, VIN Sense, Detect L	1.80	2.00
XC6405DE83MR	CE Function, High Active, VIN Sense, Detect L	2.50	2.80
XC6405DE84MR	CE Function, High Active, VIN Sense, Detect L	2.85	3.20
XC6405DE85MR	CE Function, High Active, VIN Sense, Detect L	3.00	3.30
XC6405DE86MR	CE Function, High Active, VIN Sense, Detect L	3.50	3.80
XC6405FV87MR	Cd Function, VIN Sense, Detect L	3.00	4.20
XC6405FV88MR	Cd Function, VIN Sense, Detect L	3.30	4.00
XC6405DE89MR	CE Function, High Active, VIN Sense, Detect L	1.20	2.00
XC6405DE90MR	CE Function, High Active, VIN Sense, Detect L	1.30	2.00
XC6405DE91MR	CE Function, High Active, VIN Sense, Detect L	1.50	2.00

Except for the standard products, minimum ordering quantity is 15K.

■ABSOLUTE MAXIMUM RATINGS

PARAMETER		SYMBOL	RATINGS	UNITS
Input Voltage		V_{IN}	7.0	V
VR Output Current		V_{RIOUT}	700	mA
VR Output Voltage		V_{ROUT}	V_{SS} -0.3 ~ V_{IN} +0.3	V
VD Output Current		V_{DIOUT}	50	mA
VD Output Voltage		V_{DOUT}	V_{SS} -0.3 ~ 7.0	V
V_{CE} / V_{SEN} / Cd Pin Voltage		$\frac{V_{CE}}{V_{SEN}\ /\ Cd}$	V_{SS} -0.3 ~ V_{IN} +0.3	V
Power Dissipation	SOT-25	Pd	250	mW
	SOT-89-5		500	
Operating Temperature Range		Topr	- 40 ~ + 85	℃
Storage Temperature Range		Tstg	- 55 ~ + 125	℃

■ELECTRICAL CHARACTERISTICS XC6405 series

●XC6405 Series

Ta=25℃

	PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
VOLTAGE REGULATOR	Output Voltage (*2, 3)	$V_{ROUT(E)}$	I_{ROUT}=30mA	×0.98	$V_{ROUT(T)}$	×1.02	V	①
	Maximum Output Current (0.9 ~ 2.4V product)	$I_{ROUTMAX}$	V_{IN}=$V_{ROUT(T)}$+2.0V	400	-	-	mA	①
	Maximum Output Current (2.5 ~ 4.9V product)	$I_{ROUTMAX}$	V_{IN}=$V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, VIN=6.0V	500	-	-	mA	①
	Load Regulation	$\triangle V_{ROUT}$	1mA≦I_{ROUT}≦100mA	-	15	50	mV	①
	Dropout Voltage (*4)	Vdif1	I_{ROUT}=30mA	E-1			mV	①
		Vdif2	I_{ROUT}=100mA	E-2			mV	①
	Supply Current (No Pull-up Resistor)	I_{DD}	V_{IN}=V_{EN}=$V_{ROUT(T)}$+1.0V, V_{ROUT}≦0.9V, V_{IN}=2.0V	-	90	145	μA	②
	Supply Current (With Pull-up Resistor)	I_{DD}	V_{IN}=V_{EN}=$V_{ROUT(T)}$+1.0V, V_{ROUT}≦0.9V, V_{IN}=2.0V	-	100	165	μA	②
	Line Regulation	$\frac{\triangle V_{ROUT}}{\triangle V_{IN} \cdot V_{ROUT}}$	$V_{ROUT(T)}$+1.0V≦V_{IN}≦6.0V When V_{ROUT}≦0.9V, 2.0V≦V_{IN}≦6.0V, I_{ROUT}=30mA When V_{ROUT}≦1.75V, I_{ROUT}=10mA	-	0.01	0.20	% / V	①
	Input Voltage	V_{IN}	-	2.0	-	6.0	V	-
	Output Voltage Temperature Characteristics	$\frac{\triangle V_{ROUT}}{\triangle Topr \cdot V_{ROUT}}$	I_{ROUT}=30mA -40℃≦Topr≦85℃	-	±100	-	ppm /℃	①
	Ripple Rejection Rate	PSRR	V_{IN}=[$V_{ROUT(T)}$+1.0]V+0.5$V_{p\text{-}pAC}$ When $V_{ROUT(T)}$≦1.25V → V_{IN}=2.25V+0.5Vp-pAC When $V_{ROUT(T)}$≧4.75V → V_{IN}=5.75V+0.5Vp-pAC I_{ROUT}=50mA, f=10kHz	-	65	-	dB	③
	Current Limiter (2.4V or less)	I_{Rlim}	V_{IN}=$V_{ROUT(T)}$+2.0V	-	600	-	mA	①
	Current Limiter (2.5V or more)	I_{Rlim}	V_{IN}=$V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	500	600	-	mA	①
	Short-Circuit Current	I_{Rshort}	V_{IN}=$V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	-	50	-	mA	①

■ELECTRICAL CHARACTERISTICS (Continued)

●XC6405 Series (Continued) Ta=25℃

	PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
VOLTAGE DETECTOR	Detect Voltage (*7, 8)	$V_{DF(E)}$		×0.98	$V_{DF(T)}$	×1.02	V	④
	Hysteresis Range (*7)	V_{HYS}		$V_{DF(T)}$ ×0.02	$V_{DF(T)}$ ×0.05	$V_{DF(T)}$ ×0.08	V	④
	Supply Current	I_{DDVD}	V_{IN} = 2.0V	-	10.0	19.0	μA	②
			V_{IN} = 3.0V	-	12.0	20.0		
			V_{IN} = 4.0V	-	14.5	24.0		
			V_{IN} = 5.0V	-	17.5	26.0		
			V_{IN} = 6.0V	-	19.0	29.0		
	Output Current (*9)	I_{DOUT}	V_{DOUT} = 0.5V, V_{IN} = 2.0V	3.0	6.0	-	mA	⑤
			V_{IN} = 3.0V	4.0	8.0	-		
			V_{IN} = 4.0V	5.0	10.0	-		
			V_{IN} = 5.0V	7.0	12.0	-		
			V_{IN} = 6.0V	10.0	15.0	-		
	Detect Voltage Temperature Characteristics	$\frac{\triangle V_{DF}}{\triangle Topr \cdot V_{DF}}$	-40℃≦Topr≦85℃	-	±100	-	ppm /℃	④
SWITCH (NO PULL-UP RESISTOR)								
	CE/EN "High" Level Voltage	$V_{CE/ENH}$		1.60	-	VIN	V	①
	CE/EN "Low" Level Voltage	$V_{CE/ENL}$		-	-	0.25	V	①
	CE/EN "High" Level Current	$I_{CE/ENH}$	$V_{CE/EN}=V_{IN}=V_{ROUT(T)}$+1.0V	-0.10	-	20	μA	②
	CE/EN "Low" Level Current	$I_{CE/ENL}$	$V_{IN}=V_{ROUT(T)}$+1.0V, $V_{CE/EN}=V_{SS}$	-0.10	-	0.10	μA	②
OPTION								
	Delay Resistance	Rdelay	V_{IN}=6.0V Delay Resistance=6.0V/Delay Current	300	500	700	kΩ	⑥

NOTE:

*1: Unless otherwise stated, $V_{IN}=V_{OUT(T)}$+1.0V

*2: $VR_{OUT(T)}$=Specified VR output voltage

*3: $V_{OUT(E)}$=Effective VR output voltage. Refer to the E-0 chart for $V_{DF(T)}$ values less than 1.5V.
(i.e. the VR output voltage when "$VR_{OUT(T)}$+1.0V" is provided at the V_{IN} pin while maintaining a certain IR_{OUT} value).

*4: $Vdif=\{V_{IN}1^{(*6)}-VR_{OUT}1^{(*5)}\}$

*5: A voltage equal to 98% of the VR output voltage whenever a stabilized $VR_{OUT}1=IR_{OUT}\{VR_{OUT(T)}+1.0V\}$ is input.

*6: $V_{IN}1$=The input voltage when $V_{OUT}1$, which appears as input voltage is gradually decreased.

*7: V_{DF} (T) : Specified detect voltage value

*8: V_{DF} (E) : Effective detect voltage value. Refer to the E-0 chart for $V_{DF(T)}$ values less than 1.5V.

*9: VD output current value of Detect 'L' type equal to current value during detection
and that of Detect 'H' type equal to current value before detection.

■ELECTRICAL CHARACTERISTICS (Continued)

●XC6405 AA / AD / AE / AH Series Ta=25℃

	PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
VOLTAGE REGULATOR	Output Voltage (*2, 3)	$V_{ROUT(E)}$	I_{ROUT}=30mA	×0.98	$V_{ROUT(T)}$	×1.02	V	①
	Maximum Output Current (0.9 ~ 2.4V product)	$I_{ROUTMAX}$	V_{IN}=$V_{ROUT(T)}$+2.0V	400	-	-	mA	①
	Maximum Output Current (2.5 ~ 4.9V product)	$I_{ROUTMAX}$	V_{IN}=$V_{ROUT(T)}$+2.0V, When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	500	-	-	mA	①
	Load Regulation	△V_{ROUT}	1mA≦I_{ROUT}≦100mA	-	15	50	mV	①
	Dropout Voltage (*4)	Vdif1	I_{ROUT}=30mA		E-1		mV	①
		Vdif2	I_{ROUT}=100mA		E-2		mV	①
	Supply Current (AA / AD series)	I_{DD}	V_{IN}=V_{EN}=$V_{ROUT(T)}$+1.0V, When V_{ROUT}≦0.9V, V_{IN}=2.0V	-	90	145	μA	②
	Supply Current (AE / AH series)	I_{DD}	V_{IN}=V_{EN}=$V_{ROUT(T)}$+1.0V, When V_{ROUT}≦0.9V, V_{IN}=2.0V	-	100	165	μA	②
	Line Regulation	$\frac{\triangle V_{ROUT}}{\triangle V_{IN} \cdot V_{ROUT}}$	$V_{ROUT(T)}$+1.0V≦V_{IN}≦6.0V When V_{ROUT}≦0.9V, 2.0V≦V_{IN}≦6.0V I_{ROUT}=30mA When V_{ROUT}≦1.75V, I_{ROUT}=10mA	-	0.01	0.20	% / V	①
	Input Voltage	V_{IN}		2.0	-	6.0	V	-
	Output Voltage Temperature Characteristics	$\frac{\triangle V_{ROUT}}{\triangle Topr \cdot V_{ROUT}}$	I_{ROUT}=30mA -40℃≦Topr≦85℃	-	±100	-	ppm /℃	①
	Ripple Rejection Rate	PSRR	V_{IN}=[$V_{ROUT(T)}$+1.0]V+0.5Vp-pAC When $V_{ROUT(T)}$≦1.25V → V_{IN}=2.25V+0.5Vp-pAC When $V_{ROUT(T)}$≧4.75V → V_{IN}=5.75V+0.5Vp-pAC I_{ROUT}=50mA, f=10kHz	-	65	-	dB	③
	Current Limiter (2.4V or less)	I_{Rlim}	V_{IN}=$V_{ROUT(T)}$+2.0V	-	600	-	mA	①
	Current Limiter (2.5V or more)	I_{Rlim}	V_{IN}=$V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	500	600	-	mA	①
	Short-Circuit Current	I_{Rshort}	V_{IN}=$V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	-	50	-	mA	①
VOLTAGE DETECTOR	Detect Voltage (*7, 8)	$V_{DF(E)}$		×0.98	$V_{DF(T)}$	×1.02	V	④
	Hysteresis Range (*8)	V_{HYS}		$V_{DF(T)}$ ×0.02	$V_{DF(T)}$ ×0.05	$V_{DF(T)}$ ×0.08	V	④
	Supply Current (*9)	I_{DDVD}	V_{IN} = 2.0V	-	6.5	19.0	μA	②
			V_{IN} = 3.0V	-	7.0	20.0		
			V_{IN} = 4.0V	-	7.5	24.0		
			V_{IN} = 5.0V	-	8.0	26.0		
			V_{IN} = 6.0V	-	9.0	29.0		
	Output Current (*10)	I_{DOUT}	V_{DOUT} = 0.5V, V_{IN} = 2.0V	3.0	6.0	-	mA	⑤
			V_{IN} = 3.0V	4.0	8.0	-		
			V_{IN} = 4.0V	5.0	10.0	-		
			V_{IN} = 5.0V	7.0	12.0	-		
			V_{IN} = 6.0V	10.0	15.0	-		
	Detect Voltage Temperature Characteristics	$\frac{\triangle V_{DF}}{\triangle Topr \cdot V_{DF}}$	-40℃≦Topr≦85℃	-	±100	-	ppm /℃	④

■ELECTRICAL CHARACTERISTICS (Continued)

●XC6405 AA / AD / AE / AH Series (Continued) Ta=25℃

	PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
SWITCH	EN "High" Level Voltage	V_{ENH}		1.60	-	V_{IN}	V	①
	EN "Low" Level Voltage	V_{ENL}		-	-	0.25	V	①
	EN "High" Level Current (AA / AD Series)	I_{ENH}	$V_{EN}=V_{IN}=V_{ROUT(T)}+1.0V$	-0.10	-	20	μA	②
	EN "High" Level Current (AE /AH Series)	I_{ENH}	$V_{EN}=V_{IN}=V_{ROUT(T)}+1.0V$	-0.10	-	0.10	μA	②
	EN "Low" Level Current	I_{ENL}	$V_{IN}=V_{ROUT(T)}+1.0V$, $V_{EN}=V_{SS}$	-0.10	-	0.10	μA	②

NOTE:

*1:Unless otherwise stated, $V_{IN}=V_{OUT(T)}+1.0V$

*2:$VR_{OUT(T)}$=Specified VR output voltage

*3:$V_{OUT(E)}$= Effective VR output voltage. Refer to the E-0 chart for V_{DF}(T) values less than 1.5V.
(i.e. the VR output voltage when "$VR_{OUT(T)}+1.0V$" is provided at the V_{IN} pin while maintaining a certain IR_{OUT} value).

*4:Vdif={$V_{IN}1^{(*6)}$-$VR_{OUT}1^{(*5)}$}

*5:A voltage equal to 98% of the VR output voltage whenever a stabilized $VR_{OUT}1=IR_{OUT}\{VR_{OUT}(T)+1.0V\}$ is input.

*6:$V_{IN}1$=The input voltage when $V_{OUT}1$, which appears as input voltage is gradually decreased.

*7:V_{DF} (T) : Specified detect voltage value

*8:V_{DF} (E) : Effective detect voltage value. Refer to the E-0 chart for V_{DF}(T) values less than 1.5V.

*9:VD supply current = Supply current when $V_{EN}=V_{SS}$

*10:VD output current = Sink current during detection.

■ELECTRICAL CHARACTERISTICS (Continued)

●XC6405 CA / CD / CE / CH Series

Ta=25℃

	PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
VOLTAGE REGULATOR	Output Voltage (*2, 3)	$V_{ROUT(E)}$	I_{ROUT}=30mA	×0.98	$V_{ROUT(T)}$	×1.02	V	①
	Maximum Output Current (0.9 ~ 2.4V product)	$I_{ROUTMAX}$	$V_{IN}=V_{ROUT(T)}$+2.0V	400	-	-	mA	①
	Maximum Output Current (2.5 ~ 4.9V product)	$I_{ROUTMAX}$	$V_{IN}=V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	500	-	-	mA	①
	Load Regulation	△V_{ROUT}	1mA≦I_{ROUT}≦100mA	-	15	50	mV	①
	Dropout Voltage (*4)	Vdif1	I_{ROUT}=30mA		E-1		mV	①
		Vdif2	I_{ROUT}=100mA		E-2		mV	①
	Supply Current (CA / CD series)	I_{DD}	$V_{IN}=V_{EN}=V_{ROUT(T)}$+1.0V, When V_{ROUT}≦0.9V, V_{IN}=2.0V	-	90	145	μA	②
	Supply Current (CE / CH series)	I_{DD}	$V_{IN}=V_{EN}=V_{ROUT(T)}$+1.0V, When V_{ROUT}≦0.9V, V_{IN}=2.0V	-	100	165	μA	②
	Line Regulation	$\frac{\triangle V_{ROUT}}{\triangle V_{IN} \cdot V_{ROUT}}$	$V_{ROUT(T)}$+1.0V≦V_{IN}≦6.0V When V_{ROUT}≦0.9V, 2.0V≦V_{IN}≦6.0V, I_{ROUT}=30mA When V_{ROUT}≦1.75V, I_{ROUT}=10mA	-	0.01	0.20	% / V	①
	Input Voltage	V_{IN}		2.0	-	6.0	V	-
	Output Voltage Temperature Characteristics	$\frac{\triangle V_{ROUT}}{\triangle Topr \cdot V_{ROUT}}$	I_{ROUT}=30mA -40℃≦Topr≦85℃	-	±100	-	ppm /℃	①
	Ripple Rejection Rate	PSRR	$V_{IN}=[V_{ROUT(T)}+1.0]V+0.5V_{p\text{-}pAC}$ When $V_{ROUT(T)}$≦1.25V → V_{IN}=2.25V+0.5Vp-pAC When $V_{ROUT(T)}$≧4.75V → V_{IN}=5.75V+0.5Vp-pAC I_{ROUT}=50mA, f=10kHz	-	65	-	dB	③
	Current Limiter (2.4V or less)	I_{Rlim}	$V_{IN}=V_{ROUT(T)}$+2.0V	-	600	-	mA	①
	Current Limiter (2.5V or more)	I_{Rlim}	$V_{IN}=V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	500	600	-	mA	①
	Short-Circuit Current	I_{Rshort}	$V_{IN}=V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	-	50	-	mA	①
VOLTAGE DETECTOR	Detect Voltage (*7, 8)	$V_{DF(E)}$		×0.98	$V_{DF(T)}$	×1.02	V	④
	Hysteresis Range (*8)	V_{HYS}		$V_{DF(T)}$ ×0.02	$V_{DF(T)}$ ×0.05	$V_{DF(T)}$ ×0.08	V	④
	Supply Current (*9)	I_{DDVD}	V_{IN} = 2.0V	-	6.5	19.0	μA	②
			V_{IN} = 3.0V	-	7.0	20.0		
			V_{IN} = 4.0V	-	7.5	24.0		
			V_{IN} = 5.0V	-	8.0	26.0		
			V_{IN} = 6.0V	-	9.0	29.0		
	Output Current (*10)	I_{DOUT}	V_{DOUT} = 0.5V, V_{IN} = 2.0V	3.0	6.0	-	mA	⑤
			V_{IN} = 3.0V	4.0	8.0	-		
			V_{IN} = 4.0V	5.0	10.0	-		
			V_{IN} = 5.0V	7.0	12.0	-		
			V_{IN} = 6.0V	10.0	15.0	-		
	Detect Voltage Temperature Characteristics	$\frac{\triangle V_{DF}}{\triangle Topr \cdot V_{DF}}$	-40℃≦Topr≦85℃	-	±100	-	ppm /℃	④

■ELECTRICAL CHARACTERISTICS (Continued)

●XC6405 CA / CD / CE / CH Series Ta=25℃

	PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
SWITCH	EN "High" Level Voltage	V_{ENH}		1.6	-	V_{IN}	V	①
	EN "Low" Level Voltage	V_{ENL}		-	-	0.25	V	①
	EN "High" Level Current (CA / CD Series)	I_{ENH}	$V_{EN}=V_{IN}=V_{ROUT(T)}+1.0V$	-0.10	-	20	μA	②
	EN "High" Level Current (CE /CH Series)	I_{ENH}	$V_{EN}=V_{IN}=V_{ROUT(T)}+1.0V$	-0.10	-	0.10	μA	②
	EN "Low" Level Current	I_{ENL}	$V_{IN}=V_{ROUT(T)}+1.0V$, $V_{EN}=V_{SS}$	-0.10	-	0.10	μA	②

NOTE:

*1: Unless otherwise stated, $V_{IN}=V_{OUT(T)}+1.0V$

*2: $VR_{OUT(T)}$=Specified VR output voltage

*3: $V_{OUT(E)}$=Effective VR output voltage. Refer to the E-0 chart for V_{DF}(T) values less than 1.5V.
(i.e. the VR output voltage when "$VR_{OUT(T)}+1.0V$" is provided at the V_{IN} pin while maintaining a certain IR_{OUT} value).

*4: $Vdif=\{V_{IN1}^{(*6)}-VR_{OUT1}^{(*5)}\}$

*5: A voltage equal to 98% of the VR output voltage whenever a stabilized $VR_{OUT1}=IR_{OUT}\{VR_{OUT}(T)+1.0V\}$ is input.

*6: V_{IN1}=The input voltage when V_{OUT1}, which appears as input voltage is gradually decreased.

*7: V_{DF} (T) : Specified detect voltage value

*8: V_{DF} (E) : Effective detect voltage value. Refer to the E-0 chart for V_{DF}(T) values less than 1.5V.

*9: VD supply current = supply current when $V_{EN}=V_{SS}$

*10: VD output current = sink current during detection.

■ELECTRICAL CHARACTERISTICS (Continued)

●XC6405 DA / DD / DE / DH Series

Ta=25℃

	PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
VOLTAGE REGULATOR	Output Voltage (*2, 3)	$V_{ROUT(E)}$	I_{ROUT}=30mA	×0.98	$V_{ROUT(T)}$	×1.02	V	①
	Maximum Output Current (0.9 ~ 2.4V product)	$I_{ROUTMAX}$	V_{IN}=$V_{ROUT(T)}$+2.0V	400	-	-	mA	①
	Maximum Output Current (2.5 ~ 4.9V product)	$I_{ROUTMAX}$	V_{IN}=$V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	500	-	-	mA	①
	Load Regulation	△V_{ROUT}	1mA≦I_{ROUT}≦100mA	-	15	50	mV	①
	Dropout Voltage (*4)	Vdif1	I_{ROUT}=30mA		E-1		mV	①
		Vdif2	I_{ROUT}=100mA		E-2		mV	①
	Supply Current (DA / DD series)	IDD	V_{IN}=V_{CE}=$V_{ROUT(T)}$+1.0V, When V_{ROUT}≦0.9V, VIN=2.0V	-	90	145	μA	②
	Supply Current (DE / DH series)	IDD	V_{IN}=V_{EN}=$V_{ROUT(T)}$+1.0V, When V_{ROUT}≦0.9V, VIN=2.0V	-	100	165	μA	②
	Supply Current (DA / DD / DE / DH series)	IDD	V_{IN}=$V_{ROUT(T)}$+1.0V, V_{CE}=0V, When V_{ROUT}≦0.9V, VIN=2.0V	-	0.01	0.10	% / V	②
	Line Regulation	$\frac{\triangle V_{ROUT}}{\triangle V_{IN} \cdot V_{ROUT}}$	$V_{ROUT(T)}$+1.0V≦V_{IN}≦6.0V When V_{ROUT}≦0.9V, 2.0V≦V_{IN}≦6.0V I_{ROUT}=30mA When V_{ROUT}≦1.75V, I_{ROUT}=10mA	-	0.01	0.20	% / V	①
	Input Voltage	V_{IN}		2.0	-	6.0	V	-
	Output Voltage Temperature Characteristics	$\frac{\triangle V_{ROUT}}{\triangle Topr \cdot V_{ROUT}}$	I_{ROUT}=30mA -40℃≦Topr≦85℃	-	±100	-	ppm /℃	①
	Ripple Rejection Rate	PSRR	VIN=[V_{ROUT}T(T)+1.0]V+0.5Vp-pAC When $V_{ROUT(T)}$≦1.25V → V_{IN}=2.25V+0.5Vp-pAC When $V_{ROUT(T)}$≧4.75V → V_{IN}=5.75V+0.5Vp-pAC I_{ROUT}=50mA, f=10kHz	-	65	-	dB	③
	Current Limiter (2.4V or less)	IRlim	V_{IN}=$V_{ROUT(T)}$+2.0V	-	600	-	mA	①
	Current Limiter (2.5V or more)	IRlim	V_{IN}=$V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	500	600	-	mA	①
	Short-Circuit Current	IRshort	V_{IN}=$V_{ROUT(T)}$+2.0V When $V_{ROUT(T)}$≧4.0V, V_{IN}=6.0V	-	50	-	mA	①
VOLTAGE DETECTOR	Detect Voltage (*7, 8)	V_{DF} (E)		×0.98	VDF (T)	×1.02	V	④
	Hysteresis Range (*8)	VHYS		V_{DF} (T) ×0.02	V_{DF} (T) ×0.05	V_{DF} (T) ×0.08	V	④
	Output Current (*9)	I_{DOUT}	VDOUT = 0.5V, V_{IN} = 2.0V	3.0	6.0	-	mA	⑤
			V_{IN} = 3.0V	4.0	8.0	-		
			V_{IN} = 4.0V	5.0	10.0	-		
			V_{IN} = 5.0V	7.0	12.0	-		
			V_{IN} = 6.0V	10.0	15.0	-		
	Detect Voltage Temperature Characteristics	$\frac{\triangle V_{DF}}{\triangle Topr \cdot V_{DF}}$	-40℃≦Topr≦85℃	-	±100	-	ppm /℃	④
SWITCH	CE "High" Level Voltage	V_{CE} H		1.6	-	V_{IN}	V	①
	CE "Low" Level Voltage	V_{CE} L		-	-	0.25	V	①
	CE "High" Level Current (DA / DD Series)	I_{CE} H	V_{EN}=V_{IN}=$V_{ROUT(T)}$+1.0V	-0.10	-	20	μA	②
	CE "High" Level Current (DE /DH Series)	I_{CE} H	V_{CE}=V_{IN}=$V_{ROUT(T)}$+1.0V	-0.10	-	0.10	μA	②
	CE "Low" Level Current	I_{CE} L	V_{IN}=$V_{ROUT(T)}$+1.0V, V_{CE}=V_{SS}	-0.10	-	0.10	μA	②

NOTE:
*1: Unless otherwise stated, V_{IN}=$V_{OUT(T)}$+1.0V
*2: $V_{ROUT(T)}$=Specified VR output voltage
*3: $V_{OUT(E)}$=Effective VR output voltage. Refer to the E-0 chart for $V_{DF(T)}$ values less than 1.5V.
(i.e. the VR output voltage when "$V_{ROUT(T)}$+1.0V" is provided at the V_{IN} pin while maintaining a certain I_{ROUT} value).
*4: Vdif={$V_{IN1}^{(*6)}$-$V_{ROUT1}^{(*5)}$}
*5: A voltage equal to 98% of the VR output voltage whenever a stabilized V_{ROUT1}=I_{ROUT}{$V_{ROUT(T)}$+1.0V} is input.
*6: V_{IN1}=The input voltage when V_{OUT1}, which appears as input voltage is gradually decreased.
*7: V_{DF} (T) : Specified detect voltage value
*8: V_{DF} (E) : Effective detect voltage value. Refer to the E-0 chart for $V_{DF(T)}$ values less than 1.5V.
*9: VD output current = sink current during detection.

■ELECTRICAL CHARACTERISTICS (Continued)

●XC6405 EV / EX Series

Ta=25℃

	PARAMETER	SYMBOL	CONDITIONS		MIN.	TYP.	MAX.	UNITS	CIRCUIT
VOLTAGE REGULATOR	Output Voltage	$V_{ROUT}(E)$	I_{ROUT}=30mA		×0.98	$V_{ROUT}(T)$	×1.02	V	①
	Maximum Output Current (0.9 ~ 2.4V product)	$I_{ROUT}MAX$	$V_{IN}=V_{ROUT}(T)+2.0V$		400	-	-	mA	①
	Maximum Output Current (2.5 ~ 4.9V product)	$I_{ROUT}MAX$	$V_{IN}=V_{ROUT}(T)+2.0V$ When $V_{ROUT}(T)\geqq 4.0V$, $V_{IN}=6.0V$		500	-	-	mA	①
	Load Regulation	$\triangle V_{ROUT}$	$1mA\leqq I_{ROUT}\leqq 100mA$		-	15	50	mV	①
	Dropout Voltage	Vdif1	I_{ROUT}=30mA			E-1		mV	①
		Vdif2	I_{ROUT}=100mA			E-2		mV	①
	Supply Current (EV / EX series)	IDD	$V_{IN}=V_{EN}=V_{ROUT}(T)+1.0V$, When $V_{ROUT}\leqq 0.9V$, VIN=2.0V		-	90	145	μA	②
	Line Regulation	$\frac{\triangle V_{ROUT}}{\triangle V_{IN} \cdot V_{ROUT}}$	$V_{ROUT}(T)+1.0V\leqq V_{IN}\leqq 6.0V$ When $V_{ROUT}\leqq 0.9V$, $2.0V\leqq V_{IN}\leqq 6.0V$ I_{ROUT}=30mA When $V_{ROUT}\leqq 1.75V$, I_{ROUT}=10mA		-	0.01	0.20	% / V	①
	Input Voltage	V_{IN}			2.0	-	6.0	V	-
	Output Voltage Temperature Characteristics	$\frac{\triangle V_{ROUT}}{\triangle Topr \cdot V_{ROUT}}$	I_{ROUT}=30mA $-40℃\leqq Topr\leqq 85℃$		-	±100	-	ppm /℃	①
	Ripple Rejection Rate	PSRR	VIN=[V_{ROUT}T(T)+1.0]V+0.5Vp-pAC When $V_{ROUT}(T)\leqq 1.25V$ → V_{IN}=2.25V+0.5Vp-pAC When $V_{ROUT}(T)\geqq 4.75V$ → V_{IN}=5.75V+0.5Vp-pAC I_{ROUT}=50mA, f=10kHz		-	65	-	dB	③
	Current Limiter (2.4V or less)	IRlim	$V_{IN}=V_{ROUT}(T)+2.0V$,		-	600	-	mA	①
	Current Limiter (2.5V or more)	IRlim	$V_{IN}=V_{ROUT}(T)+2.0V$, When $V_{ROUT}(T)\geqq 4.0V$, $V_{IN}=6.0V$		500	600	-	mA	①
	Short-Circuit Current	IRshort	$V_{IN}=V_{ROUT}(T)+2.0V$, When $V_{ROUT}(T)\geqq 4.0V$, $V_{IN}=6.0V$		-	50	-	mA	①
VOLTAGE DETECTOR	Detect Voltage	V_{DF} (E)			×0.98	VDF (T)	×1.02	V	④
	Hysteresis Range	VHYS			V_{DF} (T) ×0.02	V_{DF} (T) ×0.05	V_{DF} (T) ×0.08	V	④
	Output Current (*9)	I_{DOUT}	VDOUT = 0.5V	V_{IN} = 2.0V	3.0	6.0	-	mA	⑤
				V_{IN} = 3.0V	4.0	8.0	-		
				V_{IN} = 4.0V	5.0	10.0	-		
				V_{IN} = 5.0V	7.0	12.0	-		
				V_{IN} = 6.0V	10.0	15.0	-		
	Detect Voltage Temperature Characteristics	$\frac{\triangle V_{DF}}{\triangle Topr \cdot V_{DF}}$	$-40℃\leqq Topr\leqq 85℃$		-	±100	-	ppm /℃	④

NOTE:

*1: Unless otherwise stated, $V_{IN}=V_{OUT}(T)+1.0V$

*2: $V_{ROUT}(T)$=Specified VR output voltage

*3: $V_{OUT(E)}$=Effective VR output voltage. Refer to the E-0 chart for $V_{DF}(T)$ less than 1.5V.
(i.e. the VR output voltage when "$V_{ROUT}(T)+1.0V$" is provided at the VIN pin while maintaining a certain I_{ROUT} value).

*4: $Vdif=\{V_{IN1}^{(*6)}-V_{ROUT1}^{(*5)}\}$

*5: A voltage equal to 98% of the VR output voltage whenever a stabilized $V_{ROUT1}=I_{ROUT}\{V_{ROUT}(T)+1.0V\}$ is input.

*6: V_{IN1}=The input voltage when V_{OUT1}, which appears as input voltage is gradually decreased.

*7: V_{DF} (T) : Specified detect voltage value

*8: V_{DF} (E) : Effective detect voltage value. Refer to the E-0 chart for $V_{DF}(T)$ less than 1.5V.

*9: VD output current = sink current during detection.

■ELECTRICAL CHARACTERISTICS (Continued)

●XC6405 FV / FX / FY / FZ Series

Ta=25℃

	PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
VOLTAGE REGULATOR	Output Voltage (*2,3)	$V_{ROUT}(E)$	I_{ROUT}=30mA	×0.98	$V_{ROUT}(T)$	×1.02	V	①
	Maximum Output Current (0.9 ~ 2.4V product)	$I_{ROUTMAX}$	$V_{IN}=V_{ROUT}(T)+2.0V$	400	-	-	mA	①
	Maximum Output Current (2.5 ~ 4.9V product)	$I_{ROUTMAX}$	$V_{IN}=V_{ROUT}(T)+2.0V$ When $V_{ROUT}(T)\geqq 4.0V$, V_{IN}=6.0V	500	-	-	mA	①
	Load Regulation	$\triangle V_{ROUT}$	$1mA\leqq I_{ROUT}\leqq 100mA$	-	15	50	mV	①
	Dropout Voltage (*4)	Vdif1	I_{ROUT}=30mA		E-1		mV	①
		Vdif2	I_{ROUT}=100mA		E-2		mV	①
	Supply Current (FV / FX / FY / FZ series)	IDD	$V_{IN}=V_{EN}=V_{ROUT}(T)+1.0V$, When $V_{ROUT}\leqq 0.9V$, VIN=2.0V	-	90	145	μA	②
	Line Regulation	$\frac{\triangle V_{ROUT}}{\triangle V_{IN}\cdot V_{ROUT}}$	$V_{ROUT}(T)+1.0V\leqq V_{IN}\leq 6.0V$ When $V_{ROUT}\leqq 0.9V$, $2.0V\leqq V_{IN}\leqq 6.0V$ I_{ROUT}=30mA When $V_{ROUT}\leqq 1.75V$, I_{ROUT}=10mA	-	0.01	0.20	% / V	①
	Input Voltage	V_{IN}		2.0	-	6.0	V	-
	Output Voltage Temperature Characteristics	$\frac{\triangle V_{ROUT}}{\triangle Topr\cdot V_{ROUT}}$	I_{ROUT}=30mA $-40℃\leqq Topr\leqq 85℃$	-	±100	-	ppm /℃	①
	Ripple Rejection Rate	PSRR	VIN=[V_{ROUT}(T)+1.0]V+0.5Vp-pAC When $V_{ROUT}(T)\leqq 1.25V$ → V_{IN}=2.25V+0.5Vp-pAC When $V_{ROUT}(T)\geqq 4.75V$ → V_{IN}=5.75V+0.5Vp-pAC I_{ROUT}=50mA, f=10kHz	-	65	-	dB	③
	Current Limiter (2.4V or less)	IRlim	$V_{IN}=V_{ROUT}(T)+2.0V$	-	600	-	mA	①
	Current Limiter (2.5V or more)	IRlim	$V_{IN}=V_{ROUT}(T)+2.0V$ When $V_{ROUT}(T)\geqq 4.0V$, V_{IN}=6.0V	500	600	-	mA	①
	Short-Circuit Current	IRshort	$V_{IN}=V_{ROUT}(T)+2.0V$ When $V_{ROUT}(T)\geqq 4.0V$, V_{IN}=6.0V	-	50	-	mA	①
VOLTAGE DETECTOR	Detect Voltage (*7, 8)	V_{DF} (E)		×0.98	VDF (T)	×1.02	V	④
	Hysteresis Range (*8)	VHYS		V_{DF} (T) ×0.02	V_{DF} (T) ×0.05	V_{DF} (T) ×0.08	V	④
	Output Current (*9)	I_{DOUT}	VDOUT = 0.5V, V_{IN} = 2.0V	3.0	6.0	-	mA	⑤
			VDOUT = 0.5V, V_{IN} = 3.0V	4.0	8.0	-		
			VDOUT = 0.5V, V_{IN} = 4.0V	5.0	10.0	-		
			VDOUT = 0.5V, V_{IN} = 5.0V	7.0	12.0	-		
			VDOUT = 0.5V, V_{IN} = 6.0V	10.0	15.0	-		
	Detect Voltage Temperature Characteristics	$\frac{\triangle V_{DF}}{\triangle Topr\cdot V_{DF}}$	$-40℃\leqq Topr\leqq 85℃$	-	±100	-	ppm /℃	④
	Delay Resistance	Rdelay	VIN=6.0V, Cd=0V Delay Resistance=6.0V/Delay Current	300	500	700	kΩ	⑥

NOTE:

*1: Unless otherwise stated, $V_{IN}=V_{OUT}(T)+1.0V$

*2: $V_{ROUT}(T)$=Specified VR output voltage

*3: $V_{OUT(E)}$=Effective VR output voltage. Refer to the E-0 chart for $V_{DF}(T)$ values less than 1.5V.
(i.e. the VR output voltage when "$V_{ROUT}(T)+1.0V$" is provided at the V_{IN} pin while maintaining a certain I_{ROUT} value).

*4: $Vdif=\{V_{IN1}^{(*6)}-V_{ROUT1}^{(*5)}\}$

*5: A voltage equal to 98% of the VR output voltage whenever a stabilized $V_{ROUT1}=I_{ROUT}\{V_{ROUT}(T)+1.0V\}$ is input.

*6: V_{IN1}=The input voltage when V_{OUT1}, which appears as input voltage is gradually decreased.

*7: V_{DF} (T) : Specified detect voltage value

*8: V_{DF} (E) : Effective detect voltage value. Refer to the E-0 chart for $V_{DF}(T)$ values less than 1.5V.

*9: VD supply current = sink current during detection.

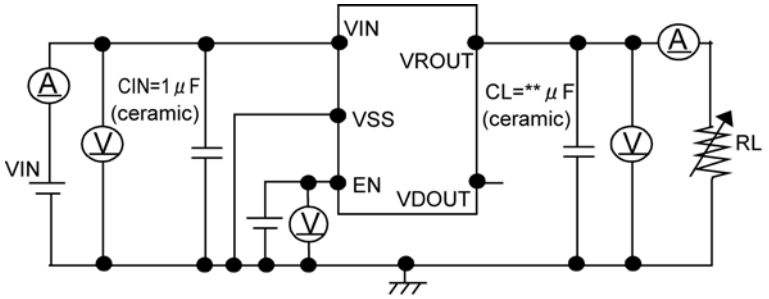
■VR DROPOUT VOLTAGE

SYMBOL	E-0		E-1		E-1	
PARAMETER / SPECIFIED DETECT VOLTAGE OUTPUT VOLTAGE	OUTPUT VOLTAGE DETECT VOLTAGE (V)		DROPOUT VOLTAGE 1 (mV) (I_{OUT}=30mA) Ta=25℃		DROPOUT VOLTAGE 2 (mV) (I_{OUT}=100mA) Ta=25℃	
$V_{ROUT(T)}$ $V_{DF(T)}$	V_{ROUT} / V_{DF}		Vdif1	Vdif1	Vdif2	Vdif2
	MIN.	MAX.	TYP.	MAX.	TYP.	MAX.
0.90	0.870	0.930	1050	1100	1150	1200
1.00	0.970	1.030	1000	1100	1050	1200
1.10	1.070	1.130	900	1000	950	1100
1.20	1.170	1.230	800	900	850	1000
1.30	1.270	1.330	700	800	750	900
1.40	1.370	1.430	600	700	650	800
1.50	1.470	1.530	500	600	550	700
1.60	1.568	1.632	400	500	500	600
1.70	1.666	1.734	300	400	400	500
1.80	1.764	1.836	200	300	300	400
1.90	1.862	1.938	120	150	280	380
2.00	1.960	2.040	80	120	240	350
2.10	2.058	2.142	80	120	240	330
2.20	2.156	2.244	80	120	240	330
2.30	2.254	2.346	80	120	240	310
2.40	2.352	2.448	80	120	240	310
2.50	2.450	2.550	70	100	220	290
2.60	2.548	2.652	70	100	220	290
2.70	2.646	2.754	70	100	220	290
2.80	2.744	2.856	70	100	220	270
2.90	2.842	2.958	70	100	220	270
3.00	2.940	3.060	60	90	200	270
3.10	3.038	3.162	60	90	200	250
3.20	3.136	3.264	60	90	200	250
3.30	3.234	3.366	60	90	200	250
3.40	3.332	3.468	60	90	200	250
3.50	3.430	3.570	60	90	200	250
3.60	3.528	3.672	60	90	200	250
3.70	3.626	3.774	60	90	200	250
3.80	3.724	3.876	60	90	200	250
3.90	3.822	3.978	60	90	200	250
4.00	3.920	4.080	60	80	180	230
4.10	4.018	4.182	60	80	180	230
4.20	4.116	4.284	60	80	180	230
4.30	4.214	4.386	60	80	180	230
4.40	4.312	4.488	60	80	180	230
4.50	4.410	4.590	60	80	180	230
4.60	4.508	4.692	60	80	180	230
4.70	4.606	4.794	60	80	180	230
4.80	4.704	4.896	60	80	180	230
4.90	4.802	4.998	60	80	180	230
5.00	4.900	5.100	50	70	160	210
5.10	4.998	5.202	50	70	160	210
5.20	5.096	5.304				
5.30	5.194	5.406				
5.40	5.292	5.508				
5.50	5.390	5.610				

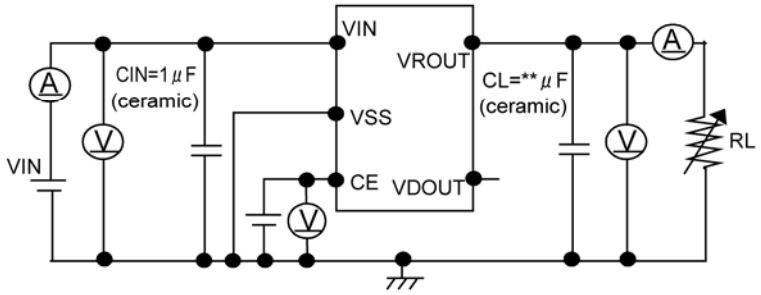
■TEST CIRCUITS

●Circuit ①

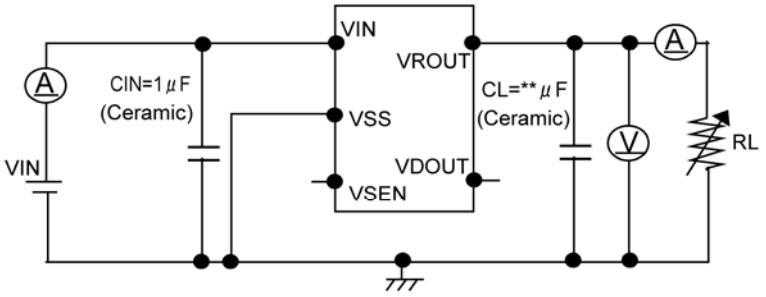
XC6405A ~ C Series



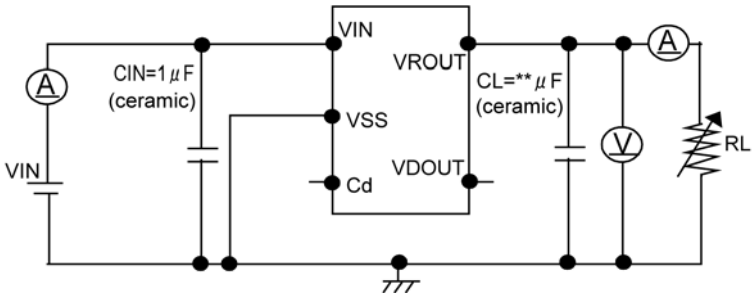
XC6405D Series



XC6405E Series



XC6405F Series



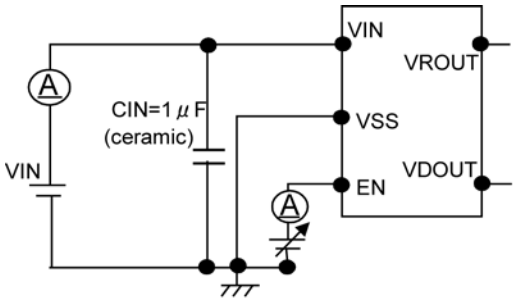
Output Capacitor Corresponding Chart

VROUT	0.9 ~1.2V	1.3 ~ 1.7V	1.8V ~ 5.1V
CL	More Than 4.7μF	More Than 2.2μF	More Than 1.0μF

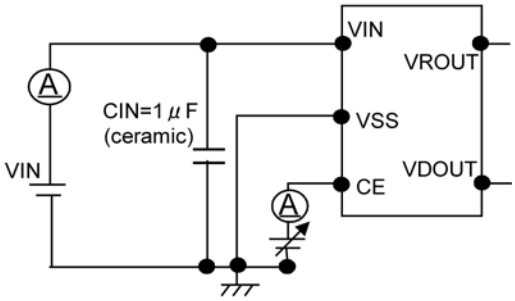
■TEST CIRCUITS (Continued)

●Circuit ②

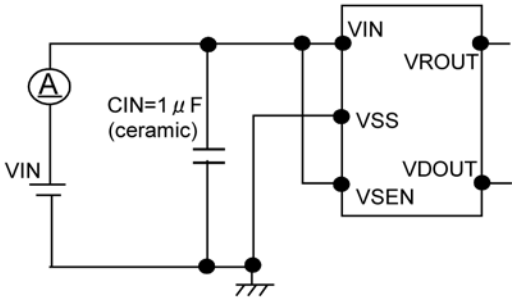
XC6405A ~ C Series



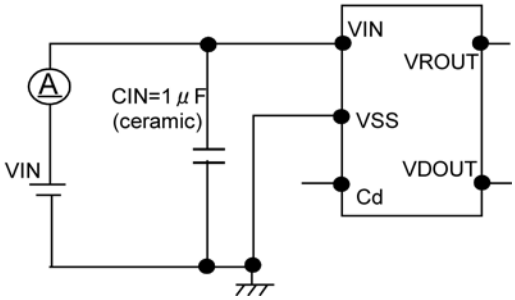
XC6405D Series



XC6405E Series



XC6405F Series



■TEST CIRCUITS (Continued)

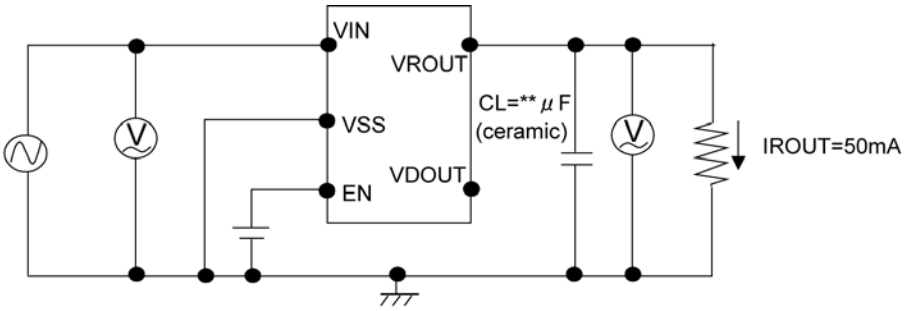
●Circuit ③

XC6405A ~ C Series

$V_{ROUT} \leqq 1.25V$
$V_{IN}=\{2.25V\}V_{DC}$
+0.5Vp-pAC

$V_{IN}=\{V_{ROUT}+1.0V\}V_{DC}$
+0.5Vp-pAC

$V_{ROUT} \geqq 4.75V$
$V_{IN}=\{5.75V\}V_{DC}$
+0.5Vp-pAC

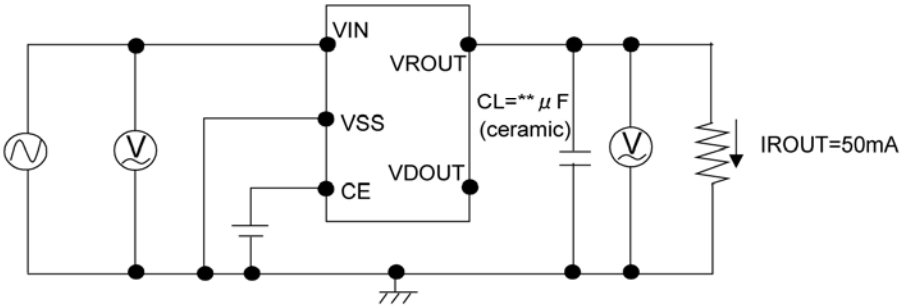


XC6405D Series

$V_{ROUT} \leqq 1.25V$
$V_{IN}=\{2.25V\}V_{DC}$
+0.5Vp-pAC

$V_{IN}=\{V_{ROUT}+1.0V\}V_{DC}$
+0.5Vp-pAC

$V_{ROUT} \geqq 4.75V$
$V_{IN}=\{5.75V\}V_{DC}$
+0.5Vp-pAC

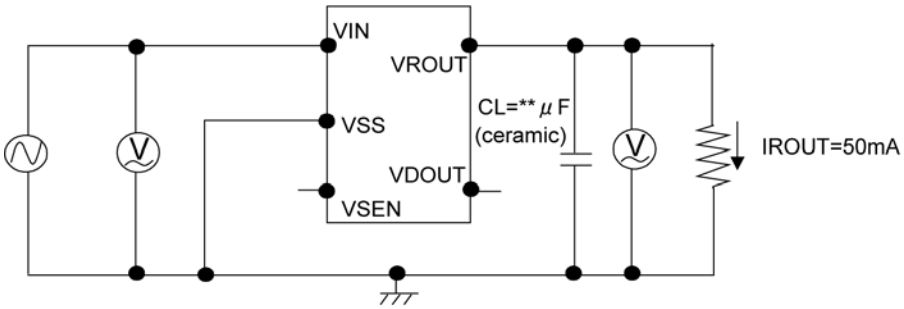


XC6405E Series

$V_{ROUT} \leqq 1.25V$
$V_{IN}=\{2.25V\}V_{DC}$
+0.5Vp-pAC

$V_{IN}=\{V_{ROUT}+1.0V\}V_{DC}$
+0.5Vp-pAC

$V_{ROUT} \geqq 4.75V$
$V_{IN}=\{5.75V\}V_{DC}$
+0.5Vp-pAC

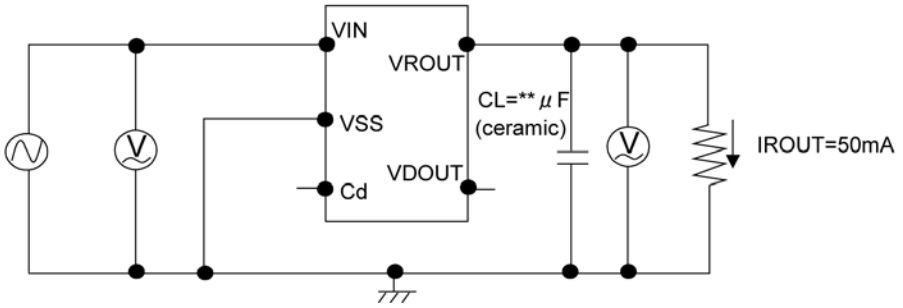


XC6405F Series

$V_{ROUT} \leqq 0.9V$
$V_{IN}=\{2.0V\}V_{DC}$
+0.5Vp-pAC

$V_{IN}=\{V_{ROUT}+1.0V\}V_{DC}$
+0.5Vp-pAC

$V_{ROUT} \geqq 4.75V$
$V_{IN}=\{5.75V\}V_{DC}$
+0.5Vp-pAC



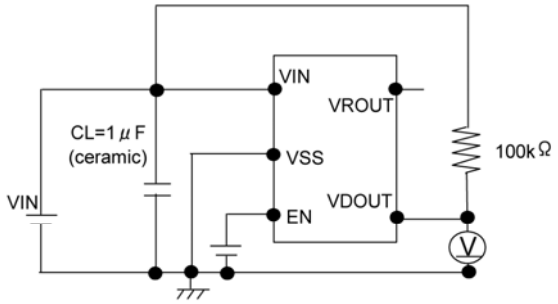
Output Capacitor Corresponding Chart

V_{ROUT}	0.9 ~1.2V	1.3 ~ 1.7V	1.8V ~ 5.1V
C_L	More Than 4.7μF	More Than 2.2μF	More Than 1.0μF

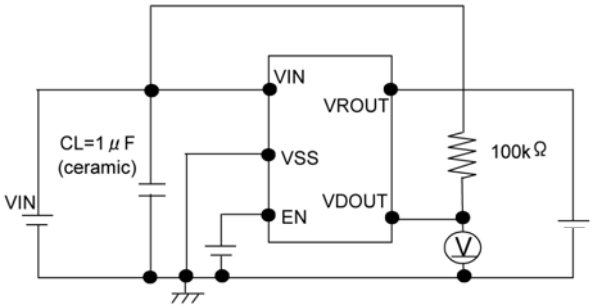
■TEST CIRCUITS (Continued)

●Circuit ④

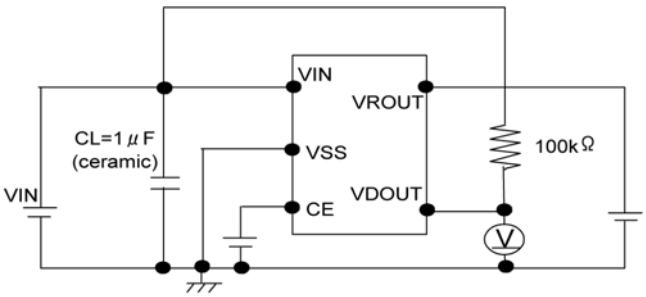
XC6405A ~ C Series
[VD Sense, VIN type]



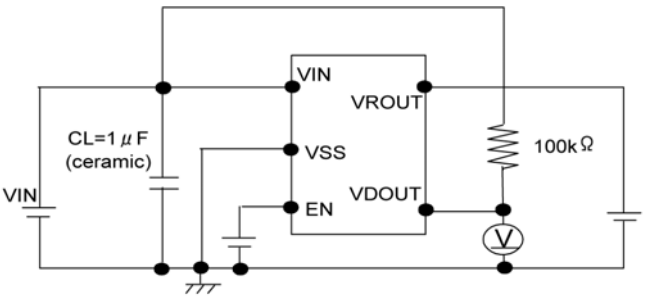
[VD Sense, VROUT type]



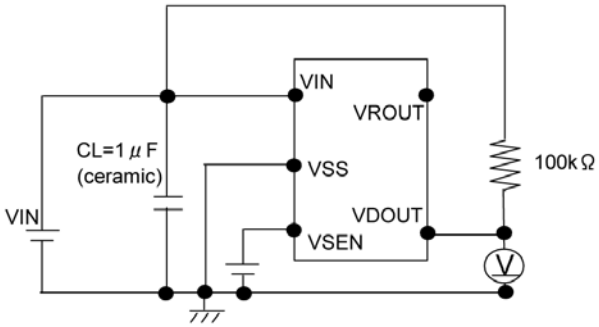
XC6405D Series
[VD Sense, VIN type]



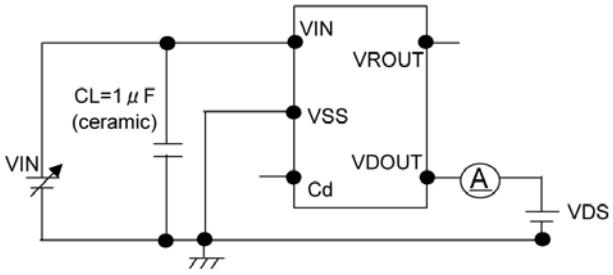
[VD Sense, VROUT type]



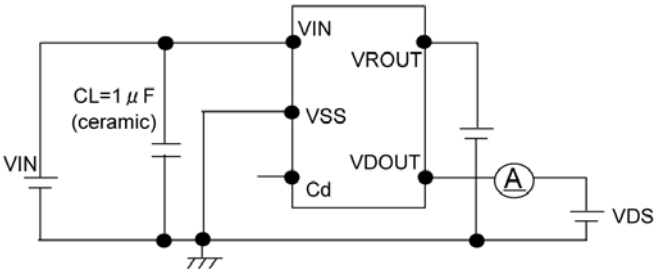
XC6405E Series



XC6405F Series
[VD Sense, VIN type]



[VD Sense, VROUT type]

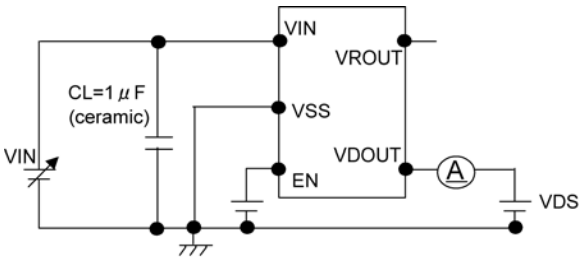


■TEST CIRCUITS (Continued)

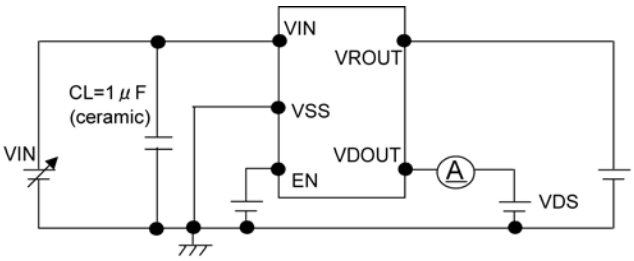
●Circuit ⑤

XC6405A ~ C Series

[VD Sense, VIN type]

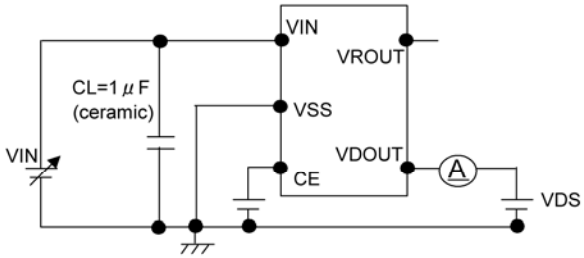


[VD Sense, VROUT type]

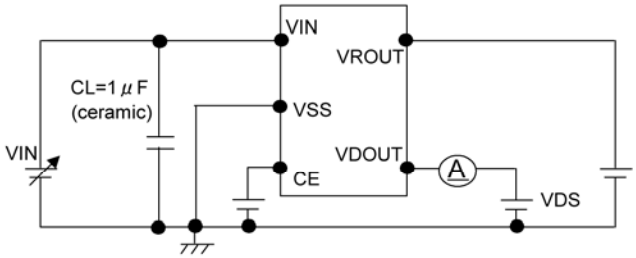


XC6405D Series

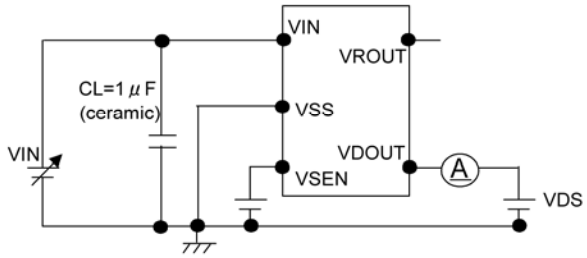
[VD Sense, VIN type]



[VD Sense, VROUT type]

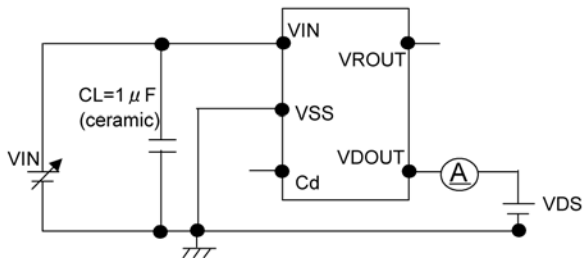


XC6405E Series

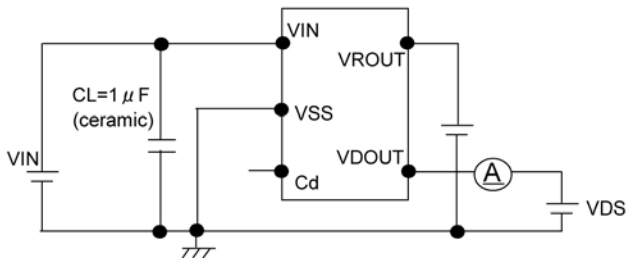


XC6405F Series

[VD Sense, VIN type]



[VD Sense, VROUT type]

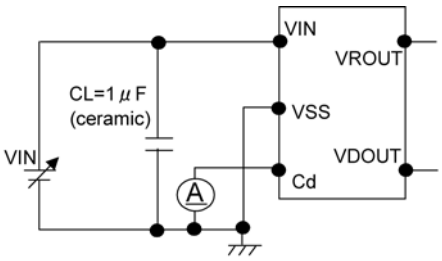


■TEST CIRCUITS (Continued)

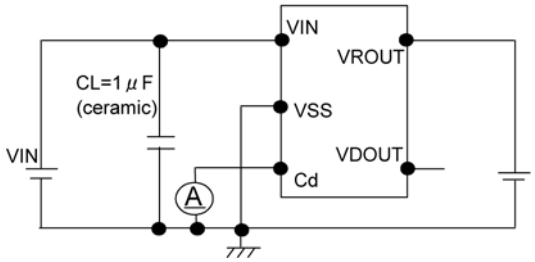
●Circuit ⑥

XC6405F Series

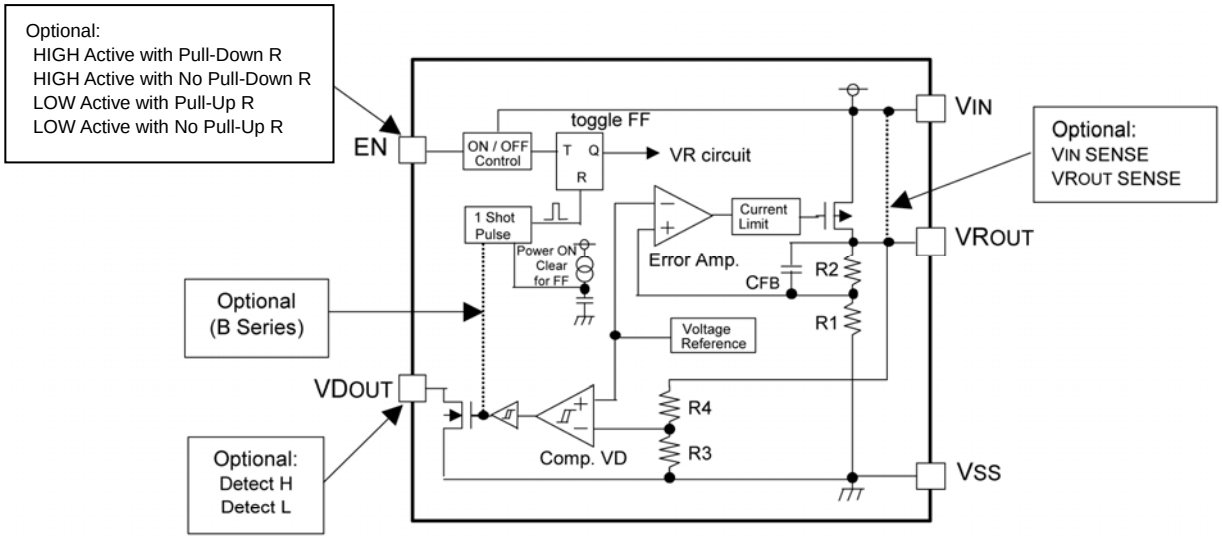
[VD Sense, VIN type]



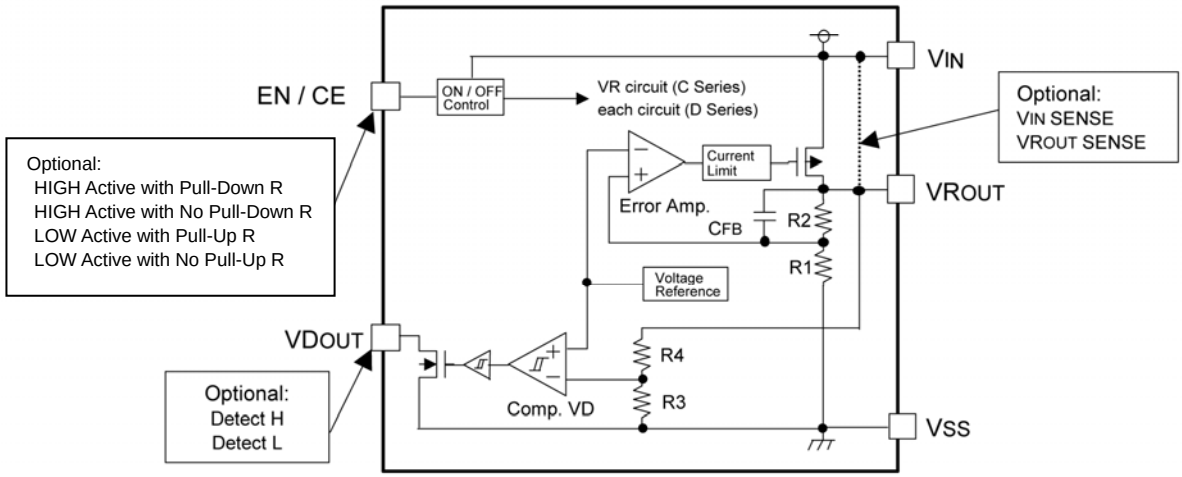
[VD Sense, VROUT type]



■BLOCK DIAGRAMS

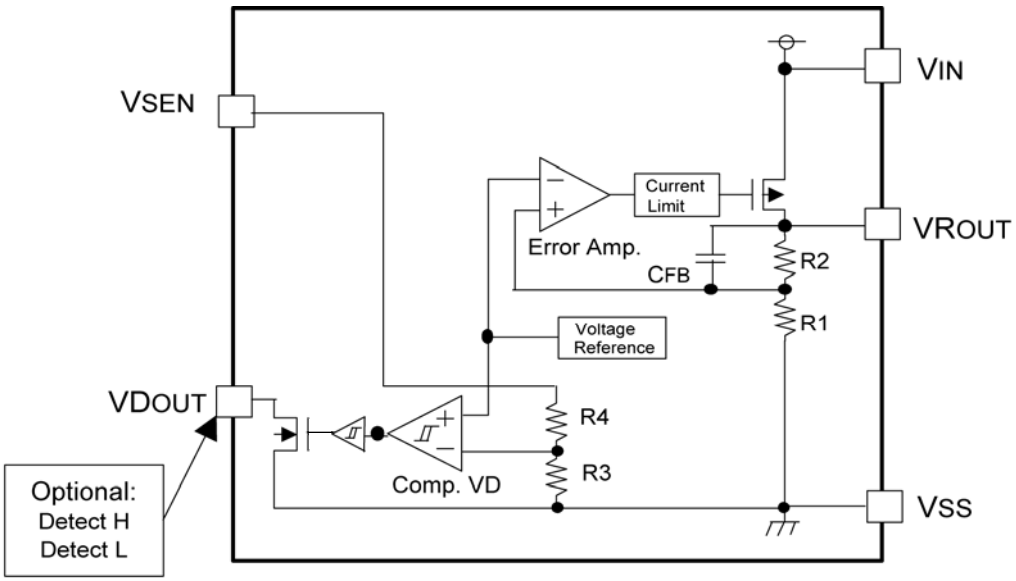


XC6405A, B Series

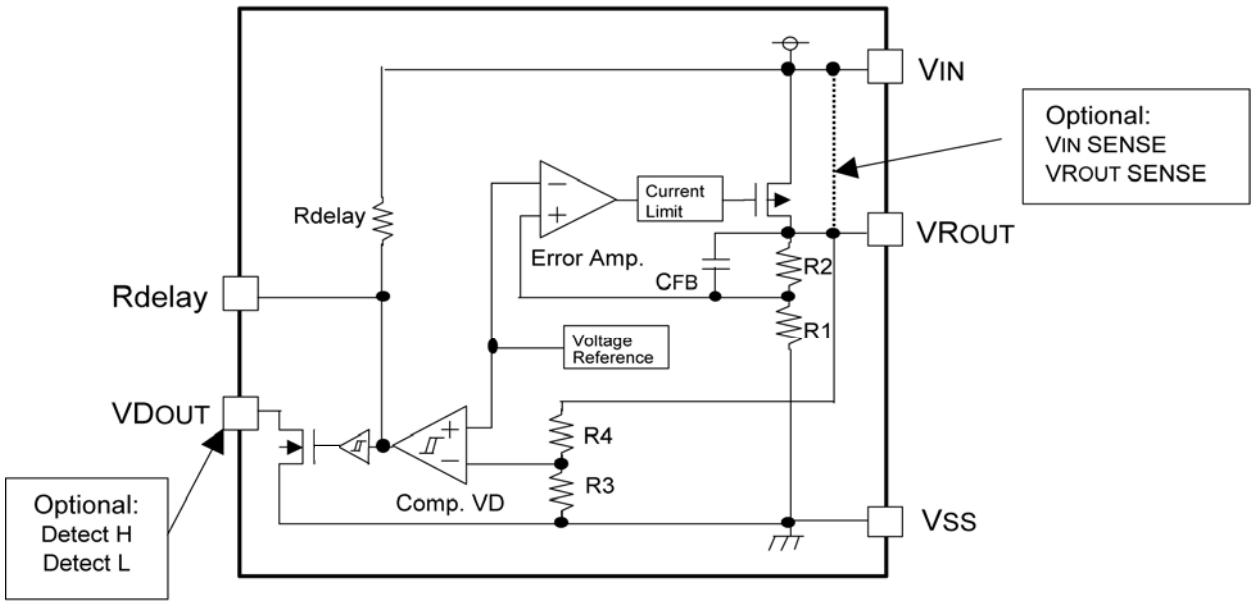


XC6405C, D Series

■BLOCK DIAGRAMS (Continued)



XC6405E Series



XC6405F Series

■OPERATIONAL EXPLANATION

<Output Voltage Regulator Control>
The voltage, divided by resistors R1 & R2, which are connected to the VROUT pin is compared with the internal reference voltage by the error amplifier. The P-channel MOSFET, which is connected to the VROUT pin, is then driven by the subsequent output signal. The output voltage at the VROUT pin is controlled & stabilized by negative feedback. The current limit circuit and short circuit protection operate in relation to the level of output current. Further, the voltage regulator's internal circuitry can be shutdown via the EN or CE pin's signal.

<Detector Function with the XC6405 Series>
The series' detector function monitors the voltage divided by resistors R3 & R4, which are connected to the VROUT pin or the VIN pin or the VSEN pin, as well as monitoring the voltage of the internal reference voltage source via the comparator. The VDSEN pin has options (please refer to the Selection Guide, item 4). A 'High' or 'Low' signal level can be output from the VDOUT pin when the VD pin voltage level goes below the detect voltage. The VD output logic has options (please refer to the Selection Guide, item 5). As VDOUT is an open-drain N-channel output, a pull-up resistor of about 220kΩ is needed to achieve a voltage output. Because of hysteresis at the detector function, output at the VDOUT pin will invert when the detect voltage level increases above the release voltage (105% of the detect voltage). Even when the XC6405A, B, C, series are in stand-by mode, the voltage detector function operates and the output voltage at VDOUT will output according to the voltage level at VDSENSE voltage.
For the XC6405A, B, C type, in stand-by, if a voltage of the recovery voltage is present at the VROUT pin (from another power source), the VDOUT pin will be high impedance mode, and the pull up voltage will be output at VDOUT. By connecting the Cdelay pin to a capacitor (Cd), the XC6405F series can apply a delay time to VDOUT voltage when releasing voltage. The delay time can be calculated from the internal resistance, Rdelay (500kΩ fixed) and the value of Cd as per the following equation.

Delay Time = Cdelay x Rdelay x 0.7

Delay Time Rdelay standard : 300 ~ 700kΩ TYP : 500kΩ

Cdelay	DELAY TIME (TYP.)	DELAY TIME (TYP.)
0.01μF	3.5 msec	2.1 ~ 4.9 msec
0.022μF	7.7 msec	4.62 ~ 10.8 msec
0.047μF	16.5 msec	9.87 ~ 23.0 msec
0.1μF	35 msec	21.0 ~ 49.0 msec
0.22μF	77 msec	46.2 ~ 108.0 msec
0.47μF	165 msec	98.7 ~ 230.0 msec
1μF	350 msec	210.0 ~ 490.0 msec

<Low ESR Capacitors>
With the XC6405 series regulator, a stable output voltage is achievable even if low ESR capacitors are used, as a phase compensation circuit is built-in to the regulator. In order to ensure the effectiveness of the phase compensation, we suggest that an output capacitor (CL) be connected as close as possible, between the output pin (VROUT) and the VSS pin. Please use an output capacitor (CL) with a capacitance, based on the chart below. We also suggest an input capacitor (CIN) of 1μF : this should be connected between VIN and VSS in order to stabilize input power source.

Output Capacitor Corresponding Chart

VROUT	0.9 ~1.2V	1.3 ~ 1.7V	1.8 ~ 5.1V
CL	More Than 4.7μF	More Than 2.2μF	More Than 1.0μF

<Current Limiter, Short-Circuit Protection>
The XC6405 series regulator offers a combination of current limit and circuit protection by means of a built-in fixed current limiter circuit and a foldback circuit. When the load current reaches the current limit level, the fixed current limiter circuit operates and output voltage drops. As a result of this drop in output voltage, the foldback circuit operates, the output voltage drops further and output current decreases. When the output pin is shorted, a current of about 50mA flows.

■OPERATIONAL EXPLANATION (Continued)

<EN / CE Pin>

The IC's internal regulator circuitry can be shut down via the signal from the EN pin with the XC6405A, B, C series. In shutdown mode, output at the VROUT pin will be pulled down to the VSS level via R1 & R2. The whole IC's circuitry can be shut down via CE pin with the XC6405D series and power consumption can be reduced to around 0μA (TYP.). While the voltage detector is in shutdown mode, the voltage detector output is in a post-detection state. When choosing Detect L, input current can be set by using the following formula.

Input Current = VIN voltage / Pull-Up Resistance

In stand-by mode, the above input current can be reduced by connecting a pull-up resistor between VROUT and VDOUT.

Note that as the XC6405*E to K types of the XC6405A to D series are 'High Active / No Pull-Down' and XC6405*R to U types of the XC6405A to D series are 'Low Active / No Pull-Up', operations will become unstable with the CE pin open (See the chart below).

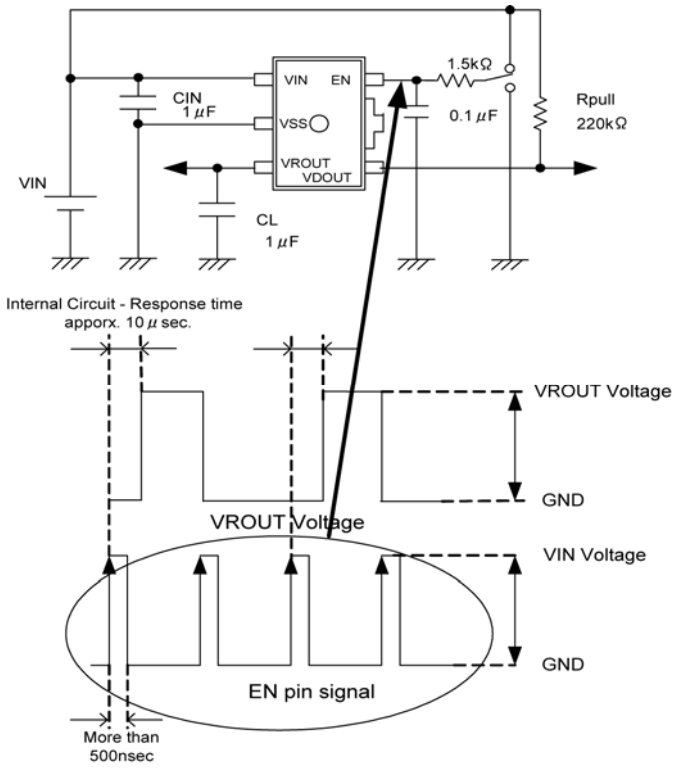
SERIES	EN/CE INPUT LOGIC
XC6405 * A ~ D	HIGH Active with Pull Down
XC6405 * E ~ K	HIGH Active with No Pull Down
XC6405 * L ~ P	LOW Active with Pull Up
XC6405 * R ~ U	LOW Active with No Pull Up

(* A ~ D Series)

We suggest that you use this IC with either a VIN voltage or a VSS voltage input at the EN or CE pin. If this IC is used with the correct specifications for the EN or CE pin, the IC will operate normally. However, supply current may increase as a result of through current in the IC's internal circuitry if a voltage other than VIN or VSS is applied.

<Toggle Operation>

The XC6405 A and B series have a built-in toggle ON/OFF switch which repeats an on/off operation via the EN pin's leading edge signal when the EN logic is High Active, and via the EN pin's falling edge signal when the EN logic is Low Active (Please also refer the figure below). The EN input signal duration should be over 500nsec. If the EN input signal is less than 500nsec, it is possible that the circuit fails to respond and the toggle function does not operate. To operate the toggle function properly when the EN pin voltage noise is large, a RC filter should be used to reduce the noise in the signal to the EN pin. In the case where input delay time is required, it is possible to set the time constant by connecting an RC network to the EN pin.



EN Logic High Active

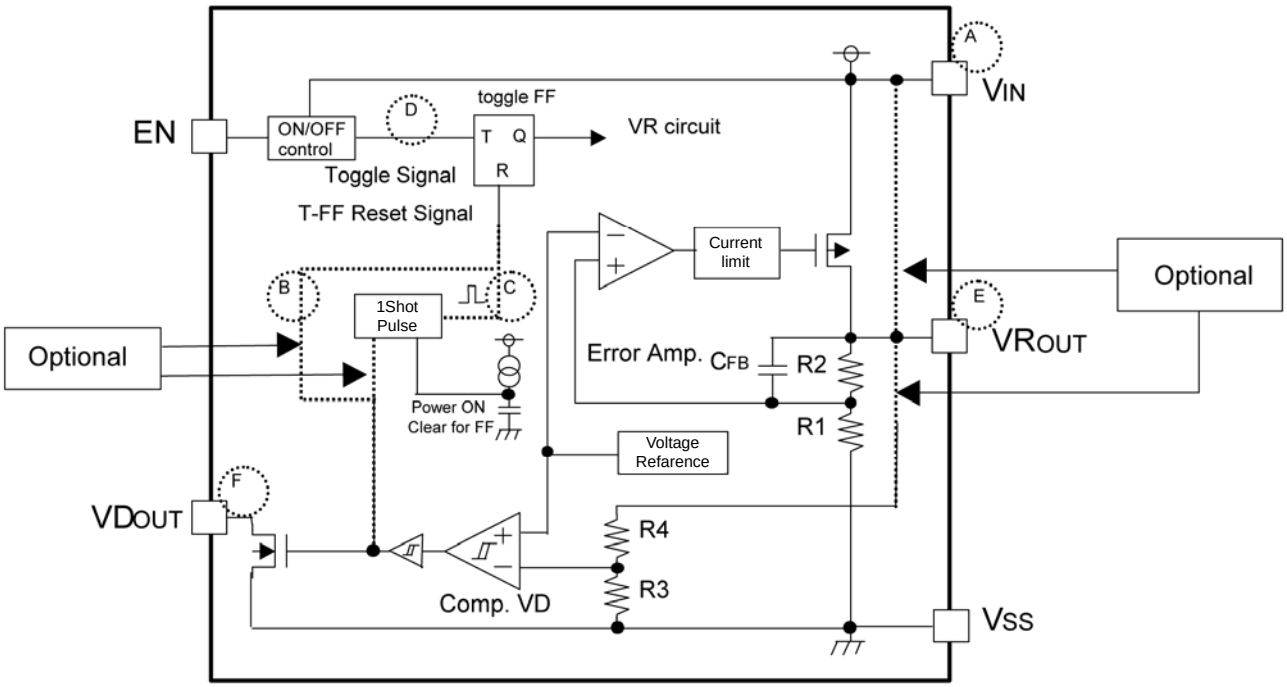
■OPERATIONAL EXPLANATION (Continued)

<Toggle Operation> (Continued)

For the XC6405B series, there are two types of toggle selection; one is a T-type flip-flop (T-FF) used for toggle operation which can be reset internally by a signal directly from the voltage detector (VIN Sense type only. See also the Selection Guide on page 2). The other type is where the reset is applied internally through a one shot pulse circuit (VIN, VROUT type only. See also the Selection Guide).

The type, which applies the reset directly via the signal from the voltage detector function, applies the voltage detector comparator's output signal (reset signal) to the reset of T-FF reset, and turns the VR output OFF when the input voltage decreases below the detect voltage due to battery consumption, etc.. In order to return the VR output, apply a voltage larger than the release voltage to VIN and input a toggle signal to the T-FF. In the case where input voltage is below the release voltage, the VR output does not return even though the toggle signal is input into the T-FF.

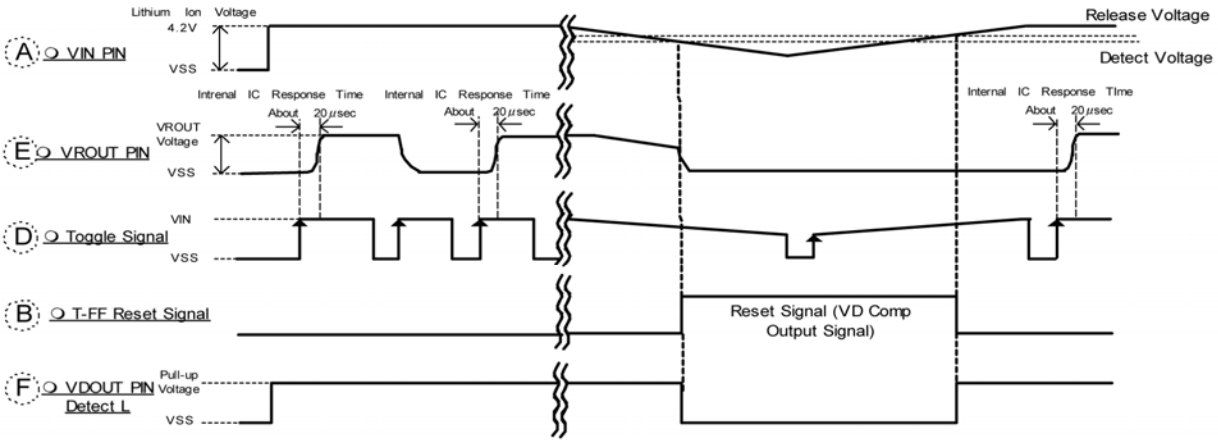
The type which applies the reset signal to the T-FF internally via a one-shot pulse circuit changes the voltage detector comparator output signal to a one-shot signal internally. Like the type which applies the reset directly via the signal from voltage detector function, this type also applies the reset to the T-FF and sets the VR output to OFF when the input voltage (VIN Sense type) and output voltage (VROUT Sense type) drop below the detect voltage level. This type can return the VR output by inputting a toggle signal, even when the Sense pin voltage (VIN or VROUT pin voltage) is below the release voltage. Please refer to the block diagram below and the timing chart on the following page. Please choose the option suitable to the application.



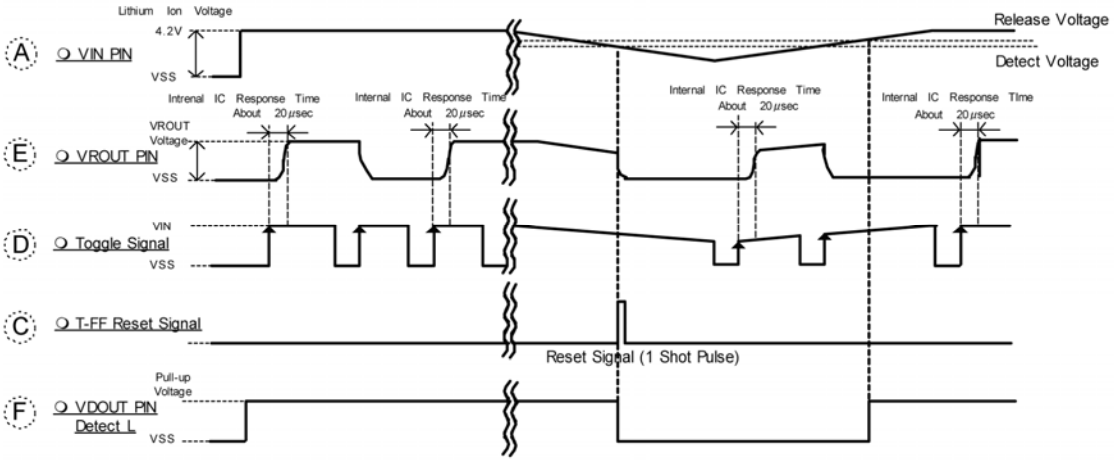
Block Diagram for XC6405B Series Timing Chart

■TIMING CHART

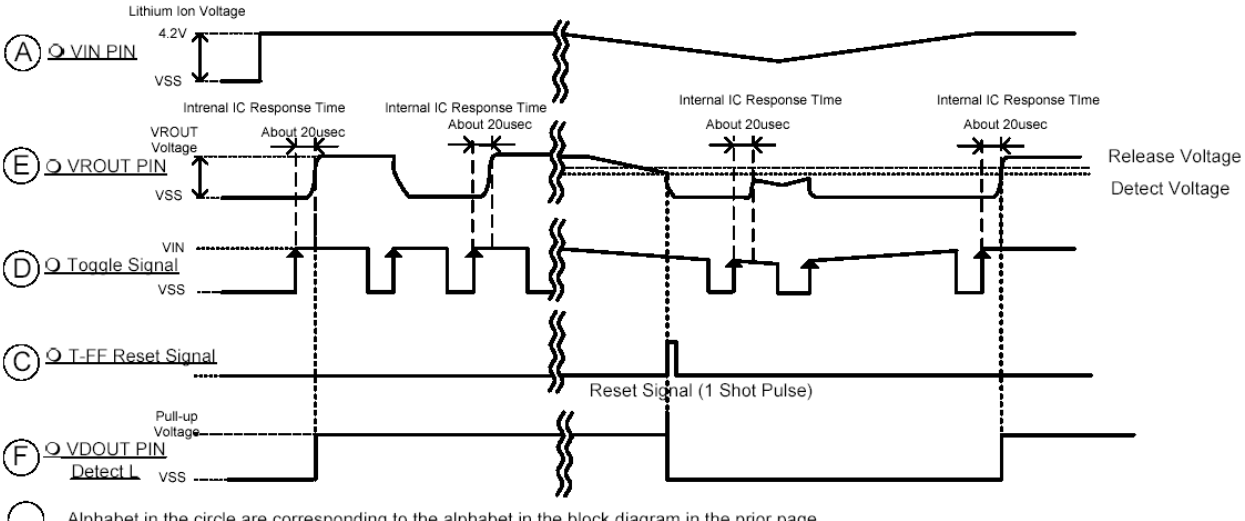
●Using the VD output level signal as the reset signal of T-FF (VD Sense = VIN PIN)



●Changing the VD output level signal into a one shot pulse to use T-FF as the reset signal (VD Sense = VIN PIN)



●Changing the VD output level signal into a one shot pulse to use T-FF as the reset signal (VD Sense = VROUT PIN)



○ Alphabet in the circle are corresponding to the alphabet in the block diagram in the prior page.

■NOTES ON USE

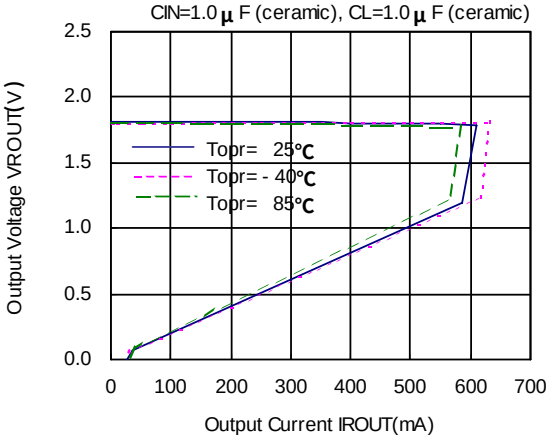
1. Please use this IC within the stated absolute maximum ratings. The IC is liable to malfunction should the ratings be exceeded.
2. Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current. Please strengthen V_{IN} and V_{SS} wiring in particular.
3. Please wire the input capacitor (C_{IN}) and the output capacitor (C_L) as close to the IC as possible.
   Should rapid input fluctuation or load fluctuation occur, please increase the capacitor value such as C_{IN} or C_L to stabilize the operation.

■TYPICAL PERFORMANCE CHARACTERISTICS

(1) VR Output Voltage vs. VR Output Current

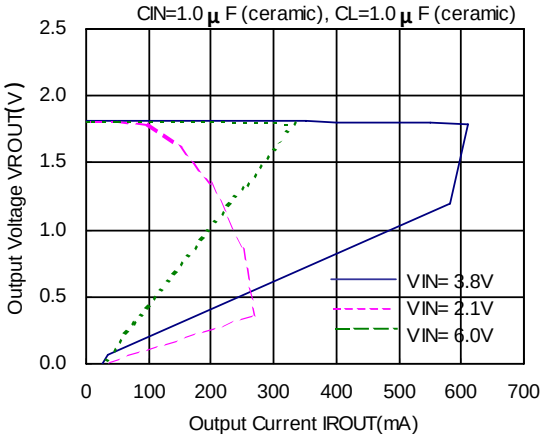
XC6405 Series (VR:1.8V)

VIN=3.8V,
CIN=1.0μF (ceramic), CL=1.0μF (ceramic)



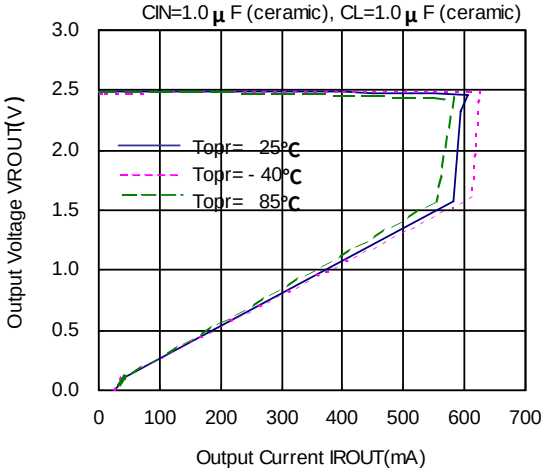
XC6405 Series (VR:1.8V)

CIN=1.0μF (ceramic), CL=1.0μF (ceramic)



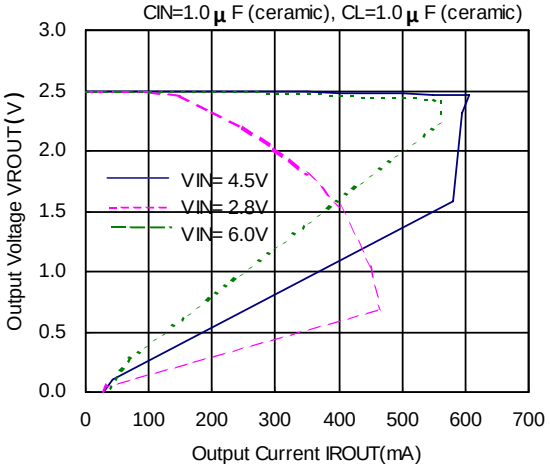
XC6405 Series (VR:2.5V)

VIN=4.5V,
CIN=1.0μF (ceramic), CL=1.0μF (ceramic)



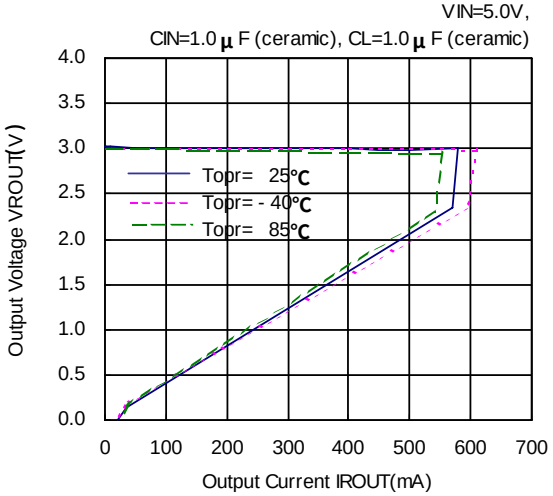
XC6405 Series (VR:2.5V)

CIN=1.0μF (ceramic), CL=1.0μF (ceramic)



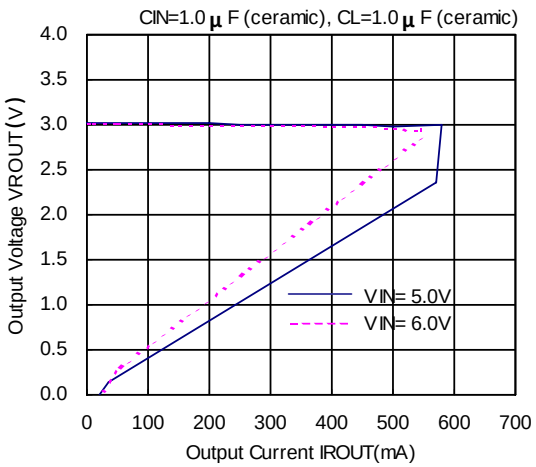
XC6405 Series (VR:3.0V)

VIN=5.0V,
CIN=1.0μF (ceramic), CL=1.0μF (ceramic)



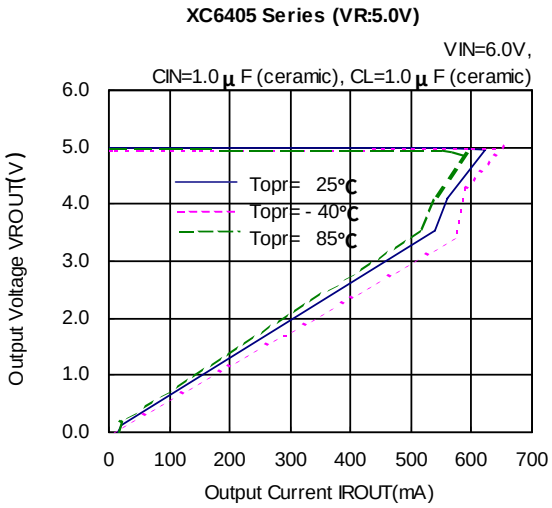
XC6405 Series (VR:3.0V)

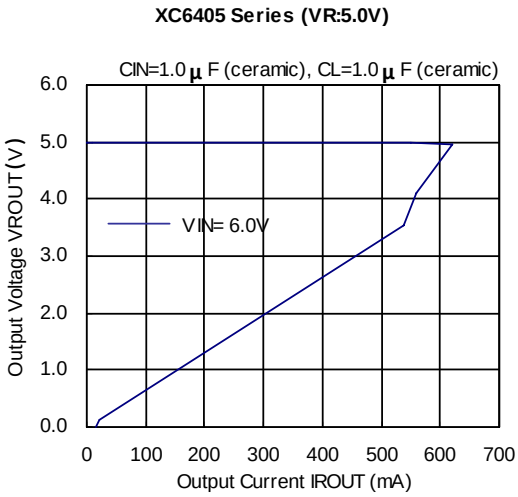
CIN=1.0μF (ceramic), CL=1.0μF (ceramic)

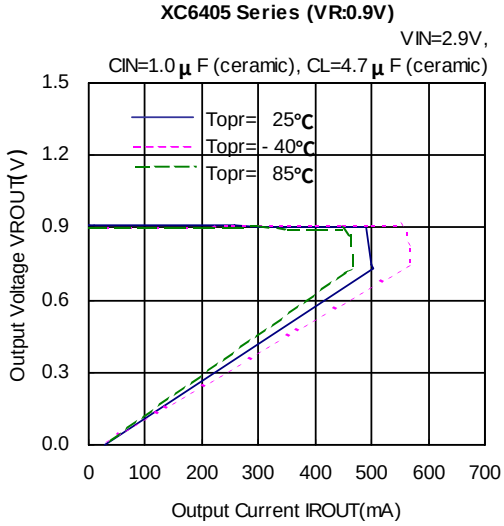


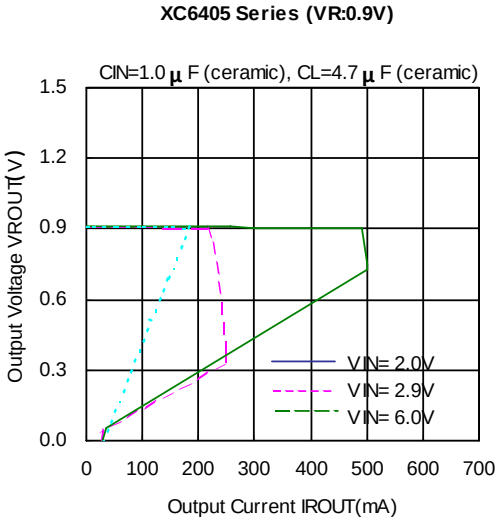
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

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



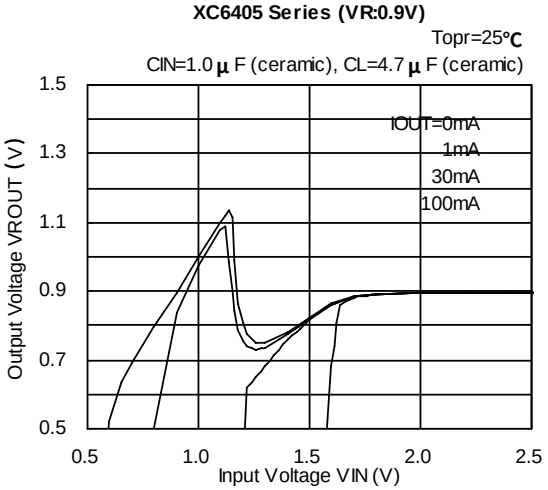


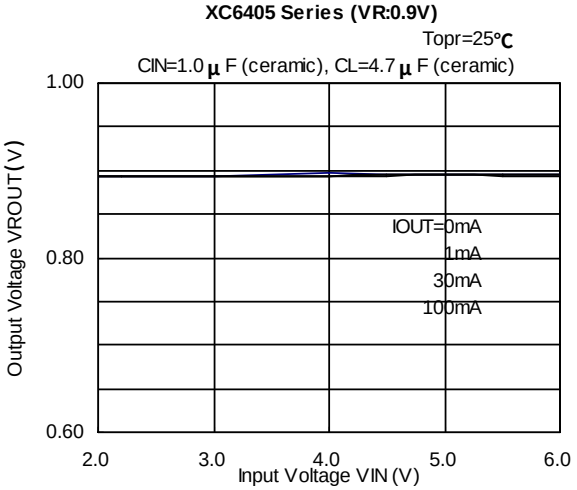


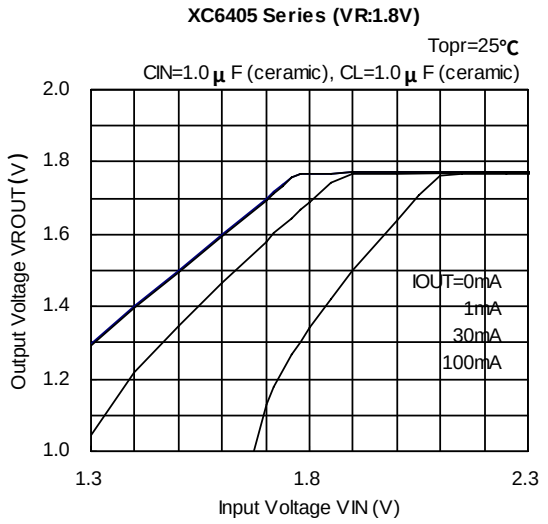


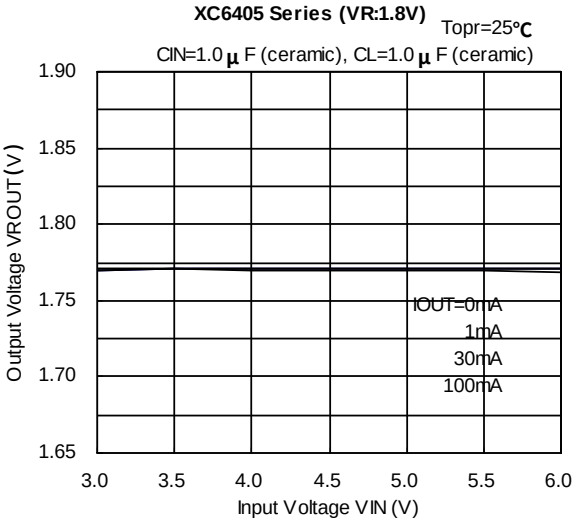
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

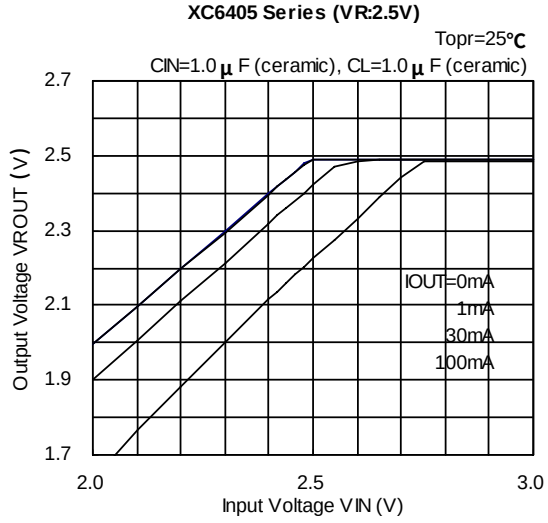
(2) VR Output Voltage vs. Input Voltage

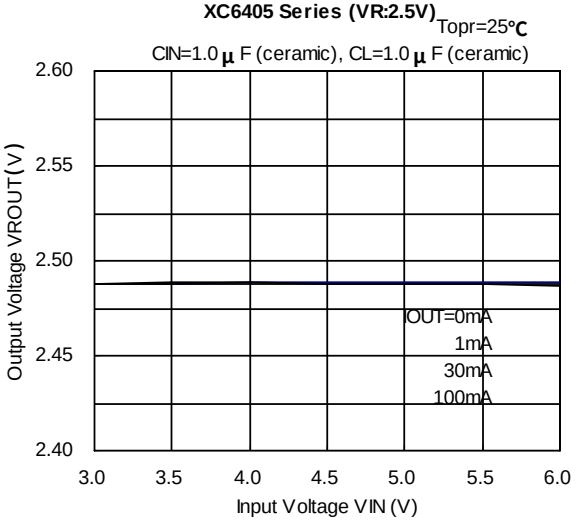






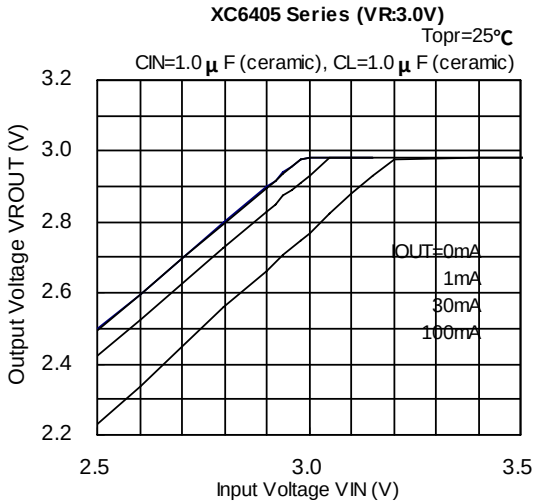


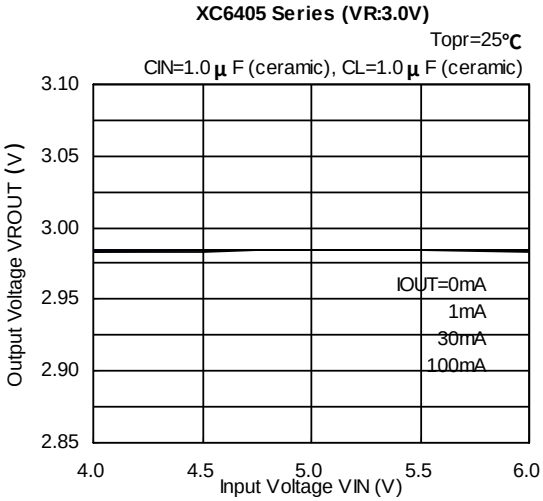


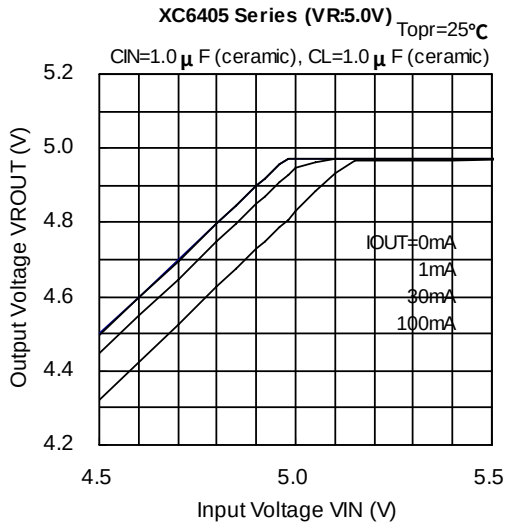


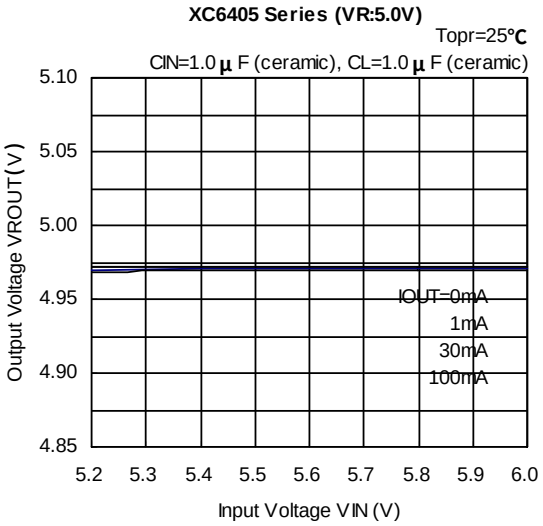
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

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





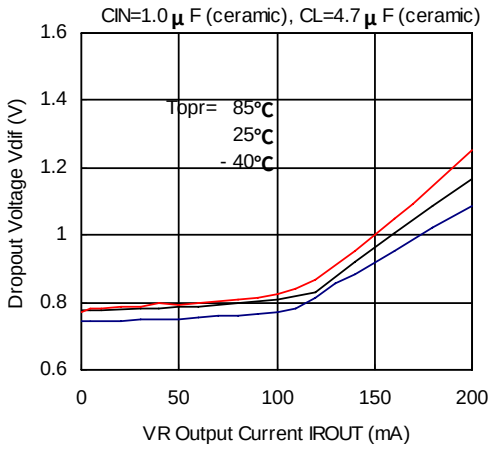




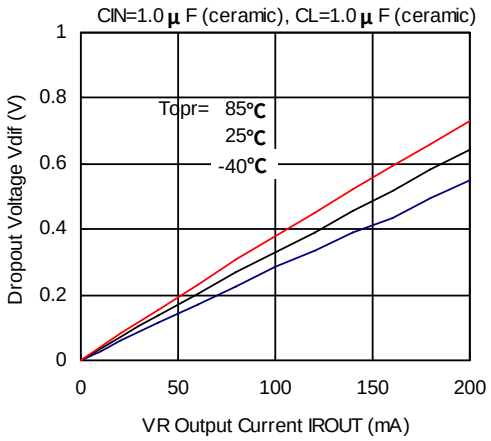
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(3) Dropout Voltage vs. VR Output Current

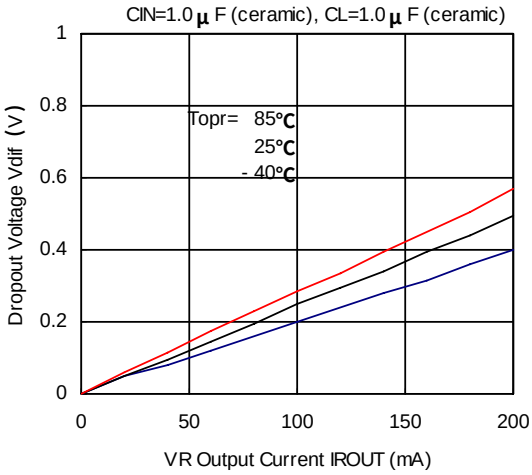
XC6405 Series (VR:0.9V)



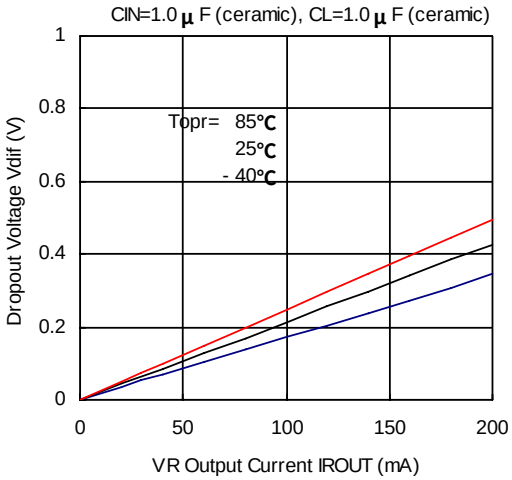
XC6405 Series (VR:1.8V)



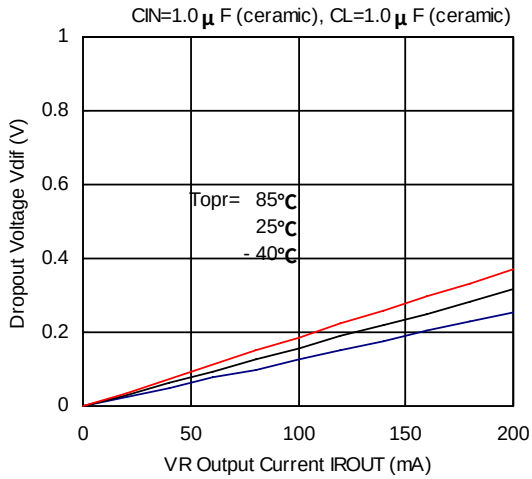
XC6405 Series (VR:2.5V)



XC6405 Series (VR:3.0V)



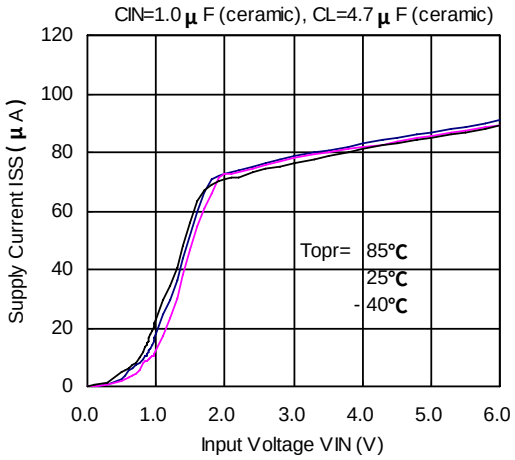
XC6405 Series (VR:5.0V)



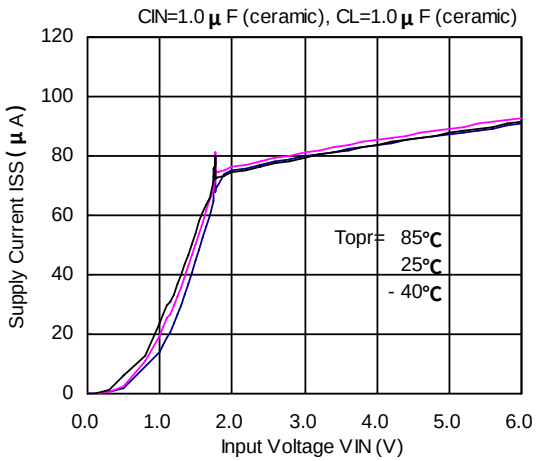
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(4) Supply Current vs. Input Voltage

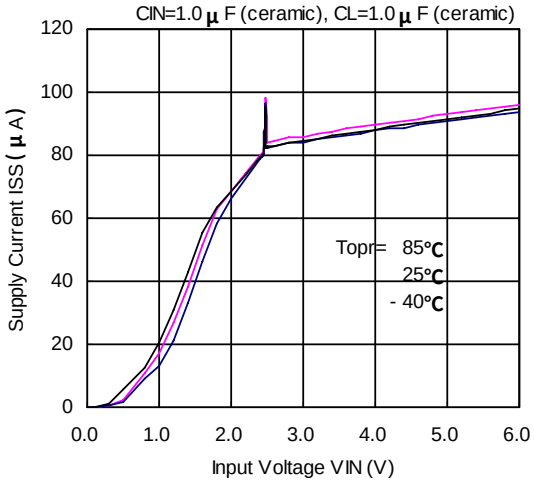
XC6405 Series (VR:0.9)



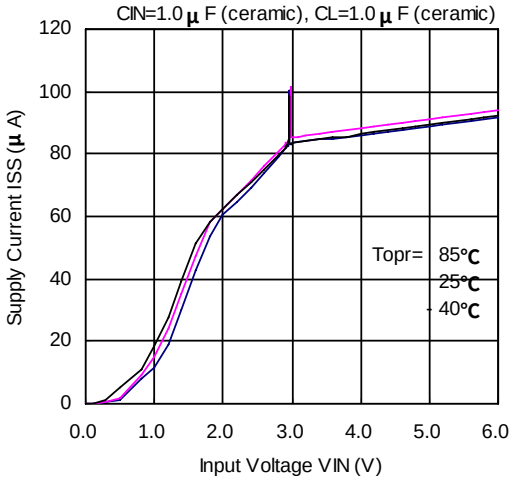
XC6403 Series (VR:1.8V)



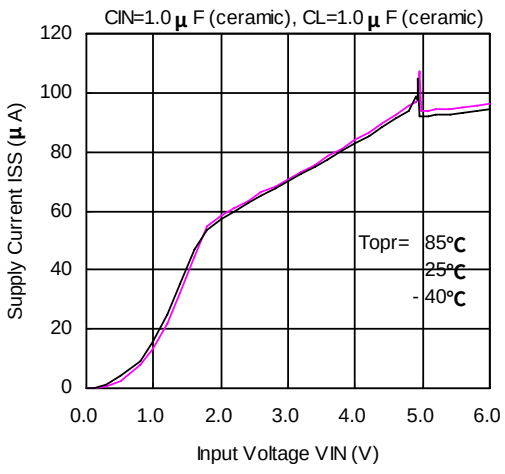
XC6405 Series (VR:2.5V)



XC6405 Series (VR:3.0V)

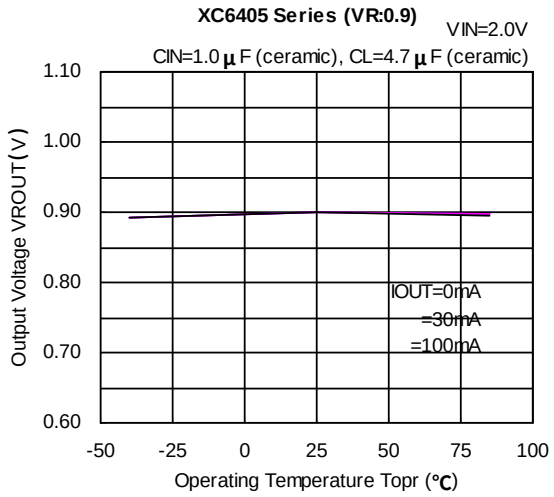


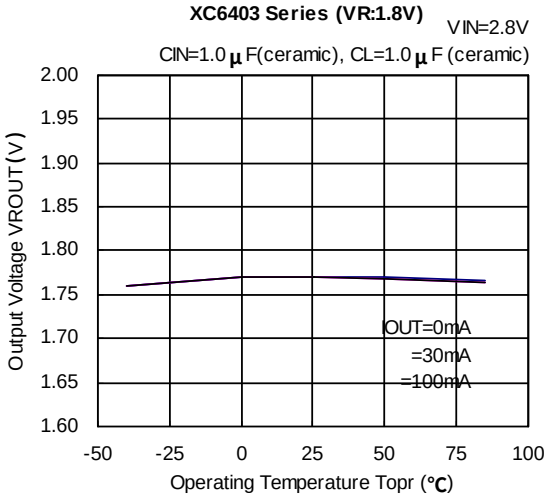
XC6405 Series (VR:5.0V)

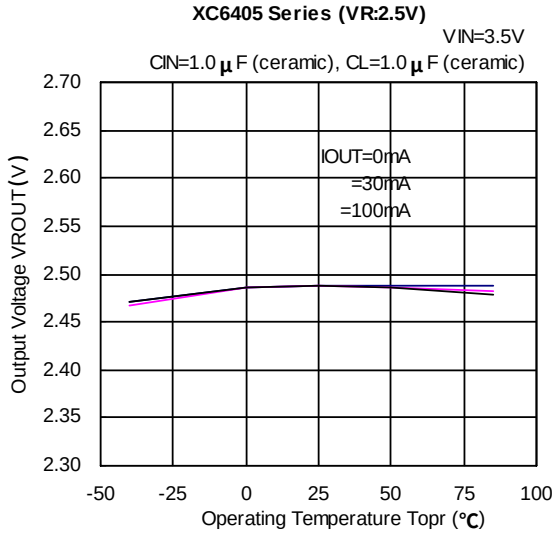


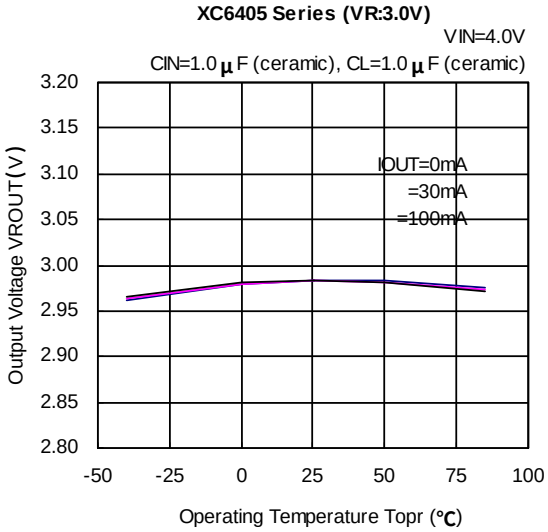
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

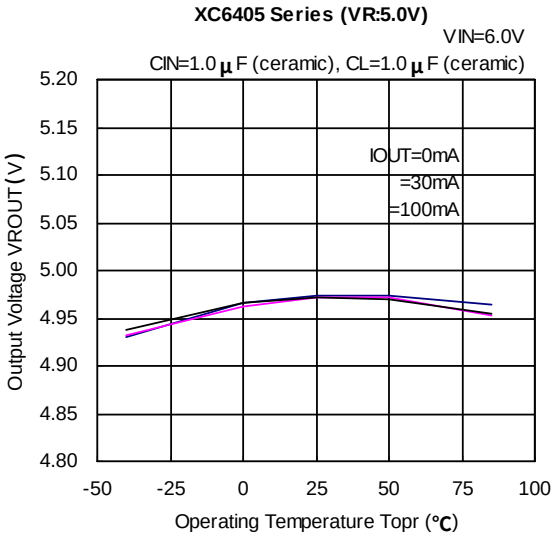
(5) VR Output Voltage vs. Operating Temperature







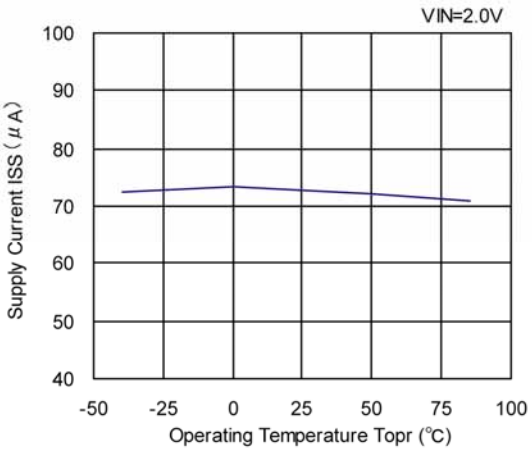




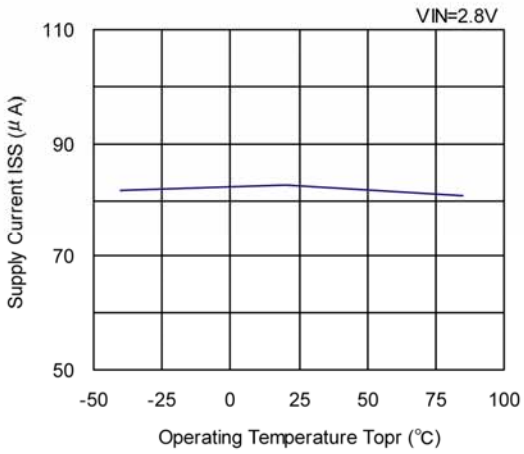
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(6) Supply Current vs. Operating Temperature

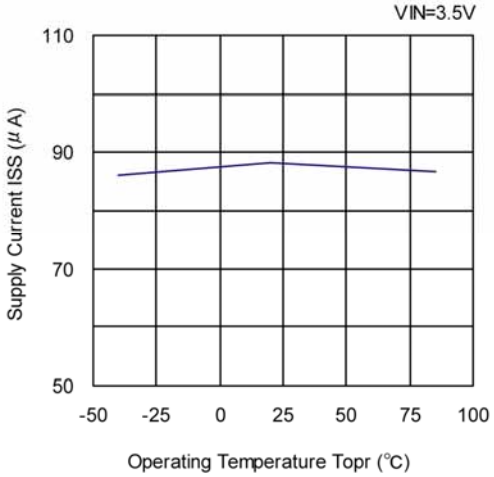
XC6405 Series (VR:0.9)



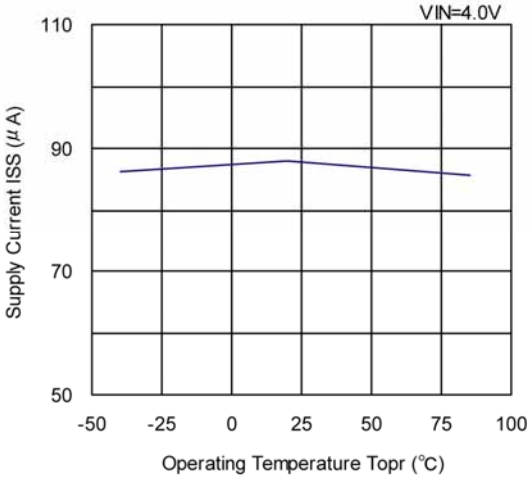
XC6403 Series (VR:1.8V)



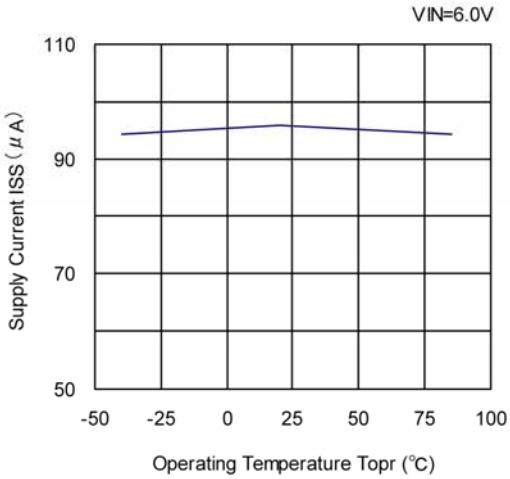
XC6405 Series (VR:2.5V)



XC6405 Series (VR:3.0V)

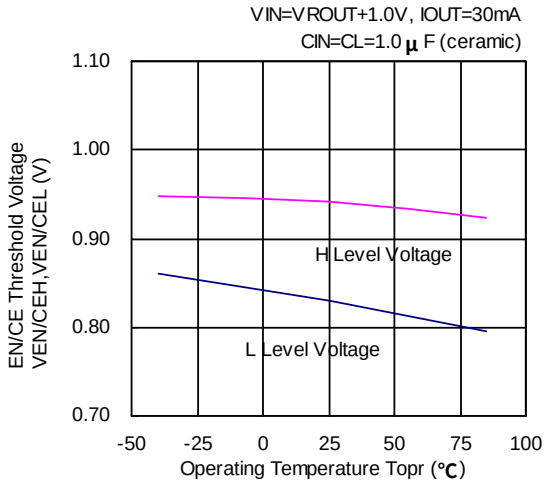


XC6405 Series (VR:5.0V)

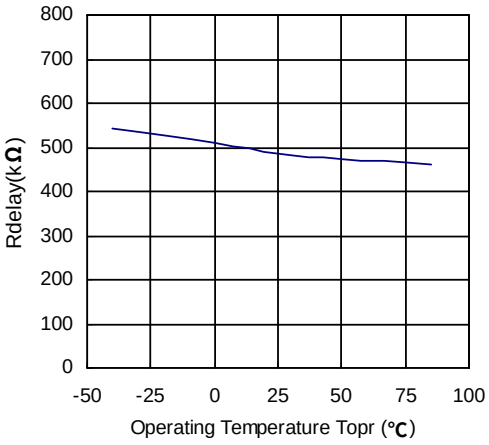


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

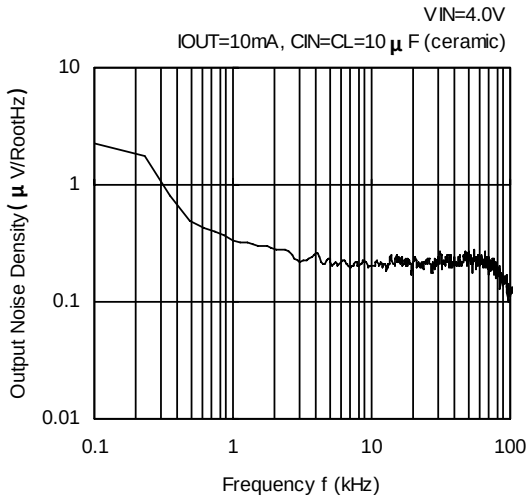
(7) EN/CE Threshold Voltage vs. Operating Temperature



(8) Rdelay vs. Operating Temperature



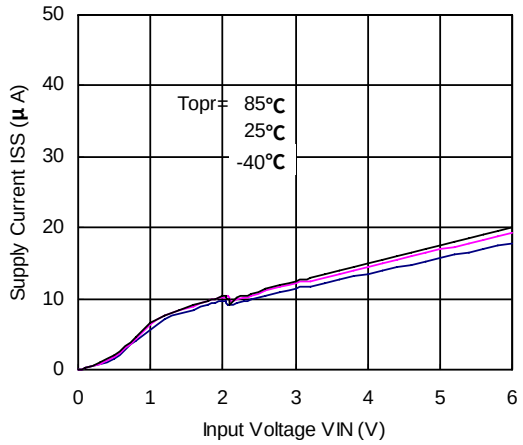
(9) Output Noise Density



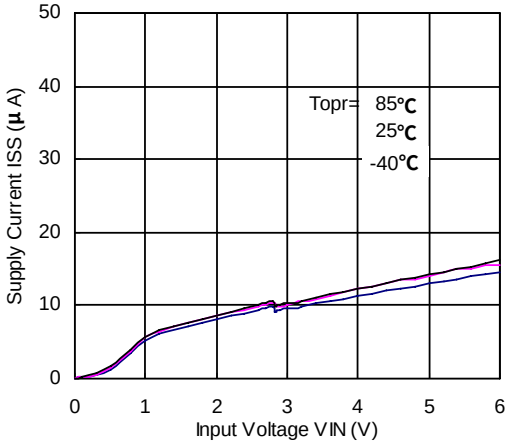
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(10) VD Supply Current vs. Input Voltage (For A to C Series only)

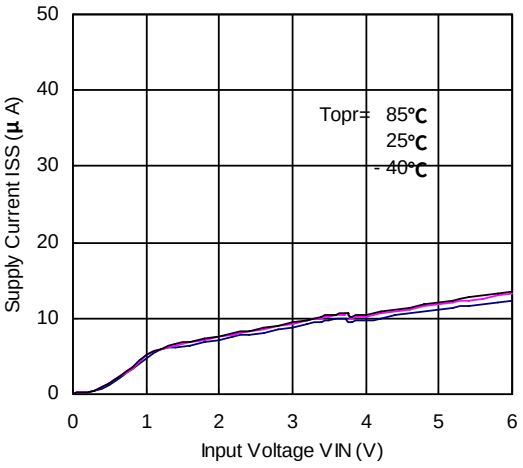
XC6405 Series (VD:2.0V)



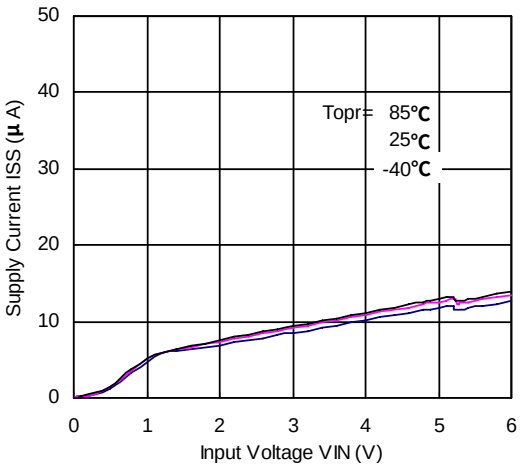
XC6405 Series (VD:2.7V)



XC6405 Series (VD:3.6V)



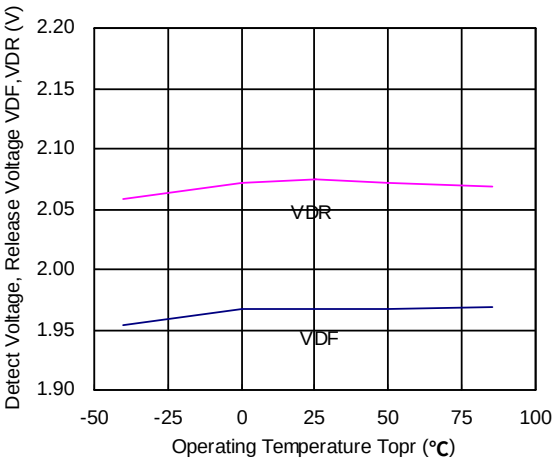
XC6405 Series (VD:5.0V)



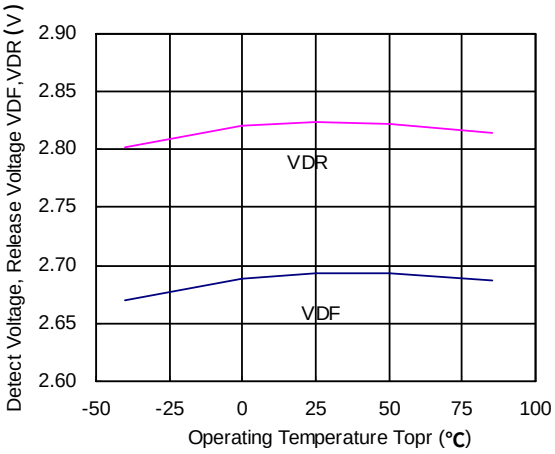
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(11) Detect Voltage & Release Voltage vs. Operating Temperature

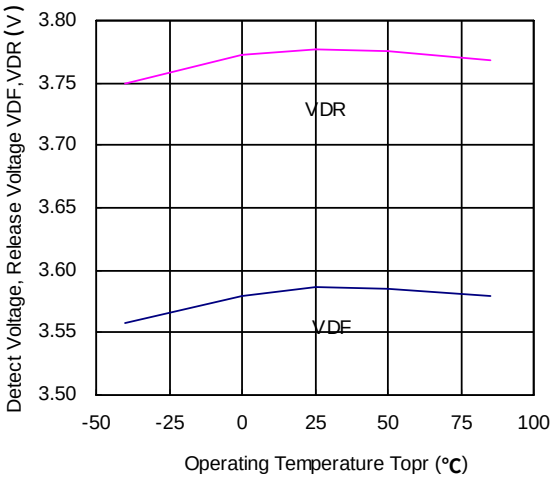
XC6405 Series (VD:2.0V)



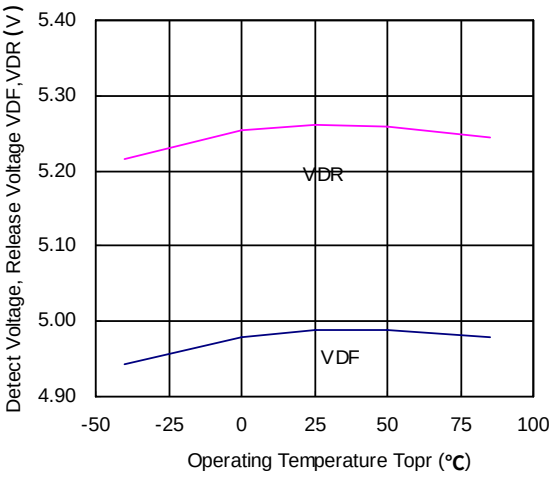
XC6405 Series (VD:2.7V)



XC6405 Series (VD:3.6V)



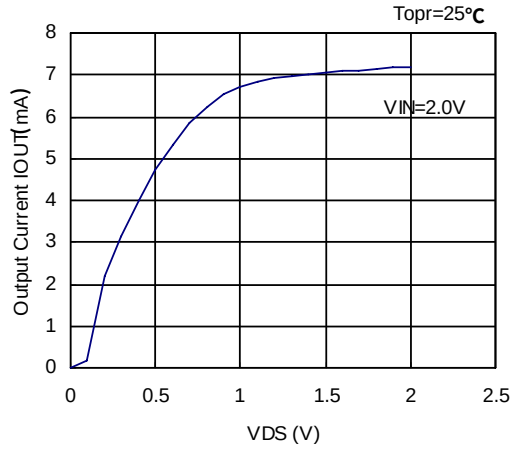
XC6405 Series (VD:5.0V)



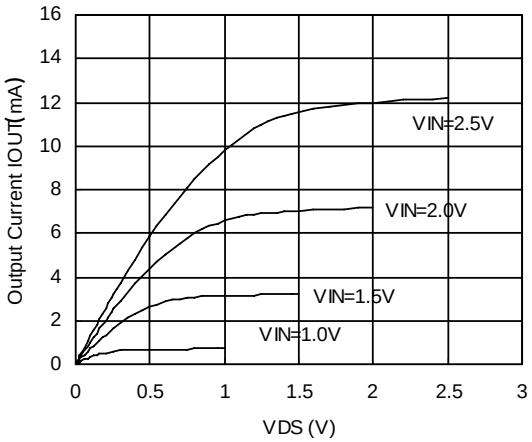
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

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

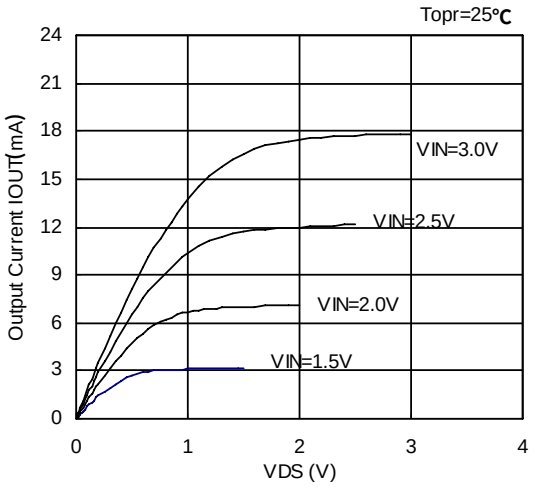
XC6405 Series (VD:2.0V)



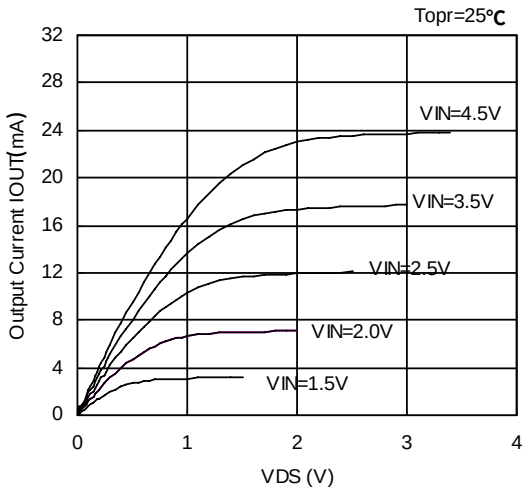
XC6405 Series (VD:2.7V)



XC6405 Series (VD:3.6V)



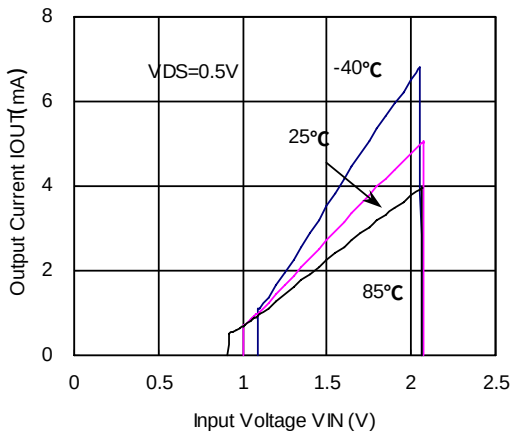
XC6405 Series (VD:5.0V)



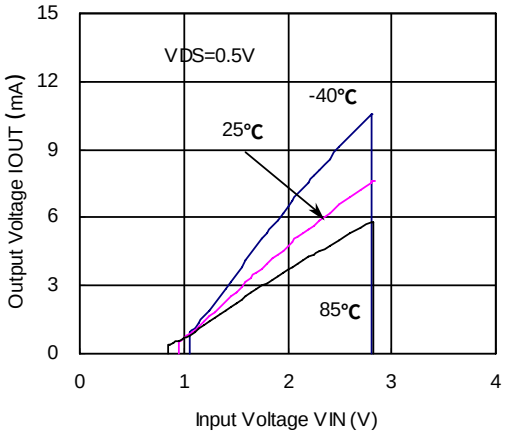
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

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

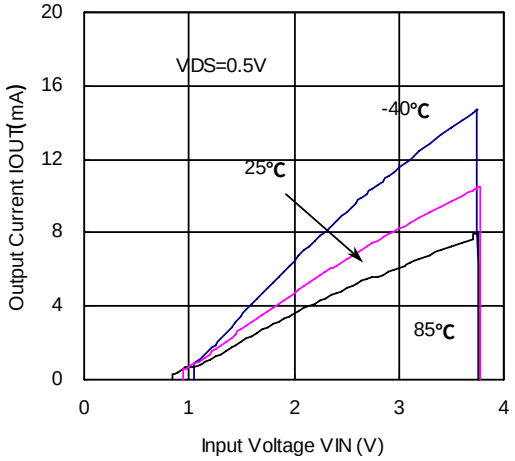
XC6405 Series (VD:2.0V)



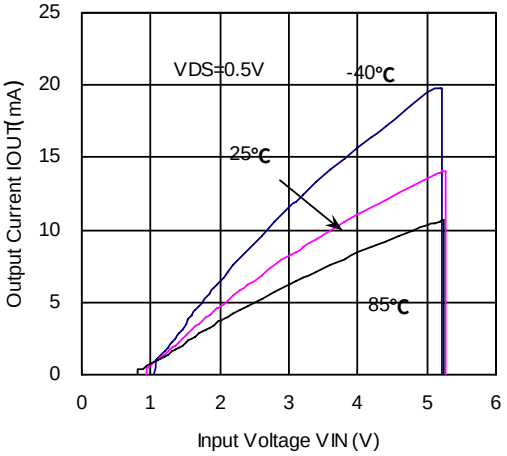
XC6405 Series (VD:2.7V)



XC6405 Series (VD:3.6V)

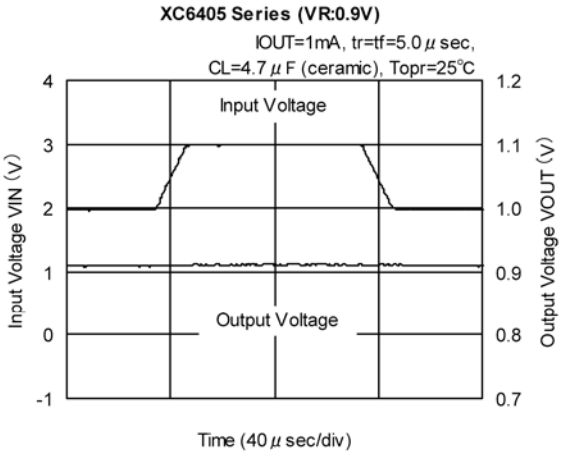


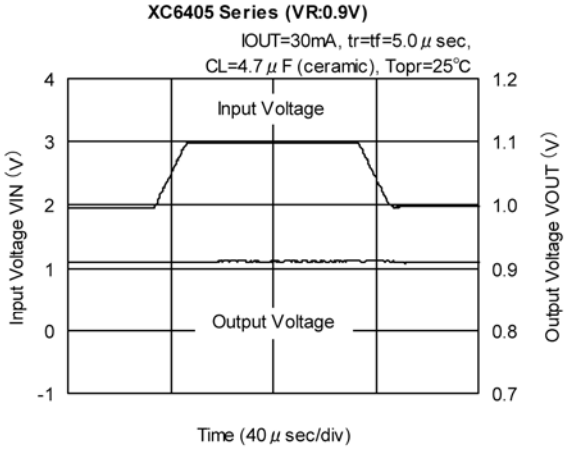
XC6405 Series (VD:5.0V)

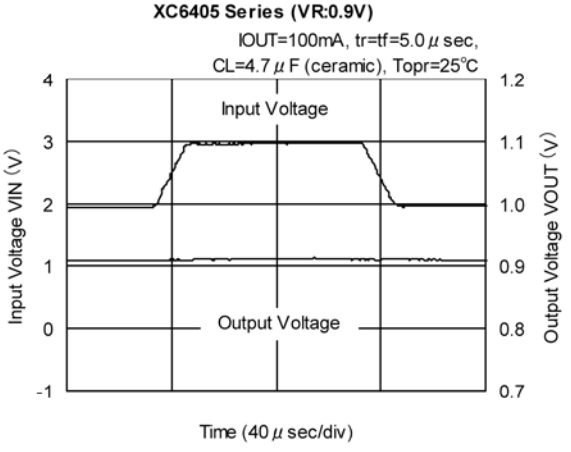


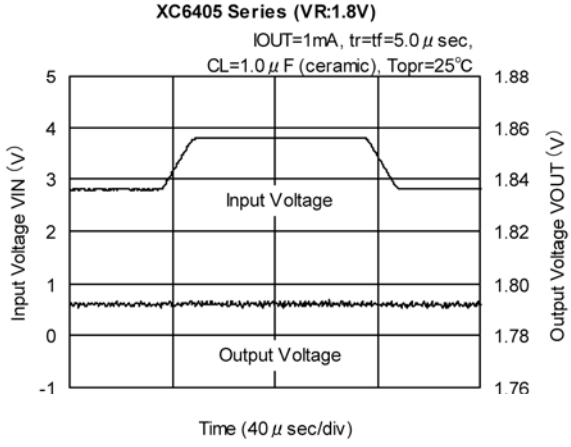
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

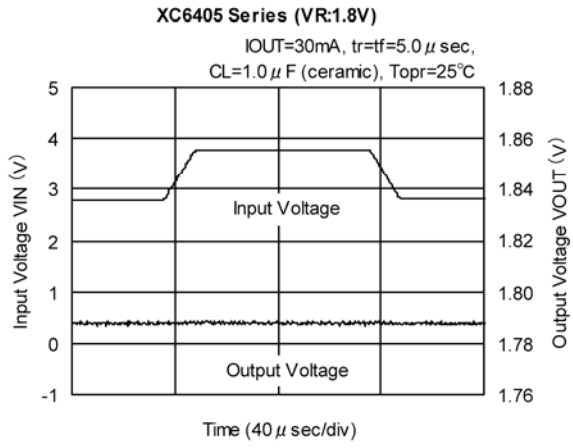
(14) Input Transient Response

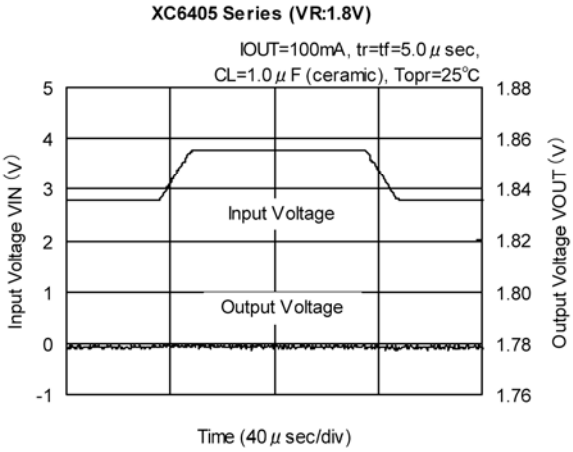






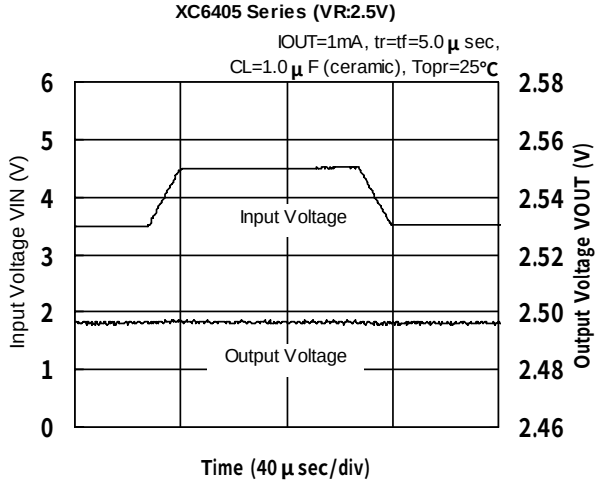


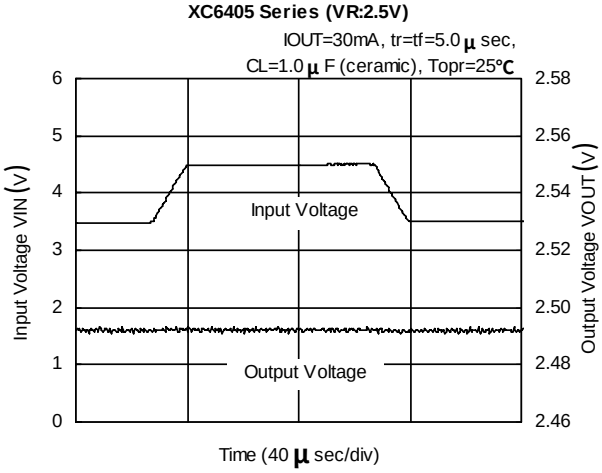


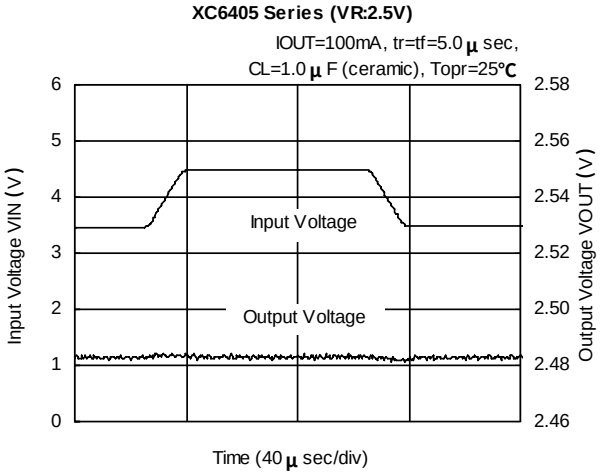


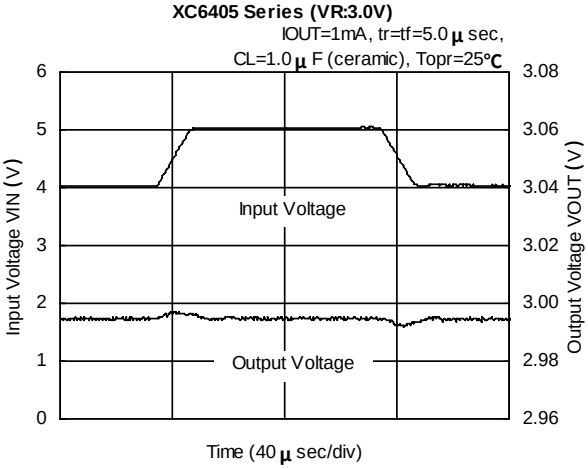
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

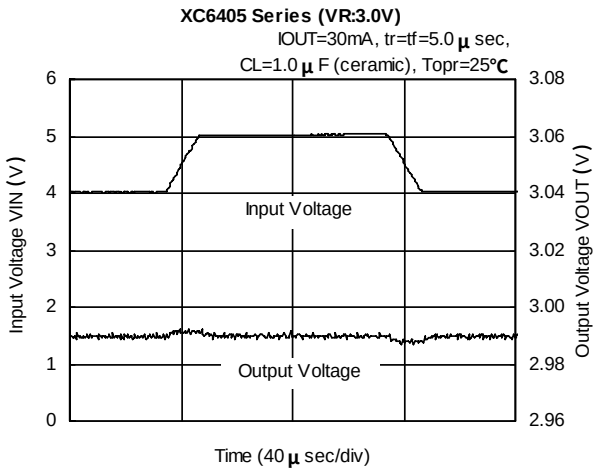
(14) Input Transient Response (Continued)

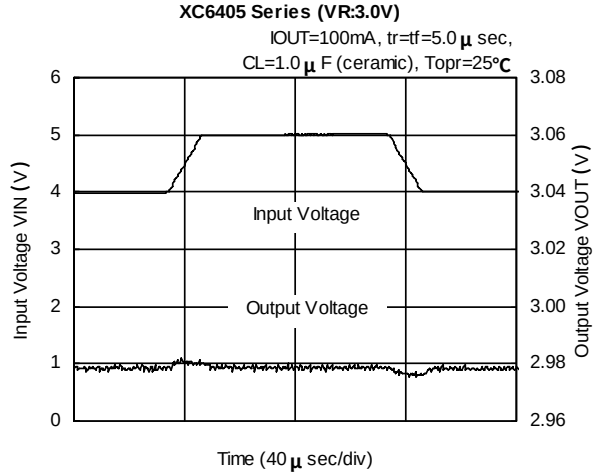










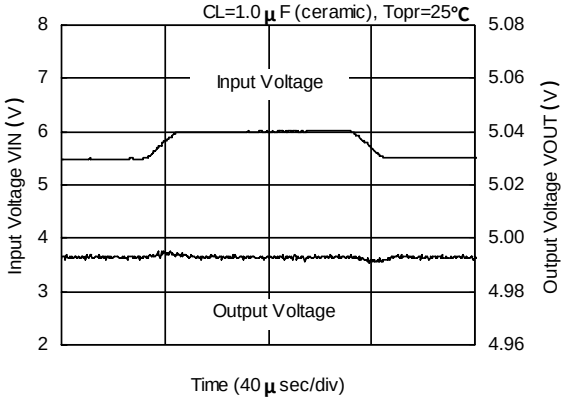


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(14) Input Transient Response (Continued)

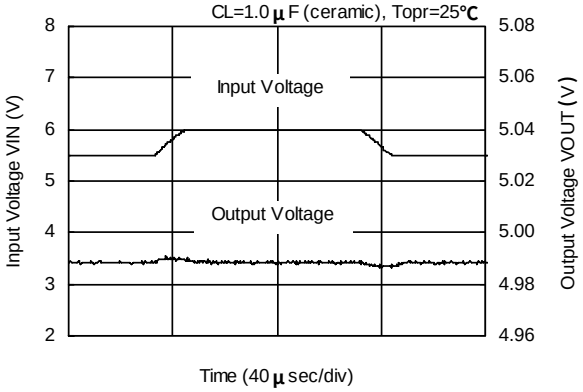
XC6405 Series (VR:5.0V)

IOUT=1mA, tr=tf=5.0μsec,
CL=1.0μF (ceramic), Topr=25℃



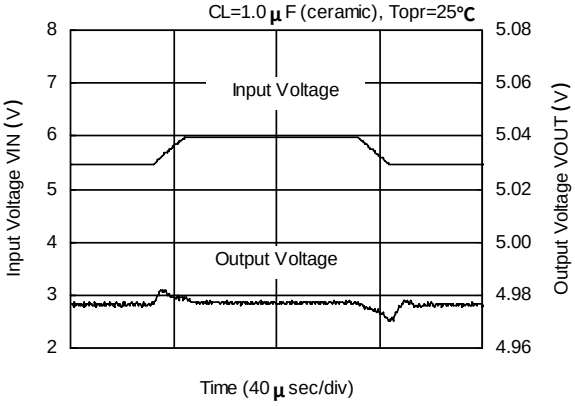
XC6405 Series (VR:5.0V)

IOUT=30mA, tr=tf=5.0μsec,
CL=1.0μF (ceramic), Topr=25℃



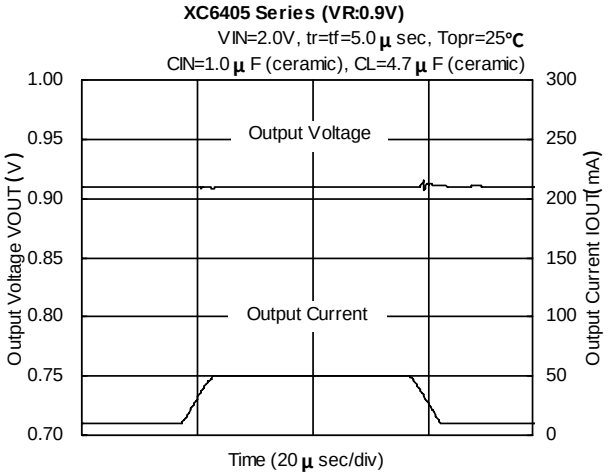
XC6405 Series (VR:5.0V)

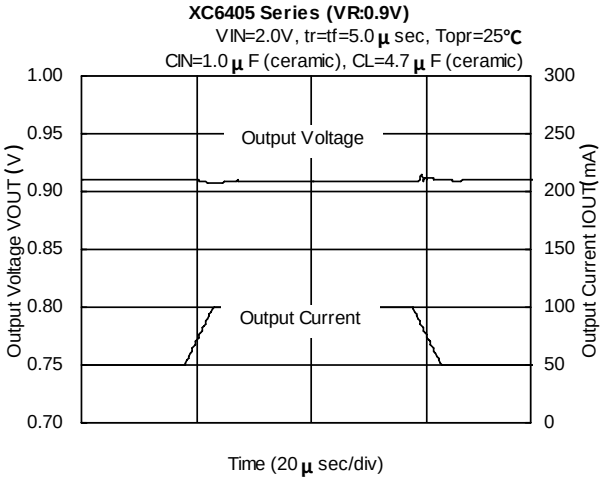
IOUT=100mA, tr=tf=5.0μsec,
CL=1.0μF (ceramic), Topr=25℃

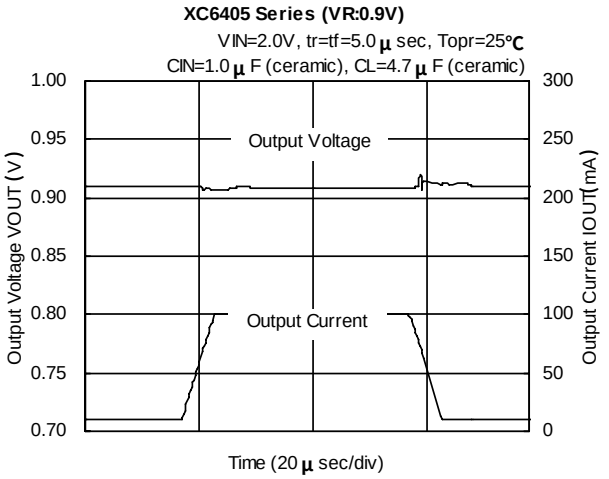


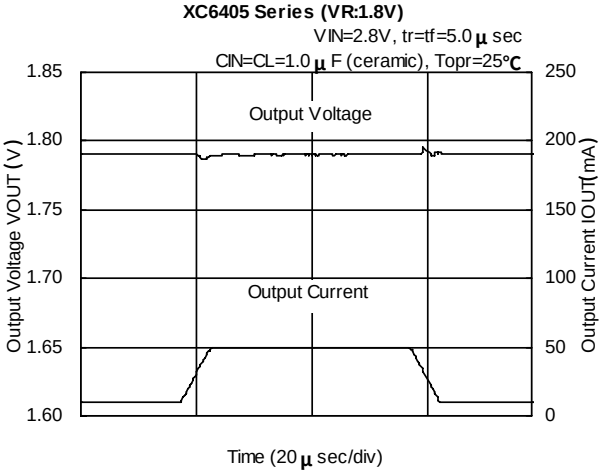
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

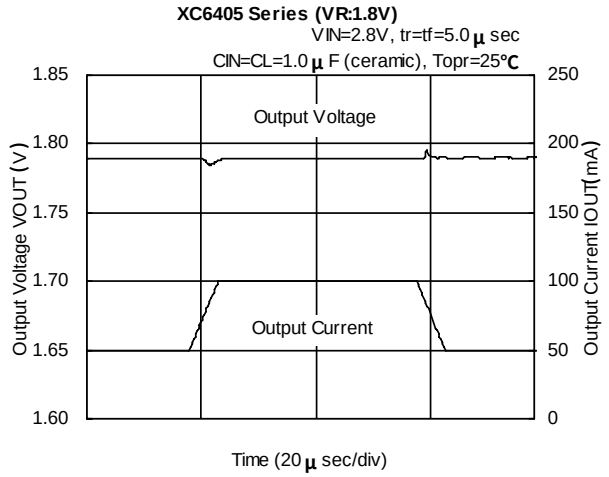
(15) Load Transient Response

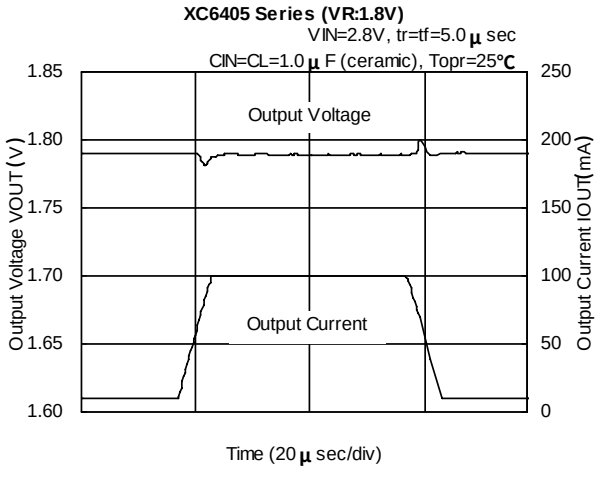






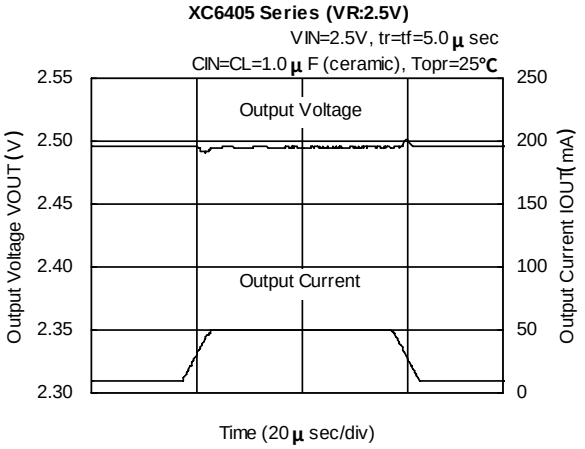


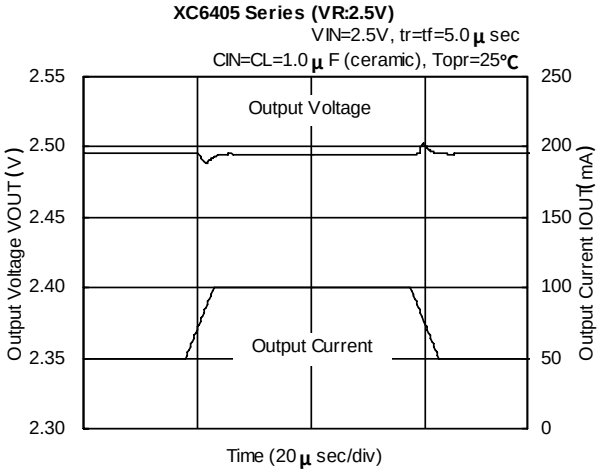


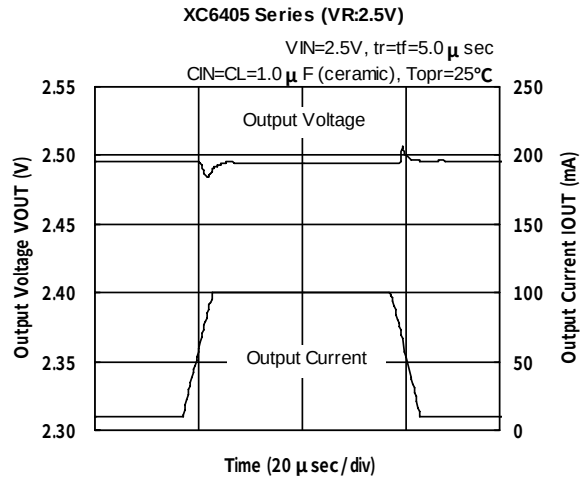


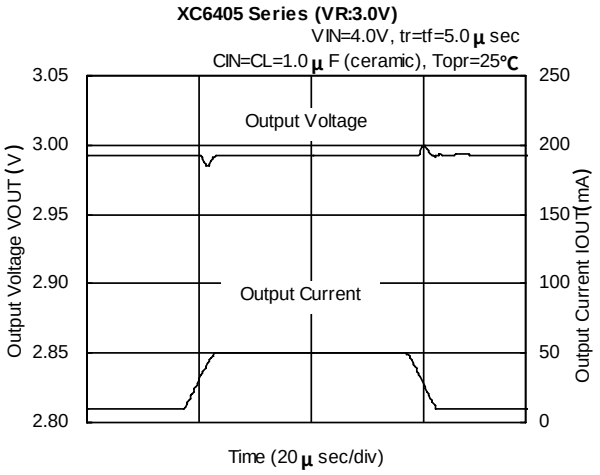
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

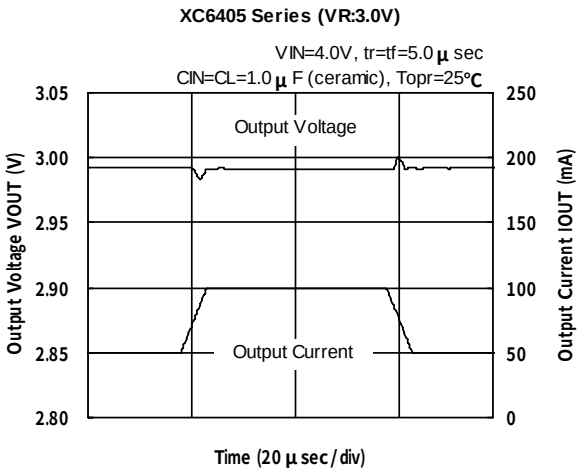
(15) Load Transient Response (Continued)

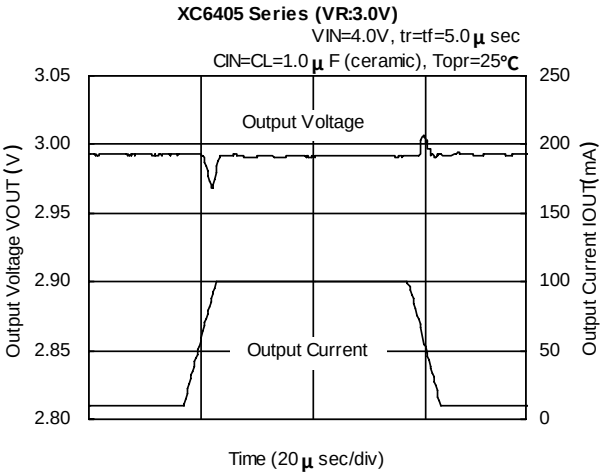






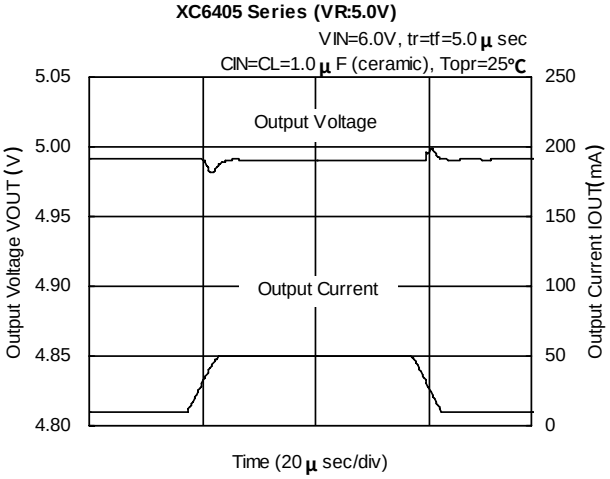


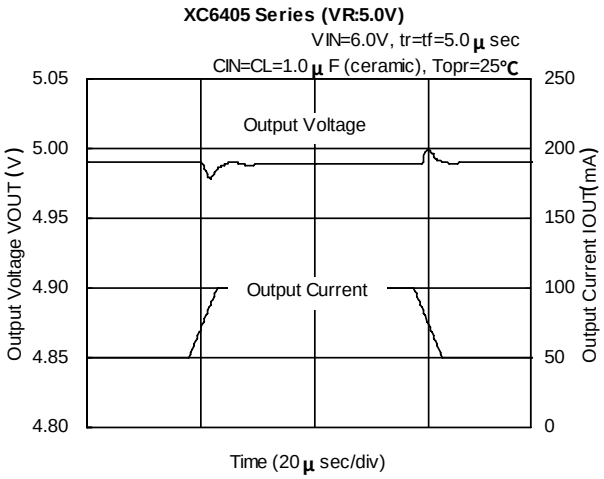


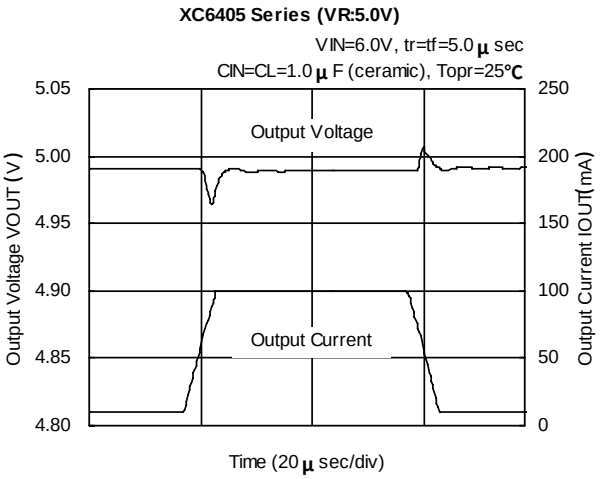


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(15) Load Transient Response (Continued)





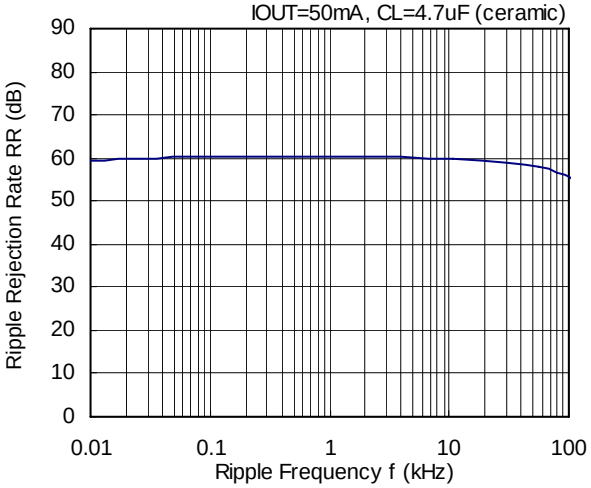


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(16) Ripple Rejection Rate

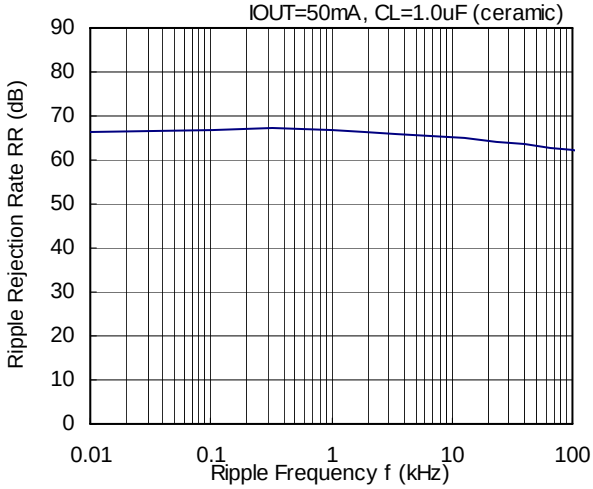
XC6405 Series (VR:0.9V)

VIN=2.25VDC+0.5Vp-pAC,
IOUT=50mA, CL=4.7uF (ceramic)



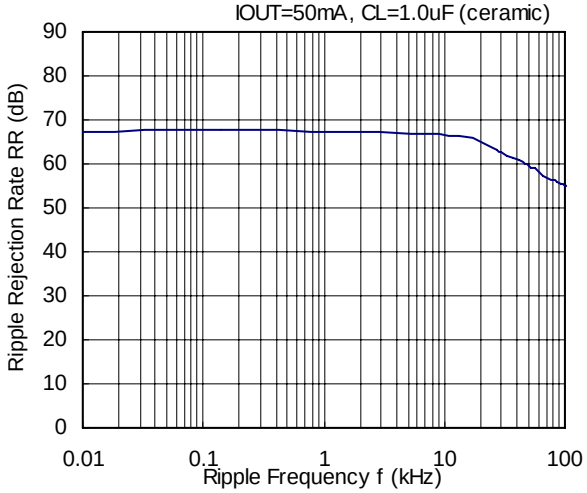
XC6405 Series (VR:1.8V)

VIN=2.8VDC+1.0Vp-pAC,
IOUT=50mA, CL=1.0uF (ceramic)



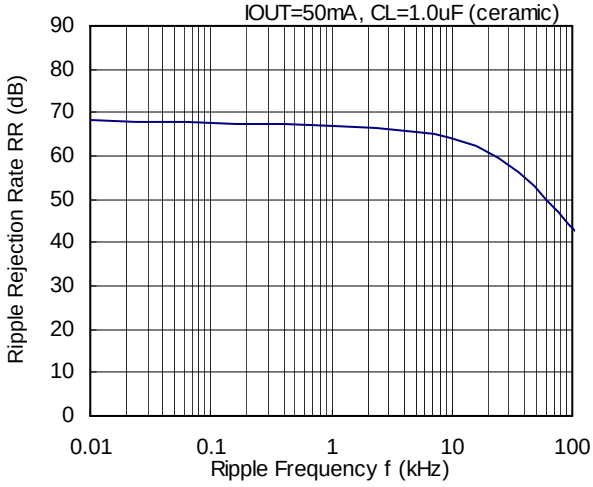
XC6405 Series (VR:2.5V)

VIN=3.5VDC+1.0Vp-pAC,
IOUT=50mA, CL=1.0uF (ceramic)



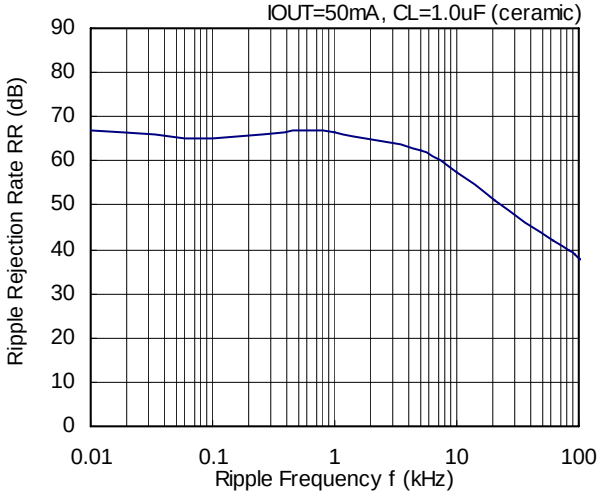
XC6405 Series (VR:3.0V)

VIN=4.0VDC+1.0Vp-pAC,
IOUT=50mA, CL=1.0uF (ceramic)



XC6405 Series (VR:5.0V)

VIN=5.75VDC+0.5Vp-pAC,
IOUT=50mA, CL=1.0uF (ceramic)



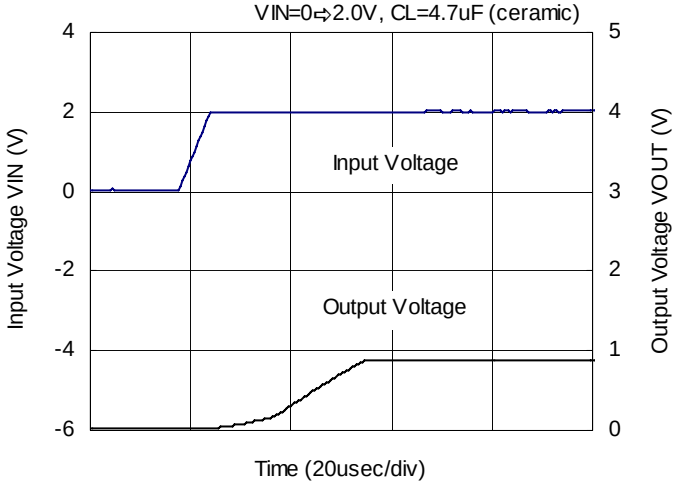
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(17) Rising Response Time

XC6405 Series (VR: 0.9V)

IOUT=1mA, tr=5.0usec

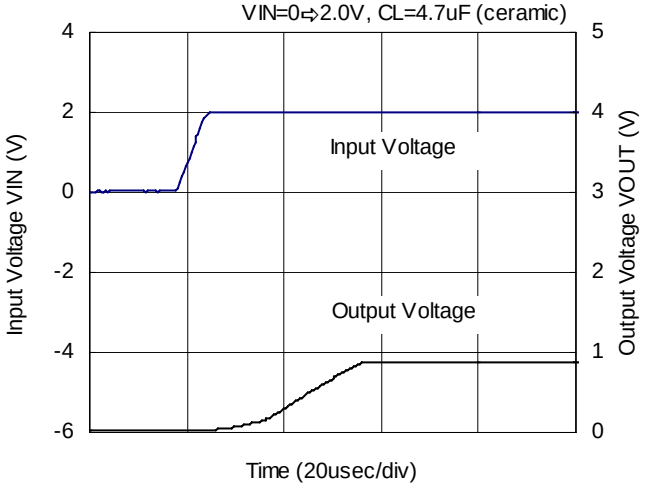
VIN=0⇨2.0V, CL=4.7uF (ceramic)



XC6405 Series (VR: 0.9V)

IOUT=30mA, tr=5.0usec

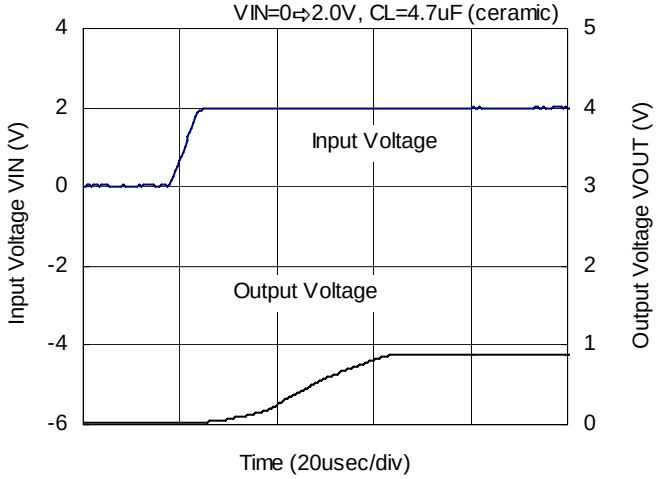
VIN=0⇨2.0V, CL=4.7uF (ceramic)



XC6405 Series (VR: 0.9V)

IOUT=100mA, tr=5.0usec

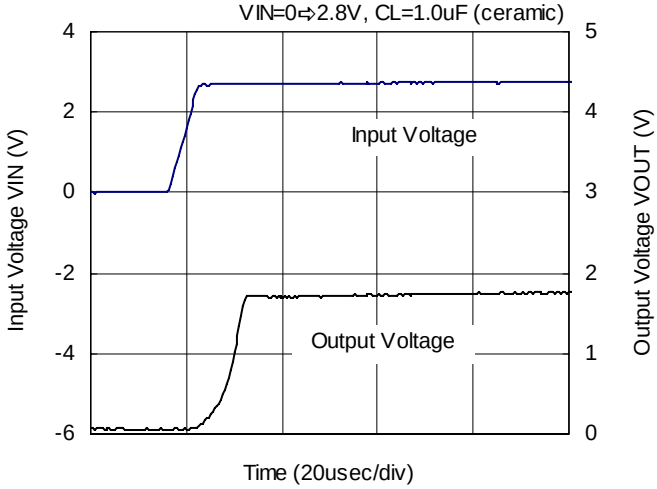
VIN=0⇨2.0V, CL=4.7uF (ceramic)



XC6405 Series (VR: 1.8V)

IOUT=1mA, tr=5.0usec

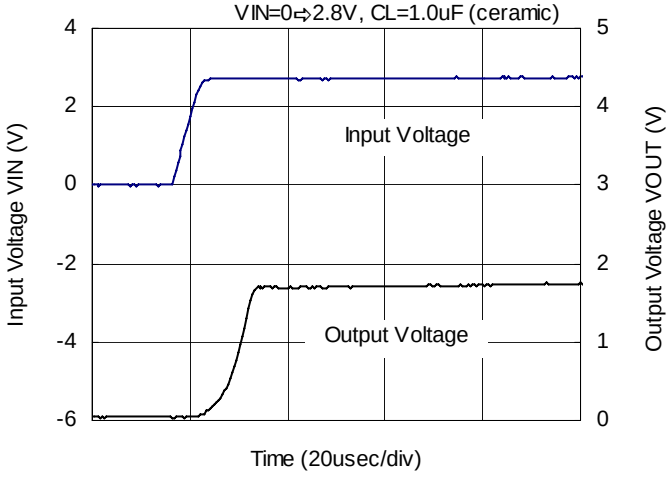
VIN=0⇨2.8V, CL=1.0uF (ceramic)



XC6405 Series (VR: 1.8V)

IOUT=30mA, tr=5.0usec

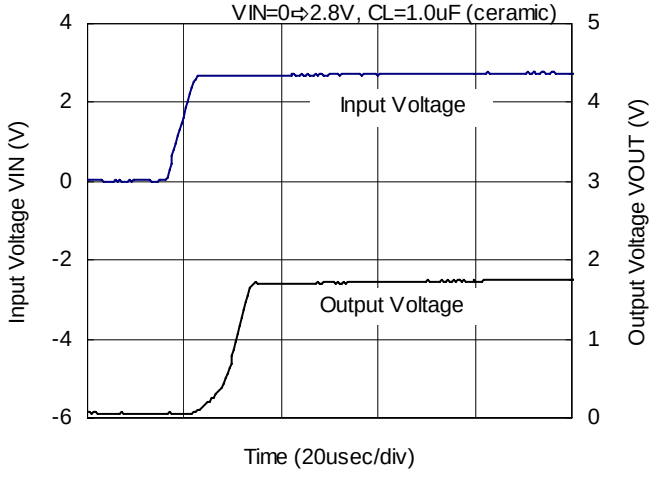
VIN=0⇨2.8V, CL=1.0uF (ceramic)



XC6405 Series (VR: 1.8V)

IOUT=100mA, tr=5.0usec

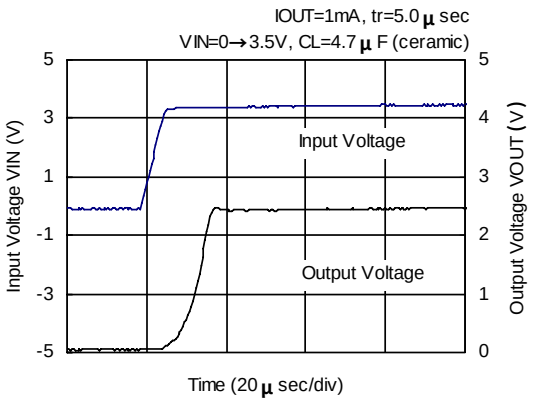
VIN=0⇨2.8V, CL=1.0uF (ceramic)



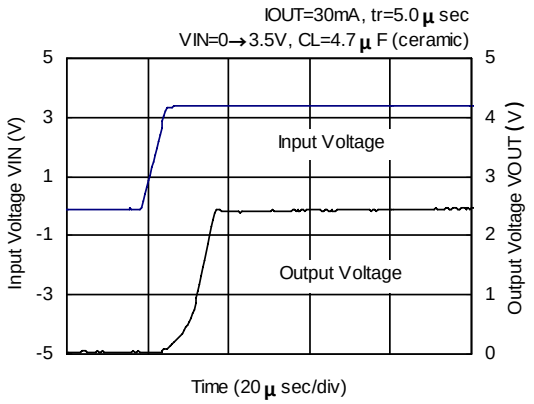
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(17) Rising Response Time (Continued)

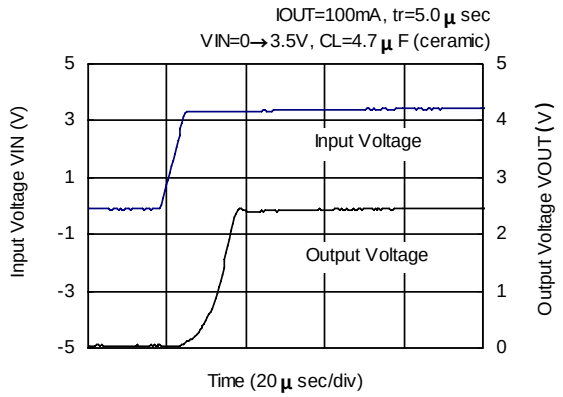
XC6405 Series (VR:2.5V)



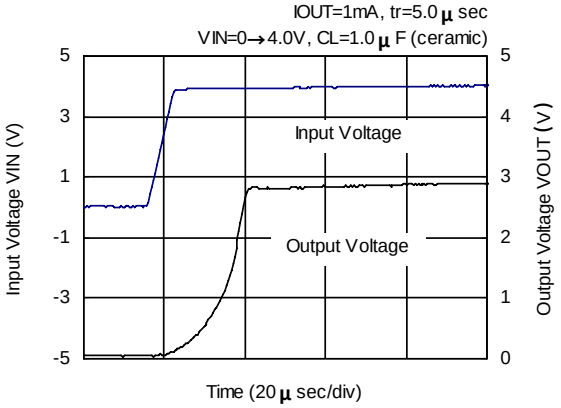
XC6405 Series (VR:2.5V)



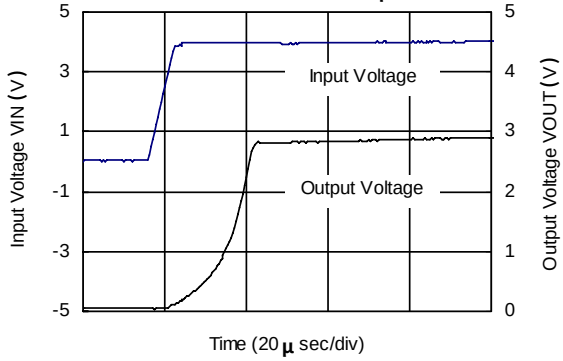
XC6405 Series (VR:2.5V)



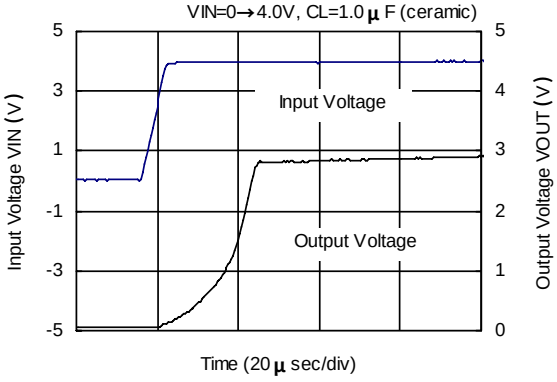
XC6405 Series (VR:3.0V)



XC6405 Series (VR:3.0V)

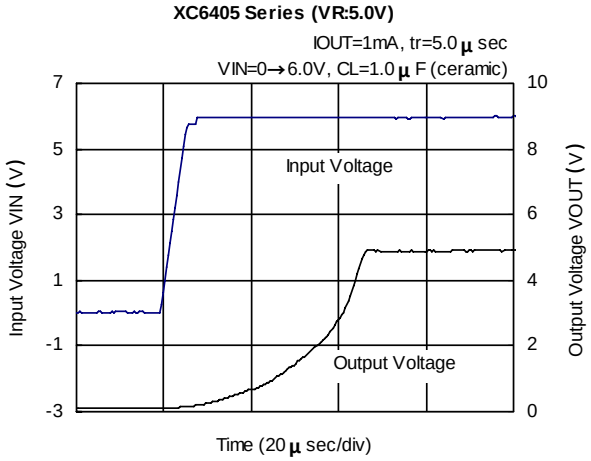


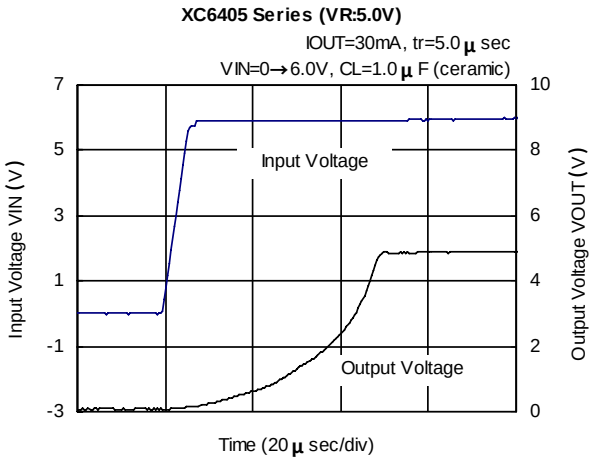
XC6405 Series (VR:3.0V)

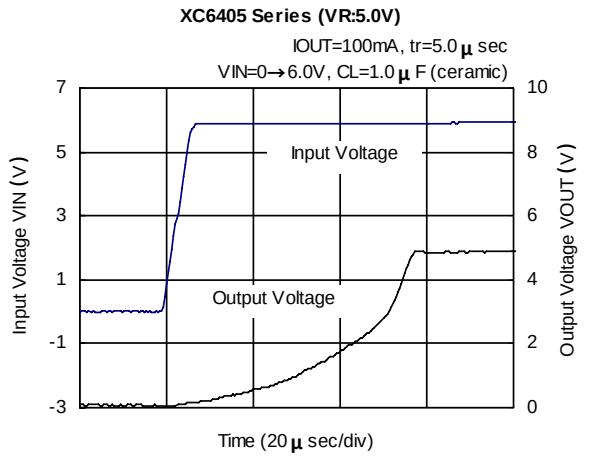


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(18) EN/CE Rising Response Time





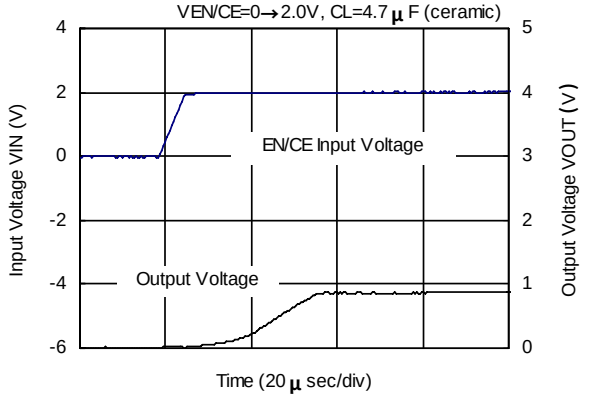


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(18) EN/CE Rising Response Time (Continued)

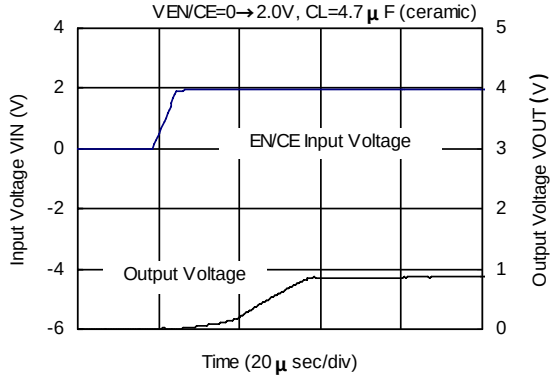
XC6405 Series (VR:0.9V)

VIN=2.0V, IOUT=1mA, tr=5.0μsec
VEN/CE=0→2.0V, CL=4.7μF (ceramic)



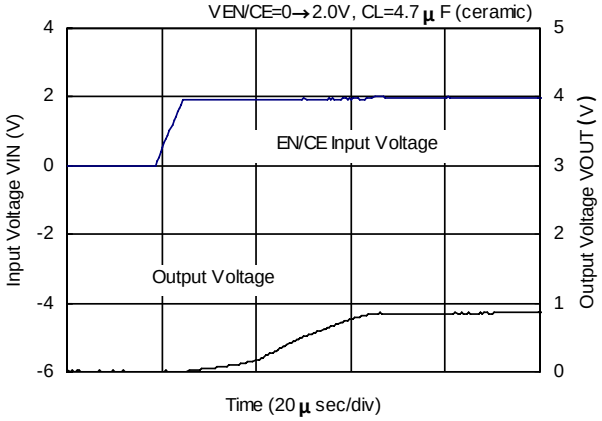
XC6405 Series (VR:0.9V)

VIN=2.0V, IOUT=30mA, tr=5.0μsec
VEN/CE=0→2.0V, CL=4.7μF (ceramic)



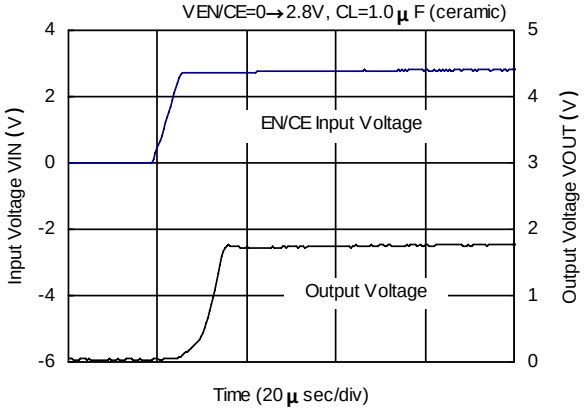
XC6405 Series (VR:0.9V)

VIN=2.0V, IOUT=100mA, tr=5.0μsec
VEN/CE=0→2.0V, CL=4.7μF (ceramic)



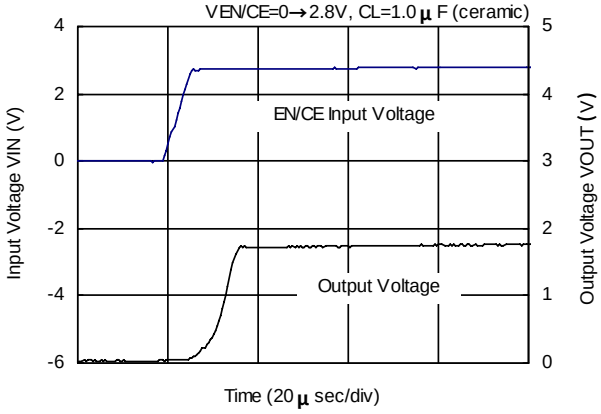
XC6405 Series (VR:1.8V)

VIN=2.8V, IOUT=1mA, tr=5.0μsec
VEN/CE=0→2.8V, CL=1.0μF (ceramic)



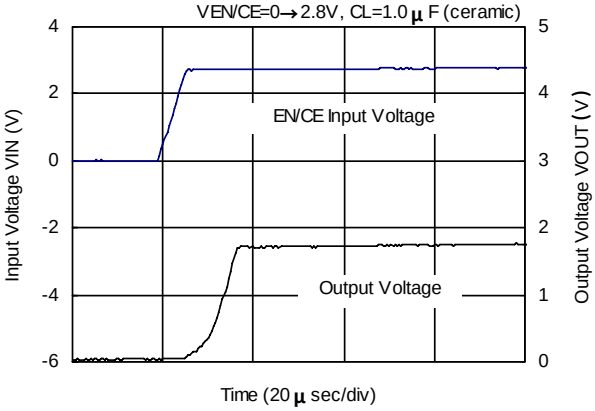
XC6405 Series (VR:1.8V)

VIN=2.8V, IOUT=30mA, tr=5.0μsec
VEN/CE=0→2.8V, CL=1.0μF (ceramic)



XC6405 Series (VR:1.8V)

VIN=2.8V, IOUT=100mA, tr=5.0μsec
VEN/CE=0→2.8V, CL=1.0μF (ceramic)

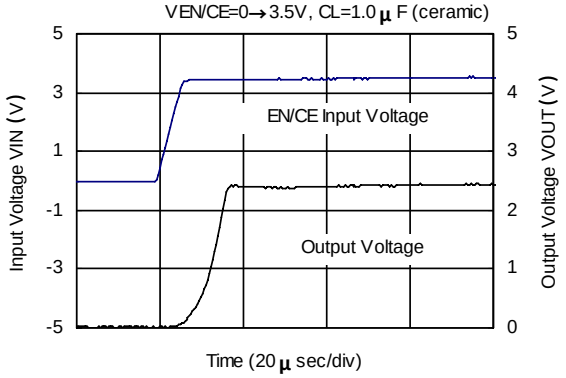


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(18) EN/CE Rising Response Time (Continued)

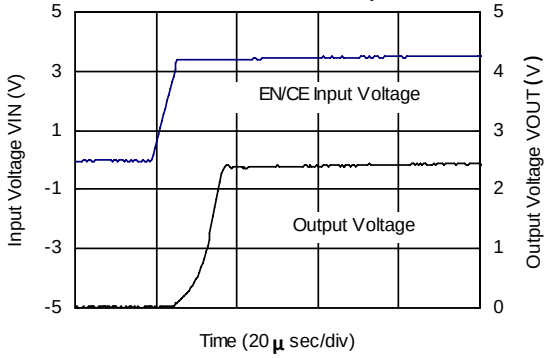
XC6405 Series (VR:2.5V)

VIN=3.5V, IOUT=1mA, tr=5.0μsec
VEN/CE=0→3.5V, CL=1.0μF (ceramic)



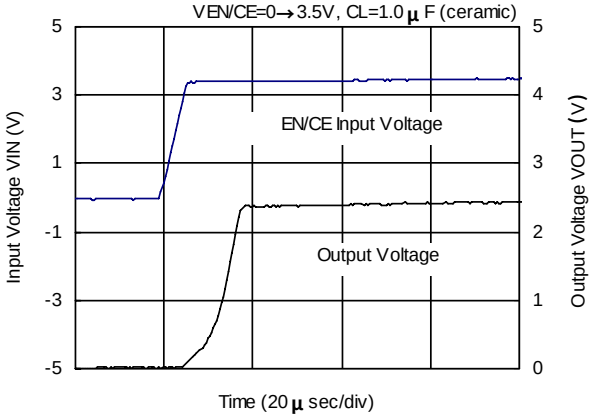
XC6405 Series (VR:2.5V)

VIN=3.5V, IOUT=30mA, tr=5.0μsec
VEN/CE=0→3.5V, CL=1.0μF (ceramic)



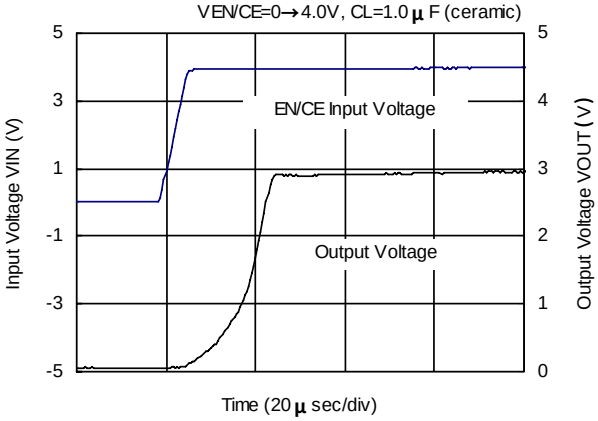
XC6405 Series (VR:2.5V)

VIN=3.5V, IOUT=100mA, tr=5.0μsec
VEN/CE=0→3.5V, CL=1.0μF (ceramic)



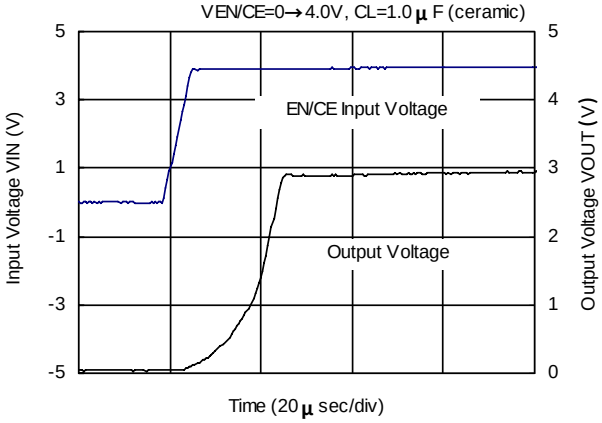
XC6405 Series (VR:3.0V)

VIN=4.0V, IOUT=1mA, tr=5.0μsec
VEN/CE=0→4.0V, CL=1.0μF (ceramic)



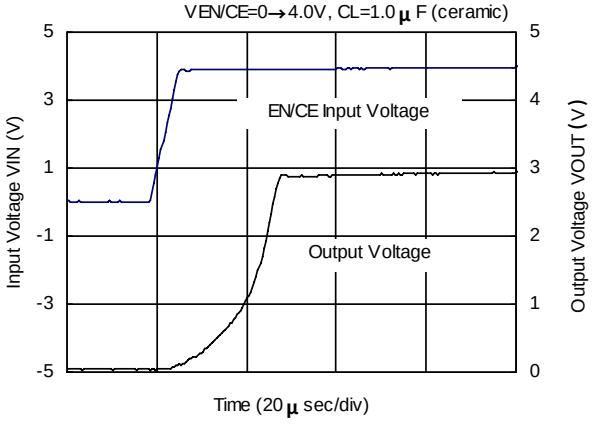
XC6405 Series (VR:3.0V)

VIN=4.0V, IOUT=30mA, tr=5.0μsec
VEN/CE=0→4.0V, CL=1.0μF (ceramic)



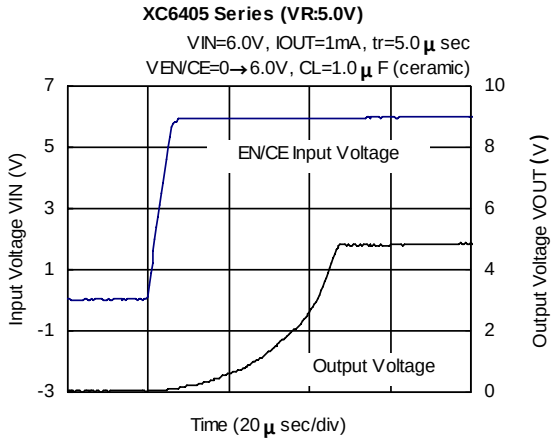
XC6405 Series (VR:3.0V)

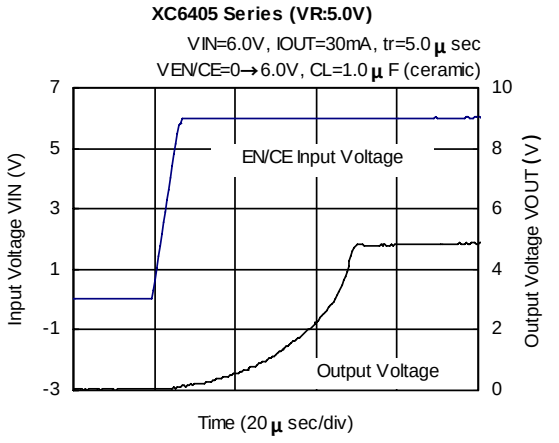
VIN=4.0V, IOUT=100mA, tr=5.0μsec
VEN/CE=0→4.0V, CL=1.0μF (ceramic)

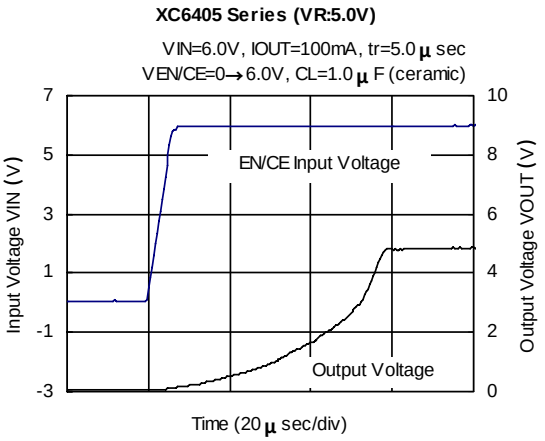


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(18) EN/CE Rising Response Time (Continued)

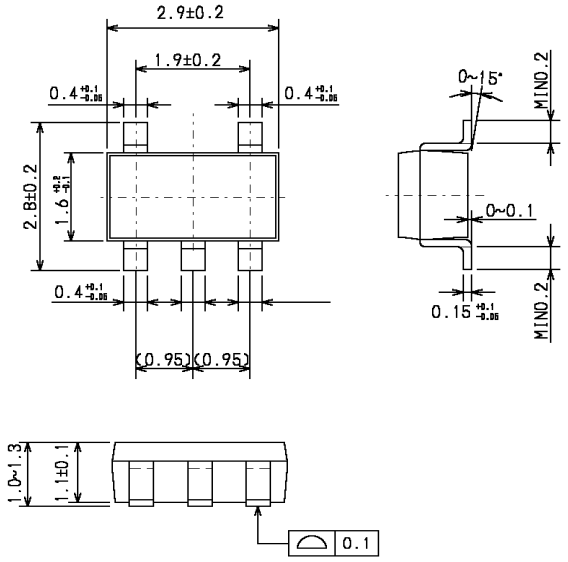




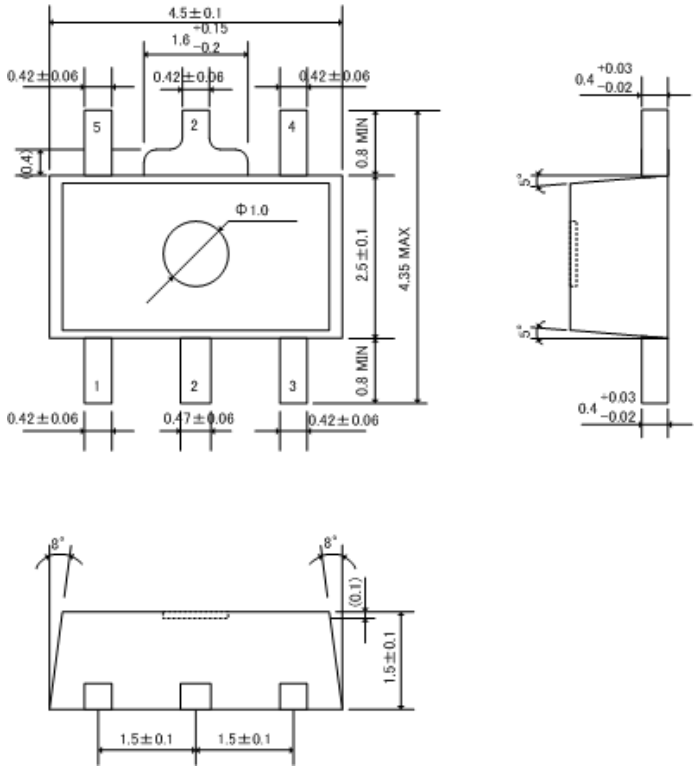


■PACKAGING INFORMATION

●SOT-25

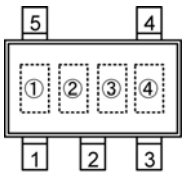


●SOT-89-5

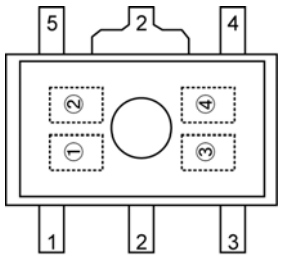


■MARKING RULE

●SOT-25 & SOT-89-5



SOT-25
(TOP VIEW)



SOT-89-5
(TOP VIEW)

① represents product series

MARK	SERIES
5	XC6405xxxxxx

②③ represents internal sequential number
Sequential numbering rule

MARK	NUMBERING RULE
1	01~09
2	10~99
3	A0~A9
4	B0~B9
5	~Z9

*G, I, J, O, Q, W excluded

2) The same marking is printed on the product with same optional functions, product type, detect voltage, and output voltage although packages are different.

④ represents production lot number
0 to 9,A to Z reverse character 0 to 9, A to Z repeated
(G, I, J, O, Q, W excluded)

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