1A LDO Voltage Regulator with “GreenOperation”

■GENERAL DESCRIPTION

☆GreenOperation-Compatible

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

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

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

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

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

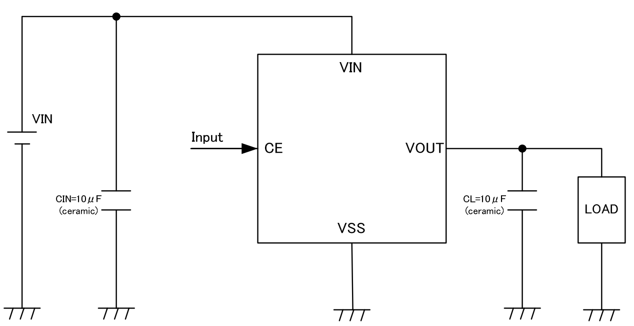
■APPLICATIONS

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

■FEATURES

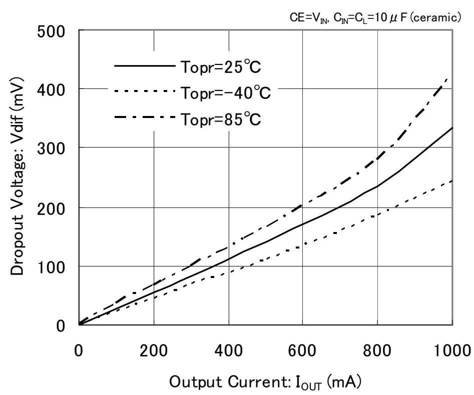
Maximum Output Current	: 1000mA (1.2V≦V_{OUT}≦5.0V)
Dropout Voltage	: 20mV @ 100mA (V_{OUT}=3.0V)
	: 60mV@ 300mA (V_{OUT}=3.0V)
Operating Voltage Range	: 1.6V ~ 6.0V
Output Voltage Range	: 0.8V ~ 5.0V (0.05V increments)
Accuracy	:±1% (V_{OUT}≧2.0V)
	:±20mV (V_{OUT}<2.0V)
Low Power Consumption	: 8μA (TYP.)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

■TYPICAL APPLICATION CIRCUIT

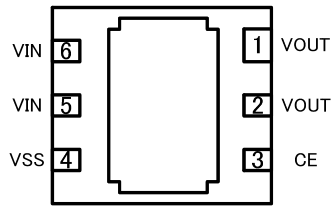


■TYPICAL PERFORMANCE CHARACTERISTICS

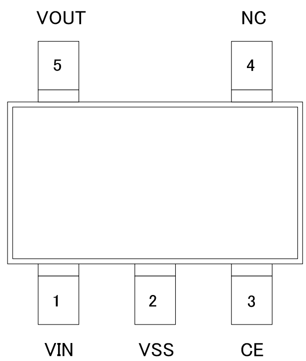
XC6220x181



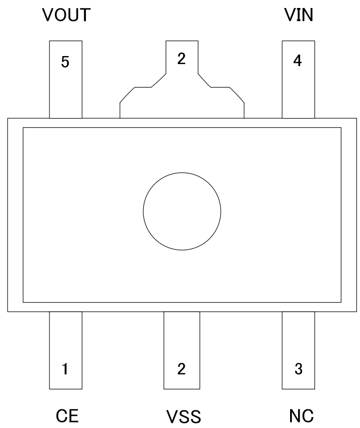
■PIN CONFIGURATION



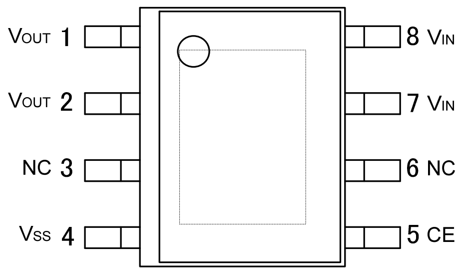
USP-6C
(BOTTOM VIEW)



SOT-25
(TOP VIEW)



SOT-89-5
(TOP VIEW)



SOP-8FD
(TOP VIEW)

* For the USP-6C, the No.5 and 6 V_{IN} pins should be connected. The No.1 and 2 pins V_{OUT} pins should be connected. The dissipation pad should be solder-plated in reference mount pattern and metal masking so as to enhance mounting strength and heat release. If the pad needs to be connected to other pins, it should be connected to the V_{SS} (No. 4) pin.

*For the SOP-8FD, two power input pins (No.7 and No.8) output pins (No.1 and 2) should be connected. The dissipation pad should be solder-plated in electrically open or connecting to the V_{SS} (No.4) pin.

■PIN ASSIGNMENT

PIN NUMBER				PIN NAME	FUNCTIONS
SOT-25	SOT-89-5	USP-6C	SOP-8FD		
3	1	3	5	CE	ON/OFF Control
1	4	6 & 5	7,8	V_{IN}	Power Input
2	2	4	4	V_{SS}	Ground
5	5	1 & 2	1,2	V_{OUT}	Output
4	3	-	3,6	NC	No connection

■CE PIN LOGIC CONDITION

PIN NAME	DESIGNATOR	CONDITIONS	IC OPERATION
CE	L	V_{CE}≦0.4V	OFF
	H	1.2V≦V_{CE}≦6.0V	ON
	OPEN	V_{CE}=OPEN(*1)	Undefined state (XC6220A/B Series)
			OFF (XC6220C/D Series)

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

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

■FUNCTIONS

PRODUCT NAME	IC FUNCTION	
	CE PULL-DOWN RESISTOR	C_L AUTO DISCHARGE
XC6220A	Not Available	Not Available
XC6220B	Not Available	Available
XC6220C	Available	Not Available
XC6220D	Available	Available

■PRODUCT CLASSIFICATION

●Ordering Information

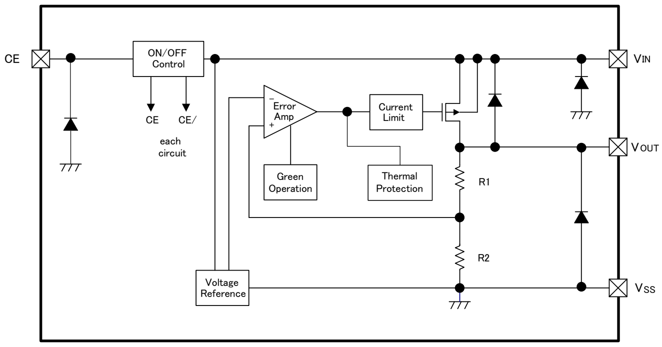
XC6220 ①②③④⑤⑥-⑦ (*1)

DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
①	Type of CE	A	without CE Pull-down resistor, without C_L discharge (Semi-custom)
		B	without CE Pull-down resistor, with C_L discharge (Standard)
		C	with CE Pull-down resistor, without C_L discharge (Semi-custom)
		D	with CE Pull-down resistor, with C_L discharge (Semi-custom)
②③	Output Voltage	08~50	e.g. 3.0V → ②=3, ③=0
④	Output Voltage (the 2nd decimal place)	1	Output voltage {○.○0v} (the 2nd decimal place is “0”)
		B	Output voltage {○.○5v} (the 2nd decimal place is “5”)
⑤⑥-⑦	Packages (Order Unit)	MR	SOT-25 (3,000/Reel)
		MR-G	SOT-25 (3,000/Reel)
		PR	SOT-89-5 (1,000/Reel)
		PR-G	SOT-89-5 (1,000/Reel)
		ER	USP-6C (3,000/Reel)
		ER-G	USP-6C (3,000/Reel)
		QR-G	SOP-8FD (1,000/Reel)

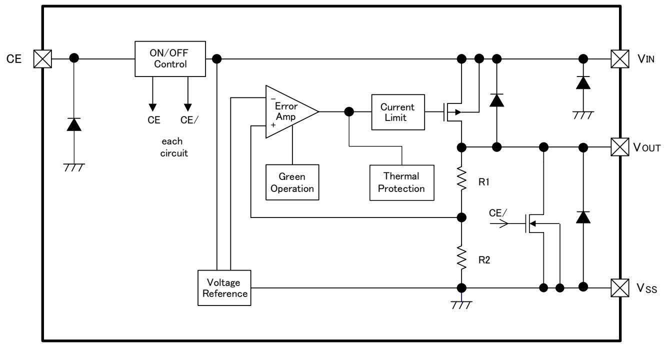
(*1) The “-G” suffix denotes Halogen and Antimony free as well as being fully EU RoHS compliant.

■BLOCK DIAGRAMS

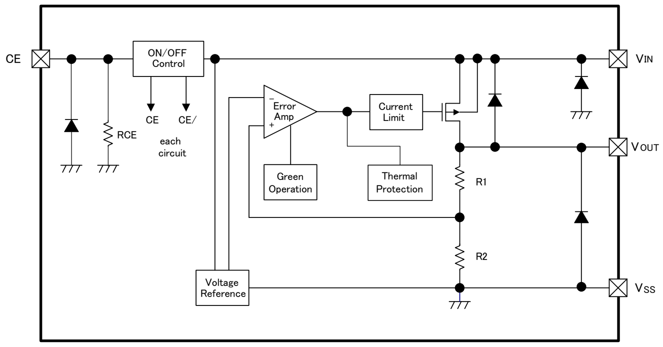
●XC6220 Series Type A (Semi-custom)



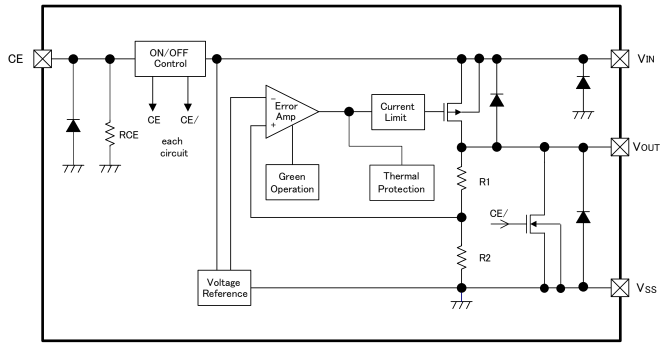
●XC6220 Series Type B



●XC6220 Series Type C (Semi-custom)



●XC6220 Series Type D (Semi-custom)



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

■ABSOLUTE MAXIMUM RATINGS

Ta=25℃

PARAMETER		SYMBOL	RATINGS	UNITS
Input Voltage		V_{IN}	V_{SS}-0.3 ~ +6.5	V
Output Current (*1)		I_{OUT}	1400	mA
Output Voltage		V_{OUT}	V_{SS} -0.3 ~ V_{IN} +0.3	V
CE Input Voltage		V_{CE}	V_{SS} -0.3 ~ 6.5	V
Power Dissipation	SOT-25	Pd	250	mW
			600（PCB mounted）(*2)	
	SOT-89-5		500	
			1300（PCB mounted）(*2)	
	USP-6C		120	
			1000（PCB mounted）(*2)	
	SOP-8FD		300	
			1500（PCB mounted）(*2)	
Operating Ambient Temperature		Topr	- 40 ~ + 85	℃
Storage Temperature		Tstg	- 55 ~ + 125	℃

*1 Please use within the range of Pd＞(V_{IN} – V_{OUT})×I_{OUT}

*2: The power dissipation figure shown is PCB mounted. Please refer to pages 26～29 for details.

■ELECTRICAL CHARACTERISTICS

●XC6220A/B/C/D Series

Ta=25℃

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

■ELECTRICAL CHARACTERISTICS (Continued)

Ta=25℃

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

* 1: $V_{OUT(E)}$ = Effective output voltage
(The output voltage when an amply stabilized "$V_{OUT(T)}$ ＋1.0V" is provided at the V_{IN} pin while maintaining a certain I_{OUT} value.)
* 2: $V_{OUT(T)}$ = Nominal output voltage. (Shown in the voltage chart E-0)
* 3: Vdif = {V_{IN1}-V_{OUT1}}
V_{IN1} is the input voltage when V_{OUT1} appears at the V_{OUT} pin while input voltage is gradually decreased.
V_{OUT1} is the voltage equal to 98% of the HS mode output voltage when an amply stabilized $V_{OUT(T)}$ +1.0V are supplied to the V_{IN} pin.
* 4: For the XC6220B/D series only. The XC6220A/C series (semi-custom) discharges by only R1 and R2 resistors as shown in the block diagrams.

■ELECTRICAL CHARACTERISTICS (Continued)

●Voltage Chart 1

Ta=25℃

SYMBOL	E-0				E-1		E-2	E-3	E-4	E-5
NOMINAL OUTPUT VOLTAGE (V)	OUTPUT VOLTAGE 1 (HS Mode) (V)		OUTPUT VOLTAGE 2 (PS Mode) (V)		DROPOUT VOLTAGE 1 Vdif 1 (mV) I_{OUT}=300mA		DROPOUT VOLTAGE 2 Vdif 2 (mV) I_{OUT}=1000mA	SUPPLY CURRENT 1 (XC6220C/D) (μA)	SUPPLY CURRENT 2 (XC6220C/D) (μA)	PS SWITCH DELAY TIME (μs)
$V_{OUT(T)}$	V_{OUT}		V_{OUT}		V_{dif1}		V_{dif2}	I_{SS1}	I_{SS2}	t_{DPS}
	MIN.	MAX.	MIN.	MAX.	TYP.	MAX.	MAX.	MAX.	MAX.	MAX.
0.80	0.7800	0.8200	0.7600	0.8400	400	575	–	112.500	22.500	650
0.85	0.8300	0.8700	0.8100	0.8900				112.625	22.625	
0.90	0.8800	0.9200	0.8600	0.9400				112.750	22.750	
0.95	0.9300	0.9700	0.9100	0.9900				112.875	22.875	
1.00	0.9800	1.0200	0.9600	1.0400	240	405		113.000	23.000	
1.05	1.0300	1.0700	1.0100	1.0900				113.125	23.125	
1.10	1.0800	1.1200	1.0600	1.1400	180	305		113.250	23.250	
1.15	1.1300	1.1700	1.1100	1.1900				113.375	23.375	
1.20	1.1800	1.2200	1.1600	1.2400	150	215	460	113.500	23.500	
1.25	1.2300	1.2700	1.2100	1.2900				113.625	23.625	
1.30	1.2800	1.3200	1.2600	1.3400				113.750	23.750	
1.35	1.3300	1.3700	1.3100	1.3900				113.875	23.875	
1.40	1.3800	1.4200	1.3600	1.4400				114.000	24.000	
1.45	1.4300	1.4700	1.4200	1.4800				114.125	24.125	
1.50	1.4800	1.5200	1.4700	1.5300	100	150	655	114.250	24.250	
1.55	1.5300	1.5700	1.5100	1.5900				114.375	24.375	
1.60	1.5800	1.6200	1.5600	1.6400				114.500	24.500	850
1.65	1.6300	1.6700	1.6100	1.6900				114.625	24.625	
1.70	1.6800	1.7200	1.6600	1.7400				114.750	24.750	
1.75	1.7300	1.7700	1.7100	1.7900				114.875	24.875	
1.80	1.7800	1.8200	1.7600	1.8400	85	130		115.000	25.000	
1.85	1.8300	1.8700	1.8100	1.8900				115.125	25.125	
1.90	1.8800	1.9200	1.8600	1.9400				115.250	25.250	
1.95	1.9300	1.9700	1.9100	1.9900				115.375	25.375	
2.00	1.9800	2.0200	1.9600	2.0400				115.500	25.500	
2.05	2.0295	2.0705	2.0090	2.0910				115.625	25.625	
2.10	2.0790	2.1210	2.0580	2.1420				115.750	25.750	
2.15	2.1285	2.1715	2.1070	2.1930				115.875	25.875	
2.20	2.1780	2.2220	2.1560	2.2440				116.000	26.000	
2.25	2.2275	2.2725	2.2050	2.2950				116.125	26.125	
2.30	2.2770	2.3230	2.2540	2.3460				116.250	26.250	
2.35	2.3265	2.3735	2.3030	2.3970				116.375	26.375	
2.40	2.3760	2.4240	2.3520	2.4480				116.500	26.500	
2.45	2.4255	2.4745	2.4010	2.4990				116.625	26.625	
2.50	2.4750	2.5250	2.4500	2.5500	65	110		116.750	26.750	
2.55	2.5245	2.5755	2.4990	2.6010				116.875	26.875	
2.60	2.5740	2.6260	2.5480	2.6520				117.000	27.000	1200
2.65	2.6235	2.6765	2.5970	2.7030				117.125	27.125	
2.70	2.6730	2.7270	2.6460	2.7540				117.250	27.250	
2.75	2.7225	2.7775	2.6950	2.8050				117.375	27.375	
2.80	2.7720	2.8280	2.7440	2.8560				117.500	27.500	
2.85	2.8215	2.8785	2.7930	2.9070				117.625	27.625	
2.90	2.8710	2.9290	2.8420	2.9580				117.750	27.750	
2.95	2.9205	2.9795	2.8910	3.0090				117.875	27.875	

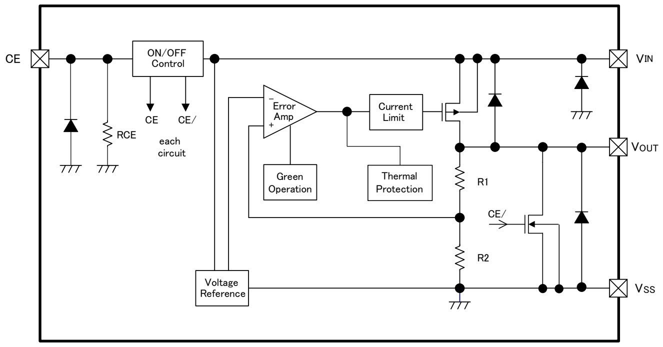
■ELECTRICAL CHARACTERISTICS (Continued)

●Voltage Chart 2

Ta=25℃

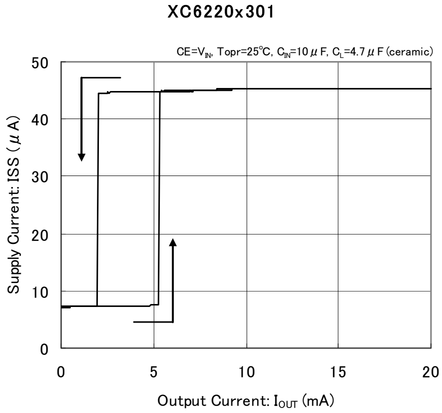
SYMBOL	E-0				E-1		E-2	E-3	E-4	E-5
NOMINAL OUTPUT VOLTAGE (V)	OUTPUT VOLTAGE (HS Mode) (V)		OUTPUT VOLTAGE (PS Mode) (V)		DROPOUT VOLTAGE 1 Vdif 1 (mV) I_{OUT}=300mA		DROPOUT VOLTAGE 2 Vdif 2 (mV) I_{OUT}=1000mA	SUPPLY CURRENT 1 (XC6220C/D) (μA)	SUPPLY CURRENT 2 (XC6220C/D) (μA)	PS SWITCH DELAY TIME (μs)
$V_{OUT(T)}$	V_{OUT}		V_{OUT}		V_{dif1}		V_{dif2}	I_{SS1}	I_{SS2}	t_{DPS}
	MIN.	MAX.	MIN.	MAX.	TYP.	MAX.	MAX.	MAX.	MAX.	MAX.
3.00	2.9700	3.0300	2.9400	3.0600	60	95	655	118.000	28.000	1200
3.05	3.0195	3.0805	2.9890	3.1110				118.125	28.125	
3.10	3.0690	3.1310	3.0380	3.1620				118.250	28.250	
3.15	3.1185	3.1815	3.0870	3.2130				118.375	28.375	
3.20	3.1680	3.2320	3.1360	3.2640				118.500	28.500	
3.25	3.2175	3.2825	3.1850	3.3150				118.625	28.625	
3.30	3.2670	3.3330	3.2340	3.3660				118.750	28.750	
3.35	3.3165	3.3835	3.2830	3.4170				118.875	28.875	
3.40	3.3660	3.4340	3.3320	3.4680				119.000	29.000	
3.45	3.4155	3.4845	3.3810	3.5190				119.125	29.125	
3.50	3.4650	3.5350	3.4300	3.5700				119.250	29.250	
3.55	3.5145	3.5855	3.4790	3.6210				119.375	29.375	
3.60	3.5640	3.6360	3.5280	3.6720				119.500	29.500	
3.65	3.6135	3.6865	3.5770	3.7230				119.625	29.625	
3.70	3.6630	3.7370	3.6260	3.7740				119.750	29.750	
3.75	3.7125	3.7875	3.6750	3.8250				119.875	29.875	
3.80	3.7620	3.8380	3.7240	3.8760				120.000	30.000	
3.85	3.8115	3.8885	3.7730	3.9270				120.125	30.125	
3.90	3.8610	3.9390	3.8220	3.9780				120.250	30.250	
3.95	3.9105	3.9895	3.8710	4.0290				120.375	30.375	
4.00	3.9600	4.0400	3.9200	4.0800				120.500	30.500	
4.05	4.0095	4.0905	3.9690	4.1310	53	85		120.625	30.625	1450
4.10	4.0590	4.1410	4.0180	4.1820				120.750	30.750	
4.15	4.1085	4.1915	4.0670	4.2330				120.875	30.875	
4.20	4.1580	4.2420	4.1160	4.2840				121.000	31.000	
4.25	4.2075	4.2925	4.1650	4.3350				121.125	31.125	
4.30	4.2570	4.3430	4.2140	4.3860				121.250	31.250	
4.35	4.3065	4.3935	4.2630	4.4370				121.375	31.375	
4.40	4.3560	4.4440	4.3120	4.4880				121.500	31.500	
4.45	4.4055	4.4945	4.3610	4.5390				121.625	31.625	
4.50	4.4550	4.5450	4.4100	4.5900				121.750	31.750	
4.55	4.5045	4.5955	4.4590	4.6410				121.875	31.875	
4.60	4.5540	4.6460	4.5080	4.6920				122.000	32.000	
4.65	4.6035	4.6965	4.5570	4.7430				122.125	32.125	
4.70	4.6530	4.7470	4.6060	4.7940				122.250	32.250	
4.75	4.7025	4.7975	4.6550	4.8450				122.375	32.375	
4.80	4.7520	4.8480	4.7040	4.8960				122.500	32.500	
4.85	4.8015	4.8985	4.7530	4.9470				122.625	32.625	
4.90	4.8510	4.9490	4.8020	4.9980				122.750	32.750	
4.95	4.9005	4.9995	4.8510	5.0490				122.875	32.875	
5.00	4.9500	5.0500	4.9000	5.1000				123.000	33.000	

■OPERATIONAL EXPLANATION



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

<GreenOperation>
The XC6220 series always operates in a green operation (GO) mode. The GO mode enables the IC to switch automatically between the high speed (HS) mode or the power save (PS) mode according to the level of output current. The switching point of the HS mode and the PS mode is fixed inside the IC. When the output current becomes I_{GOR}=1.0mA (MIN.) or below, the mode changes automatically to the PS mode after a delay time of hundreds of microseconds. Supply current in light load is greatly reduced. Also when the output current becomes I_{GO} 10mA (MAX.) or more, the mode changes automatically to the HS mode and the IC returns to high speed operation.



<Low ESR capacitor>
The XC6220 series has a built-in phase compensation circuit which means that a stable output voltage is achieved even if the IC is used with low ESR capacitors. In order to ensure stable phase compensation it is recommended that a C_L capacitor is connected as close as possible to the V_{OUT} pin and V_{SS} pin. For a stable power supply, please connect an input capacitor (C_{IN}) between the V_{IN} pin and the V_{SS} pin.
Values required for the phase compensation are shown in the chart below. If a loss of the capacitance happens, the stable phase compensation may not be obtained. Please ensure to use a capacitor which does not depend on bias or temperature too much.

Recommended output capacitor (C_L)

$V_{OUT(T)}$(V)	OUTPUT CAPACITOR VALUE(C_L)		
	C_{IN}=4.7μF	C_{IN}=10μF	C_{IN}=22μF
0.80V～0.95V	×	×	22μF
1.00V～1.45V	47μF	47μF	22μF
1.50V～1.75V	47μF	22μF	10μF
1.80V～2.95V	47μF	6.8μF	6.8μF
3.00V～3.50V	47μF	4.7μF	4.7μF
3.55V～5.00V	47μF	10μF	6.8μF

× No option

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

<CE Pin>
The IC's internal circuitry can be shutdown via the signal from the CE pin with the XC6220 series. With the XC6220A/C series, output at the V_{OUT} pin will be pulled down to the V_{SS} level. However, with XC6220B/D series, the C_L auto-discharge N-channel transistor switch is connected in parallel to R1 and R2 while the power supply is applied to the V_{IN} pin. Therefore, the time until the V_{OUT} pin reaches the V_{SS} level is shortened. The output voltage of the XC6220A/B series becomes unstable, when the CE pin is open. If this IC is used with the correct output voltage for the CE pin, the logic is fixed and the IC will operate normally. On the other hand, with the XC6220C/D series, the IC operation is stopped when the CE pin is open. However, the CE pin input current may increase as a result of through current in the pull-down resistor (R_{CE}) when the IC is under operation.

■OPERATIONAL EXPLANATION (Continued)

<C_L Discharge Function>

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

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

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

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

where
V : Output voltage after discharge
$V_{OUT(E)}$: Output voltage
t: Discharge time
τ : C_L auto-discharge resistance R_{DCHG} × Output capacitor (C_L) value C)

<Inrush Current Prevention>

The XC6220 series includes an inrush current Prevention circuit.

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

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

■NOTES ON USE

1. For temporary, transitional voltage drop or voltage rising phenomenon, the IC is liable to malfunction should the ratings be exceeded.

2. Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current. Please strengthen V_{IN} and V_{SS} wiring in particular.

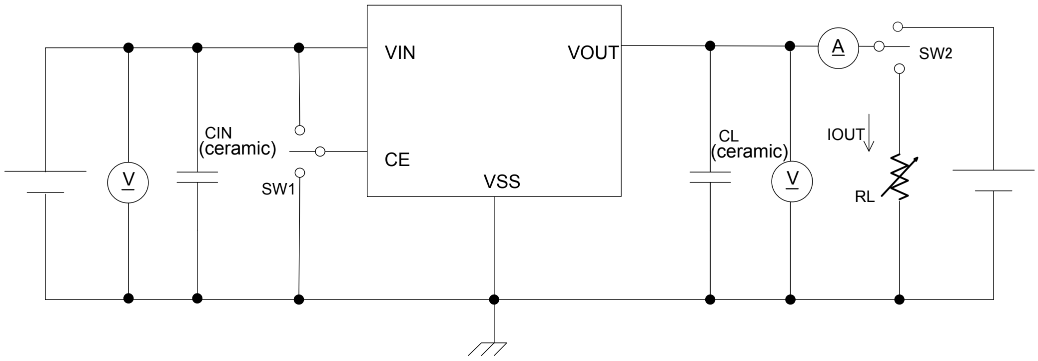
3. Please wire the input capacitor (C_{IN}) and the output capacitor (C_L) as close to the IC as possible.

4. As for the XC6220A/C series (semi-custom), the output voltage may float with a leakage current of the driver transistor between V_{IN} and V_{OUT} and R1+R2 resistance while stand-by (operation stop). Please take consideration of this and check it before use.

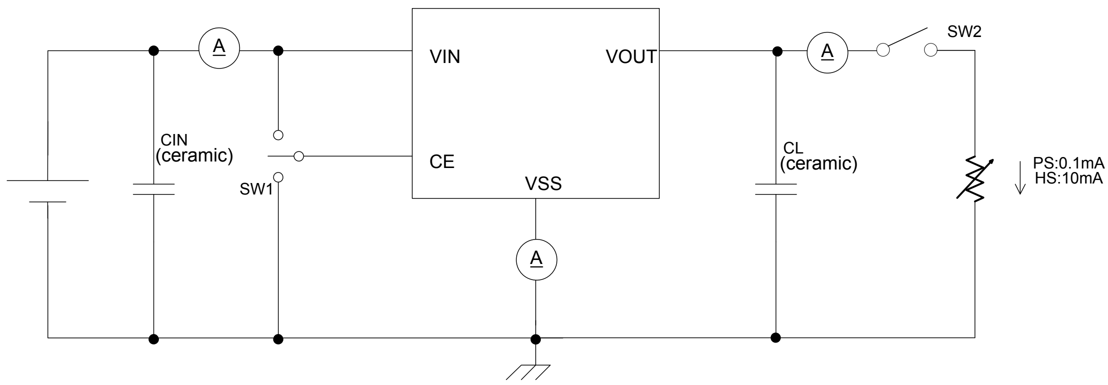
5. Torex places an importance on improving our products and their reliability. We request that users incorporate fail-safe designs and post-aging protection treatment when using Torex products in their systems.

■TEST CIRCUITS

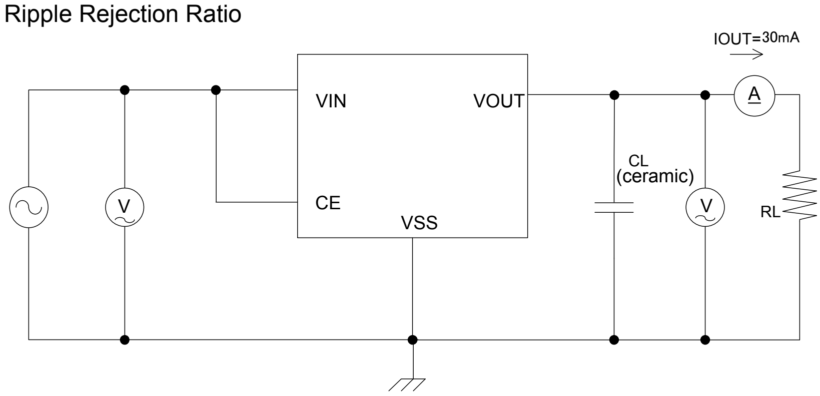
Circuit 1: Output Voltage, Output Current, Dropout Voltage, Input Voltage, Line Regulation, Load Regulation, Current Limit, Short Current, C_L Discharge Resistance, Output Voltage Temperature, Thermal Shutdown Detect Temperature, Thermal Shutdown Release Temperature



Circuit 2: Supply Current, Stand-by Current

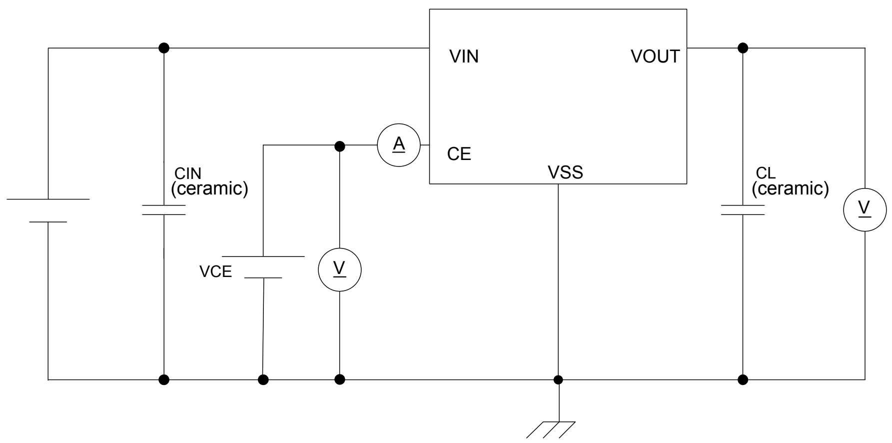


Circuit 3: Ripple Rejection Ratio

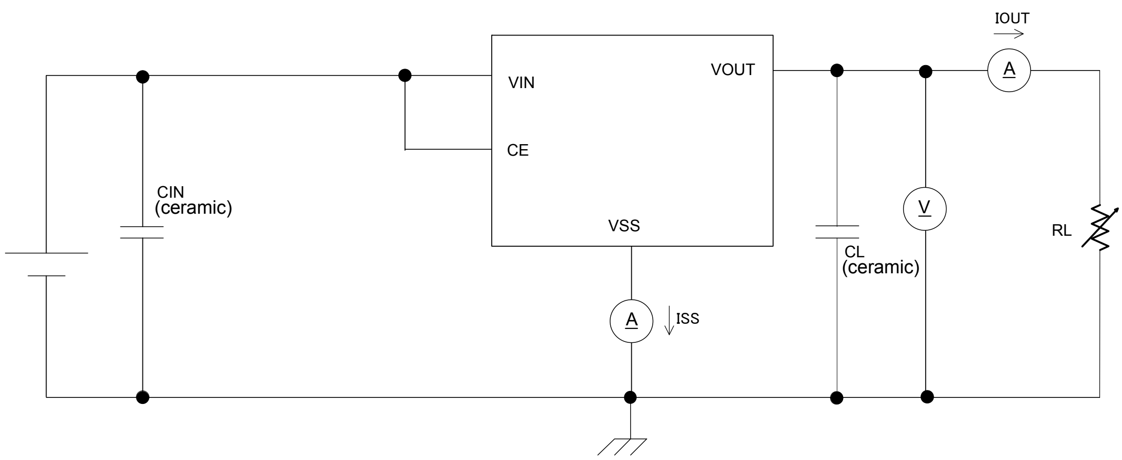


■TEST CIRCUITS (Continued)

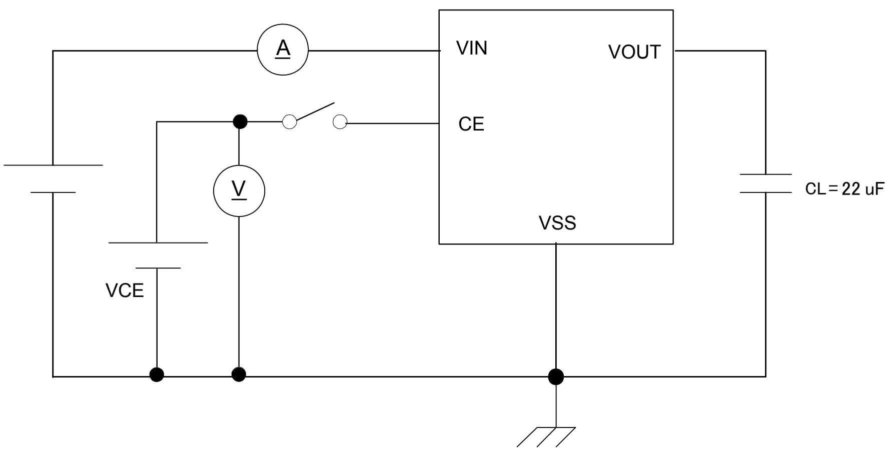
Circuit 4: CE “H” Level Voltage, CE“L” Level Voltage, CE “H” Level Current, CE “L” Level Current



Circuit 5: HS Switching Current, PS Switching Current, Switch Current Hysteresis Range, PS Switching Delay Time



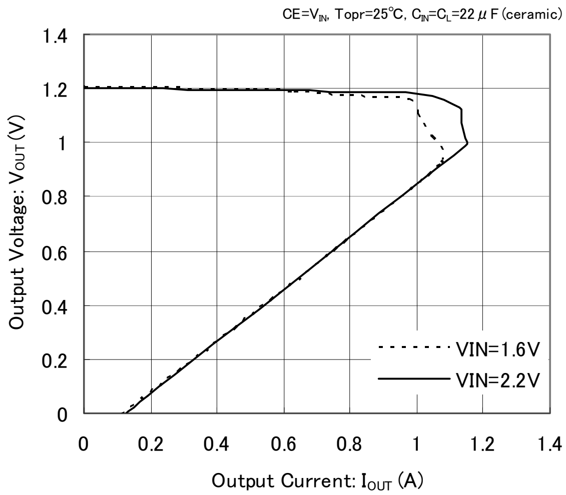
Circuit 6: Inrush Current



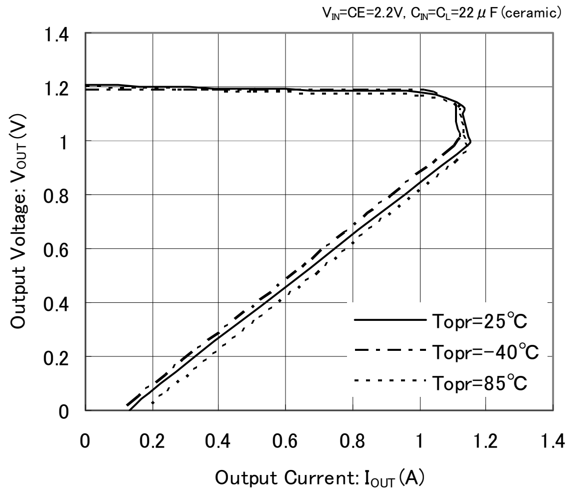
■TYPICAL PERFORMANCE CHARACTERISTICS

(1) Output Voltage vs. Output Current

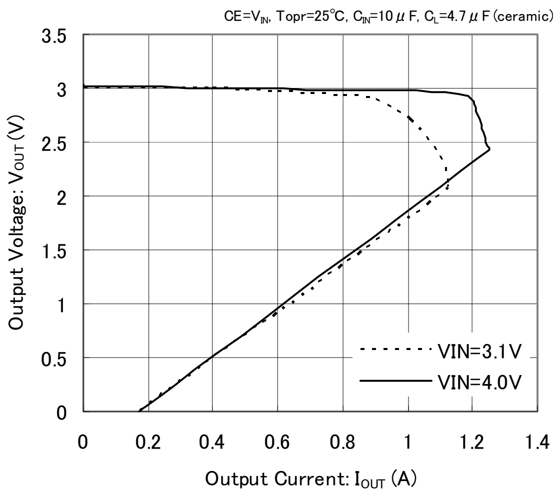
XC6220x121



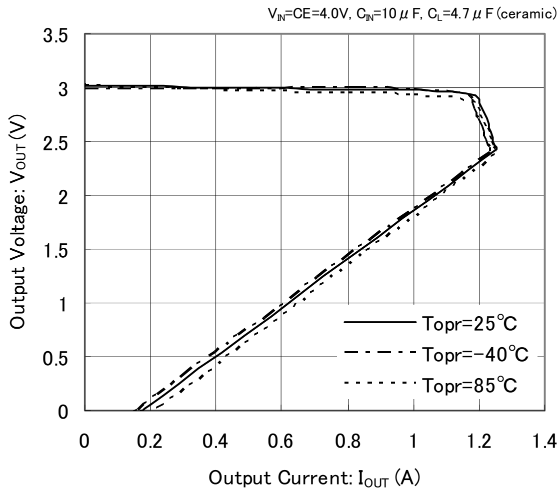
XC6220x121



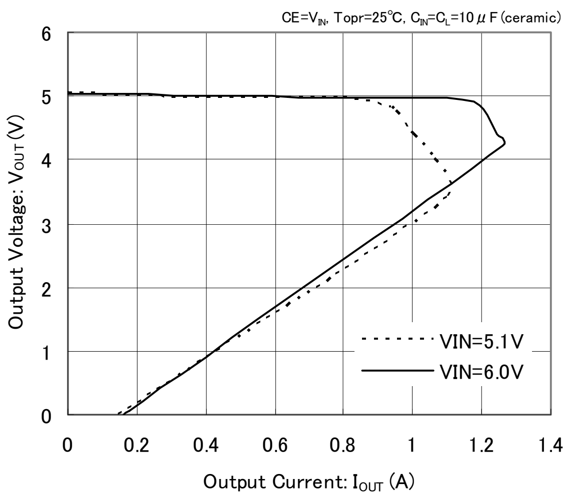
XC6220x301



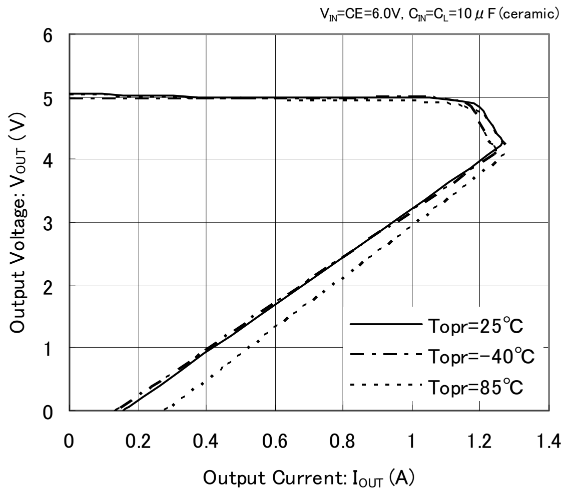
XC6220x301



XC6220x501



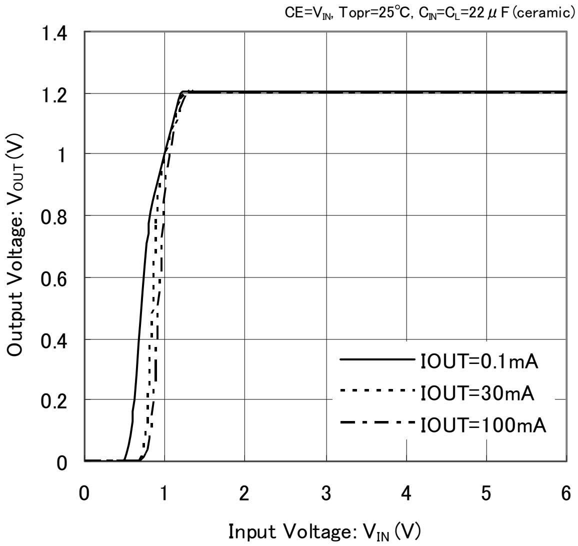
XC6220x501



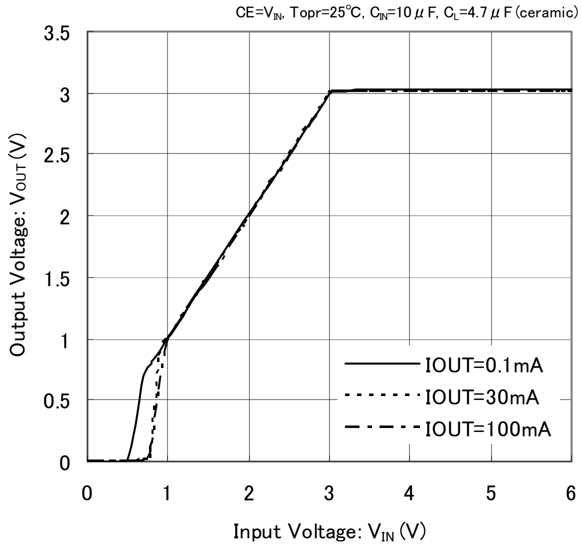
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(2) Output Voltage vs. Input Voltage

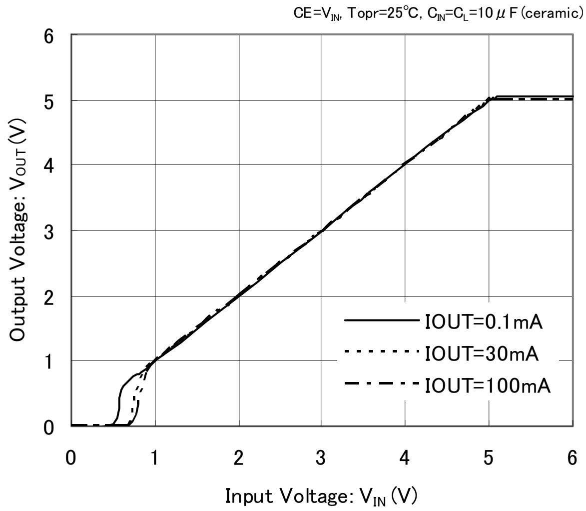
XC6220x121



XC6220x301

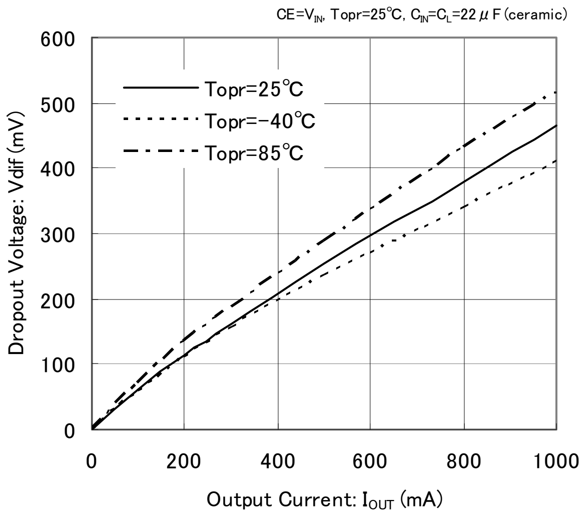


XC6220x501

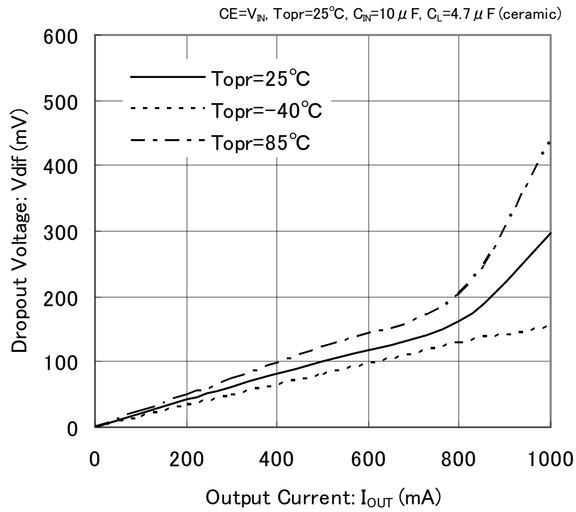


(3) Dropout Voltage vs. Output Current

XC6220x121

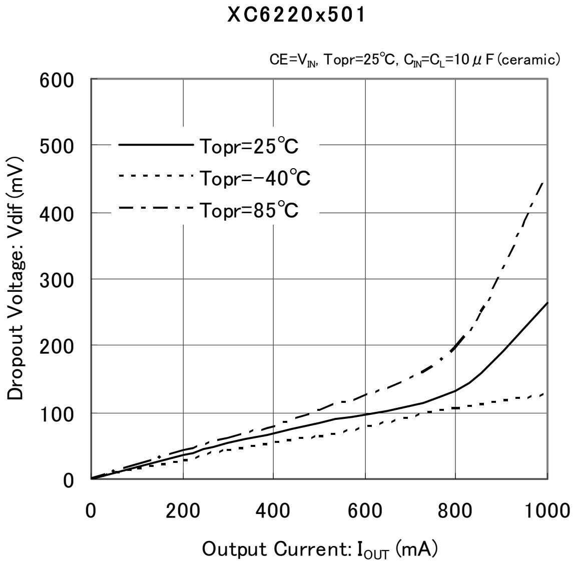


XC6220x301

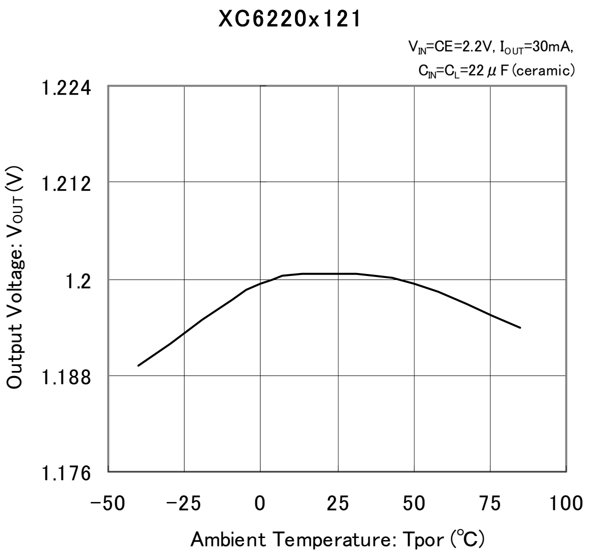


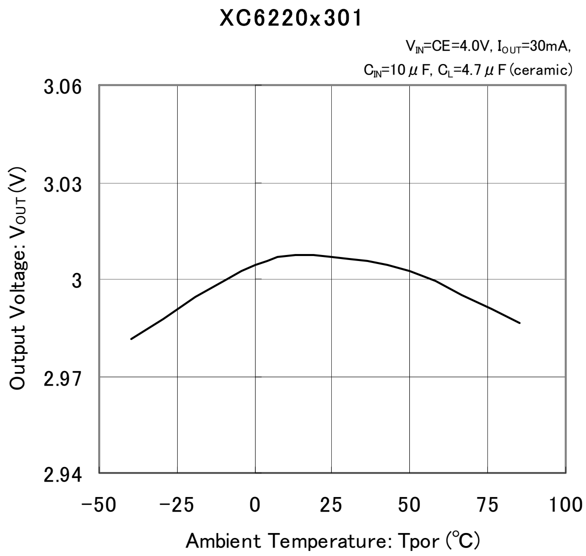
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

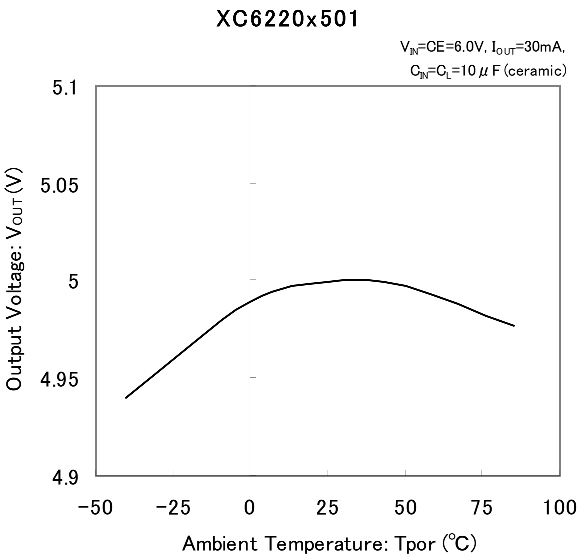
(3) Dropout Voltage vs. Output Current



(4) Output Voltage vs. Ambient Temperature

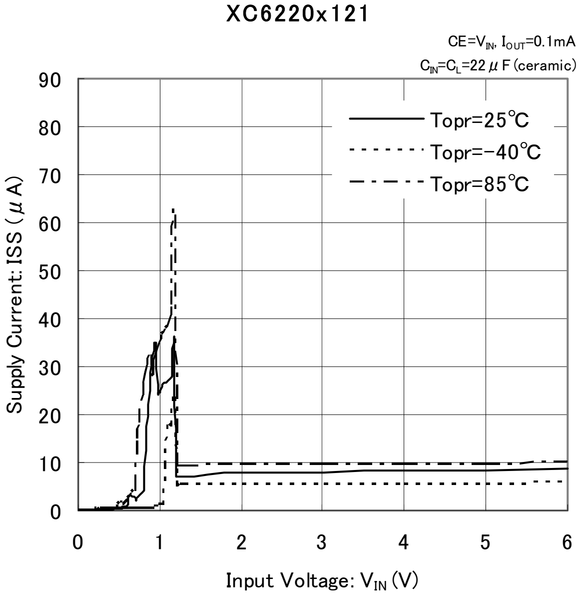


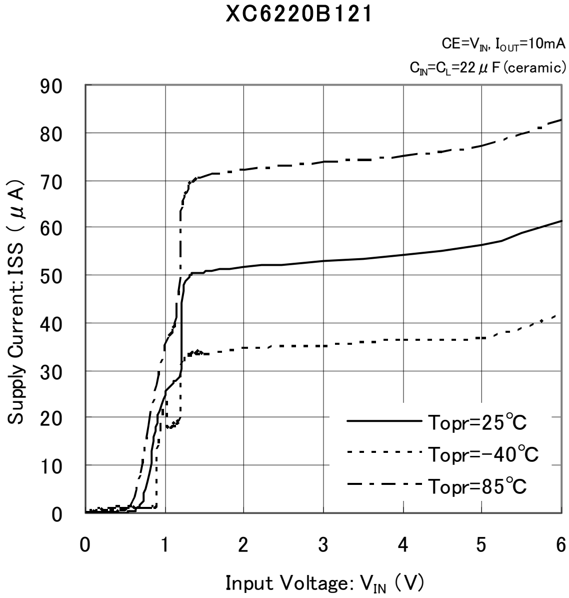


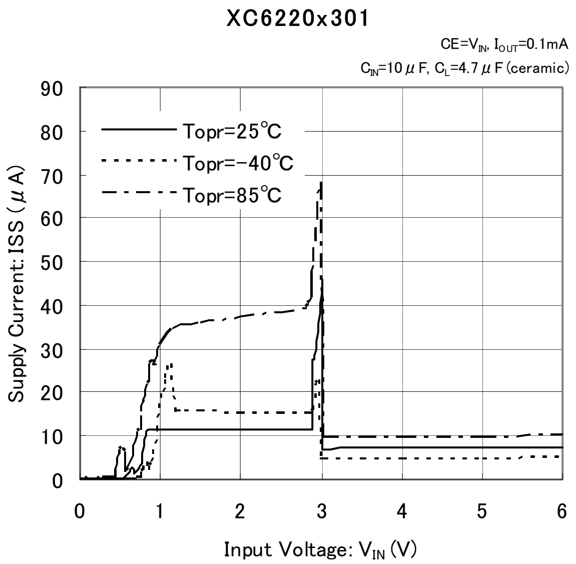


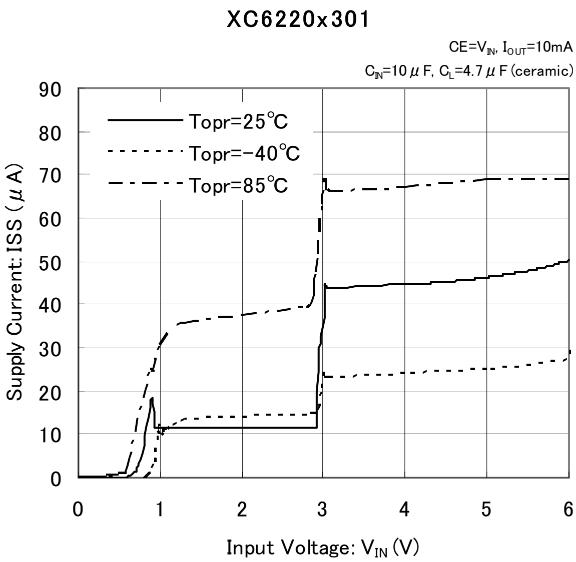
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

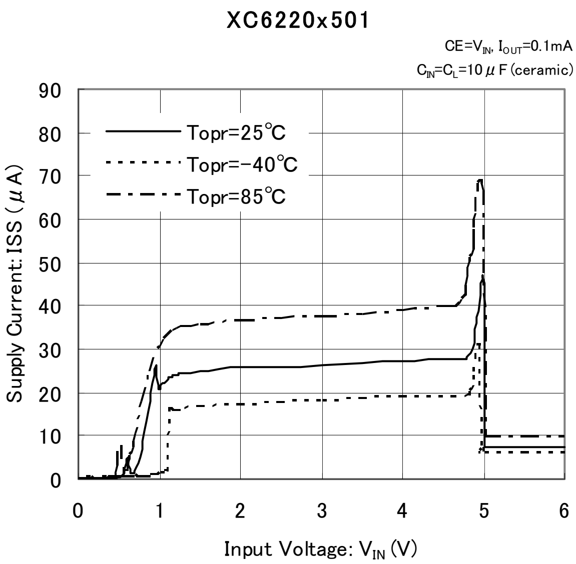
(5) Supply Current vs. Input Voltage

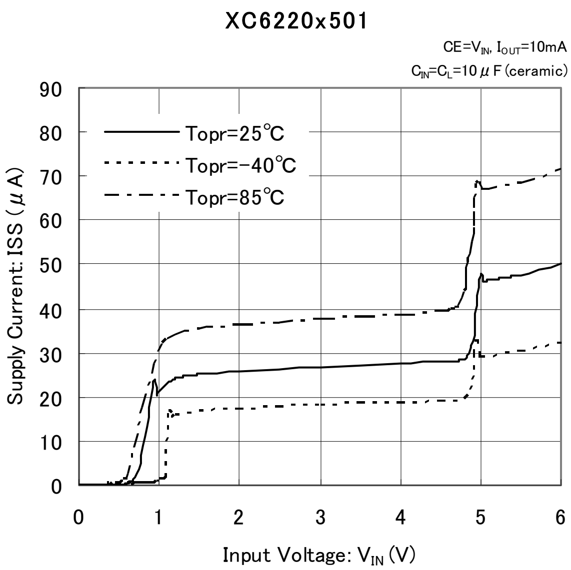






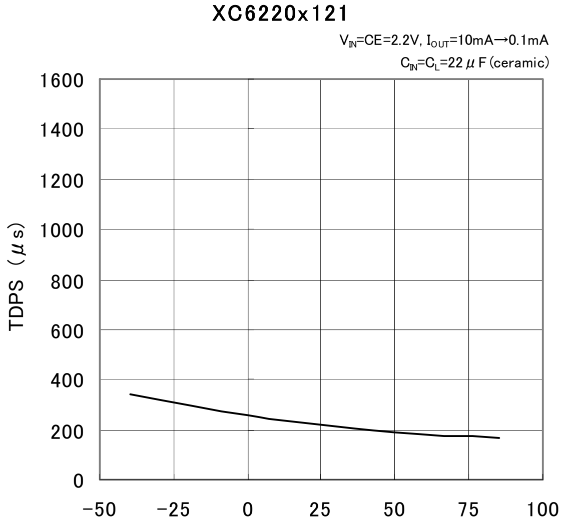


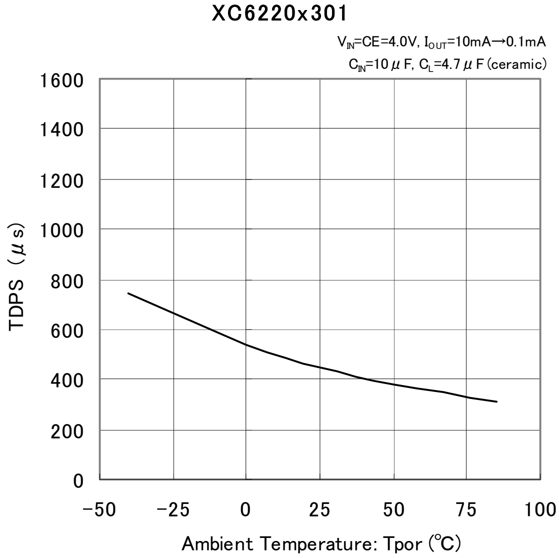


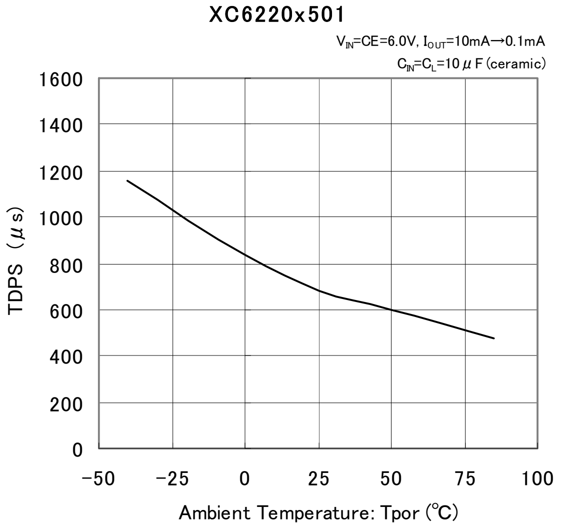


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

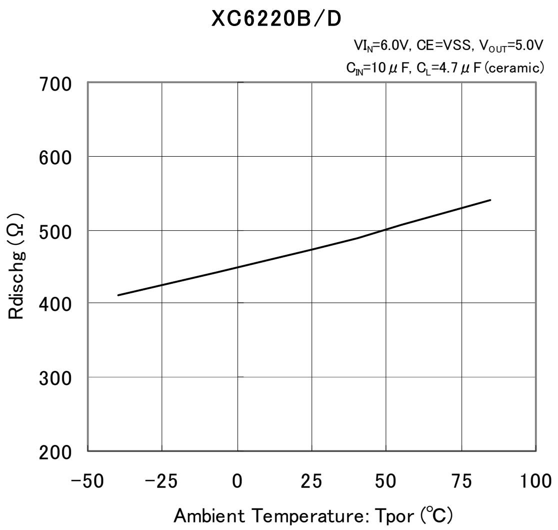
(6) PS Switching Delay Time vs. Ambient Temperature



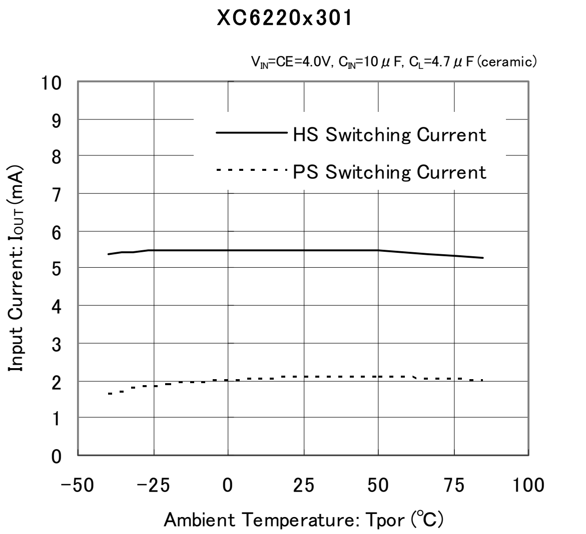




(7) CL Discharge Resistance vs. Ambient Temperature



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

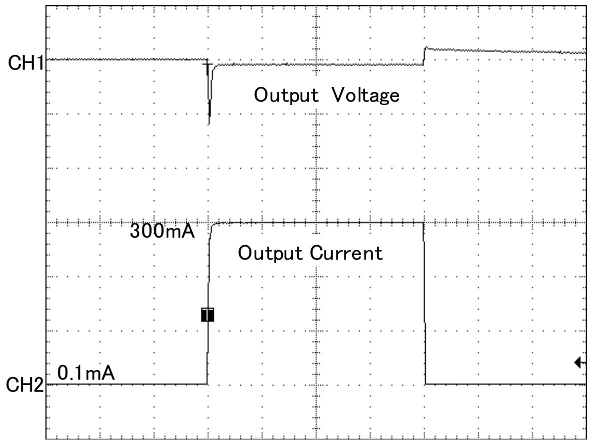


■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) Load Transient Response

XC6220x121

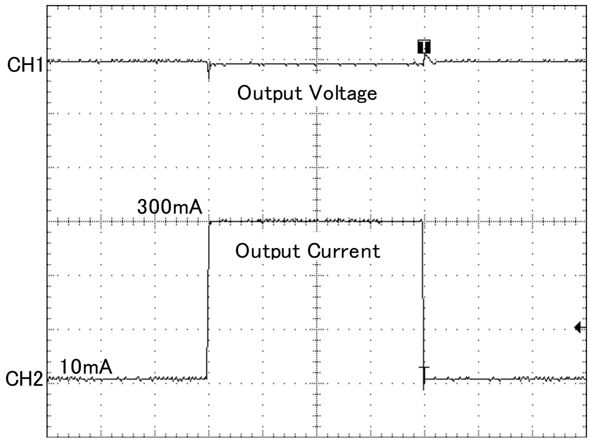
V_{IN}=CE=2.2V, Tr=Tf=5μs
Topr=25℃, C_{IN}=C_L=22μF (ceramic)



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

XC6220x121

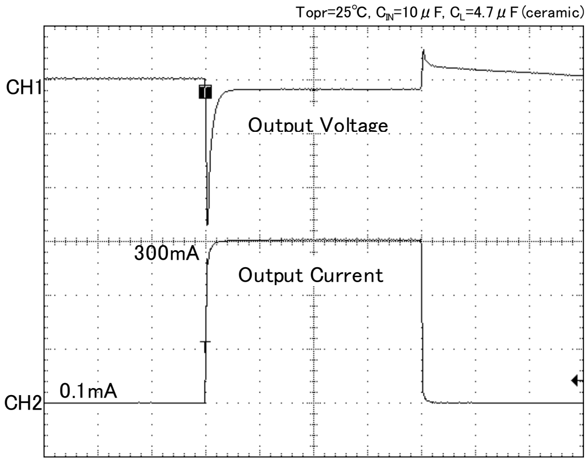
V_{IN}=CE=2.2V, Tr=Tf=5μs
Topr=25℃, C_{IN}=C_L=22μF (ceramic)



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

XC6220x301

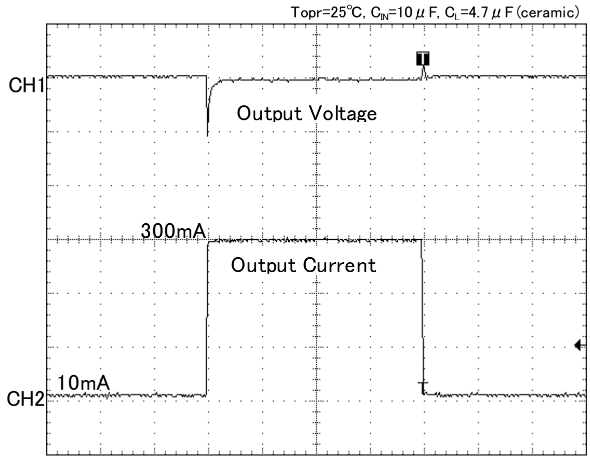
V_{IN}=CE=4.0V, Tr=Tf=5μs
Topr=25℃, C_{IN}=10μF, C_L=4.7μF (ceramic)



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

XC6220x301

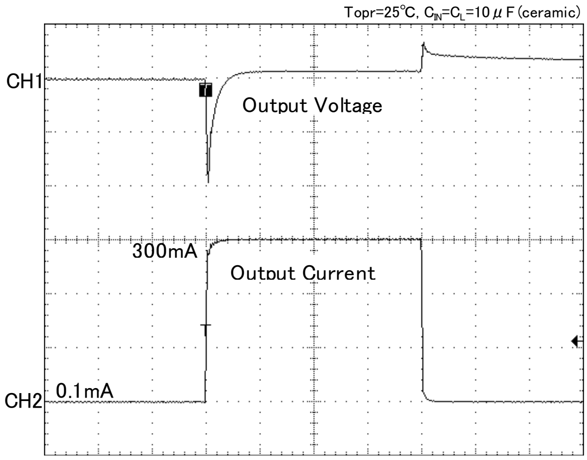
V_{IN}=CE=4.0V, Tr=Tf=5μs
Topr=25℃, C_{IN}=10μF, C_L=4.7μF (ceramic)



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

XC6220x501

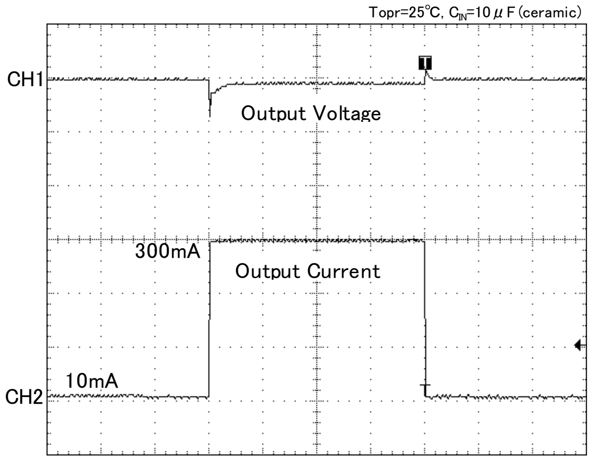
V_{IN}=CE=6.0V, Tr=Tf=5μs
Topr=25℃, C_{IN}=C_L=10μF (ceramic)



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

XC6220x501

V_{IN}=CE=6.0V, Tr=Tf=5μs
Topr=25℃, C_{IN}=10μF (ceramic)



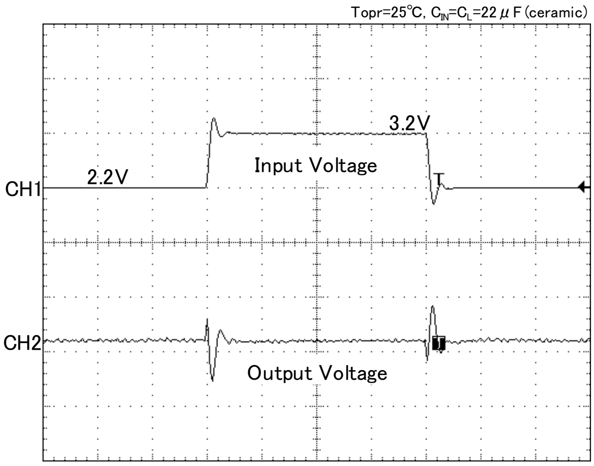
200μs/div
CH1 : 100mV/div CH2 : 100mA/div

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(10) Line Transient Response

XC6220x121

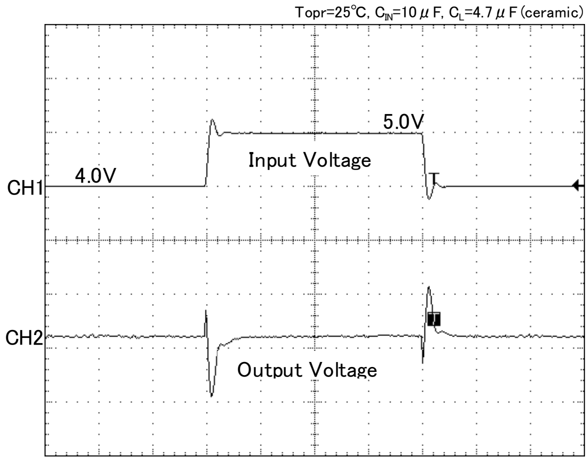
CE=V_{IN}, Tr=Tf=5μs, I_{OUT}=100mA
Topr=25℃, C_{IN}=C_L=22μF (ceramic)



100μs/div
CH1 : 1V/div　CH2 : 20mV/div

XC6220x301

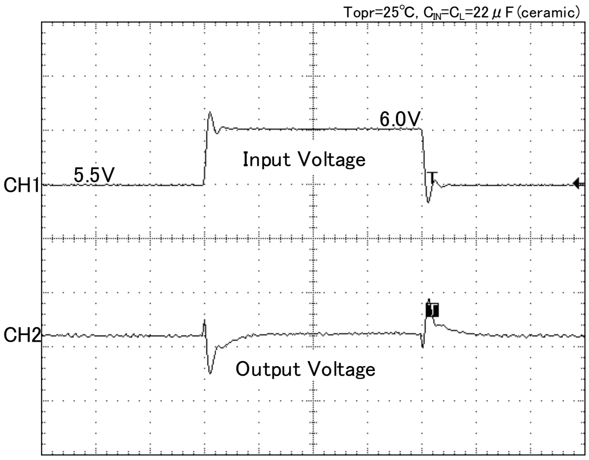
CE=V_{IN}, Tr=Tf=5μs, I_{OUT}=100mA
Topr=25℃, C_{IN}=10μF, C_L=4.7μF (ceramic)



100μs/div
CH1 : 1V/div　CH2 : 20mV/div

XC6220x501

CE=V_{IN}, Tr=Tf=5μs, I_{OUT}=100mA
Topr=25℃, C_{IN}=C_L=22μF (ceramic)

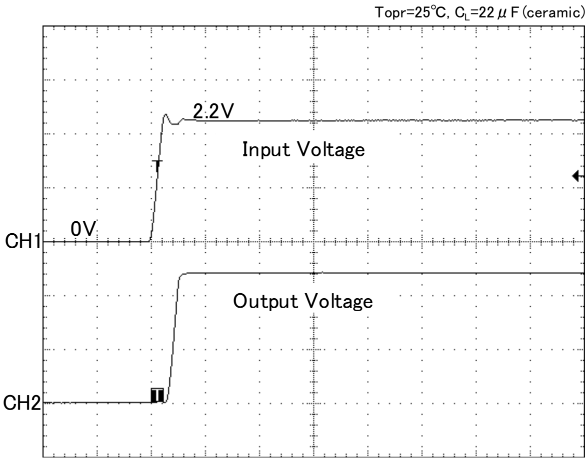


100μs/div
CH1 : 500mV/div　CH2 : 20mV/div

(11) Input Rise Characteristics

XC6220x121

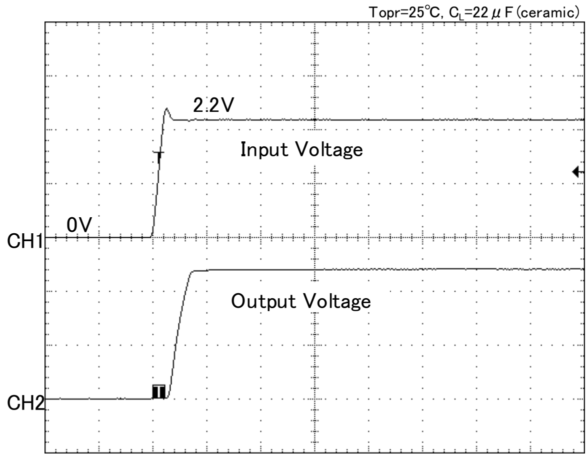
CE=V_{IN}, Tr=5μs, I_{OUT}=0.1mA
Topr=25℃, C_L=22μF (ceramic)



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

XC6220x121

CE=V_{IN}, Tr=5μs, I_{OUT}=300mA
Topr=25℃, C_L=22μF (ceramic)



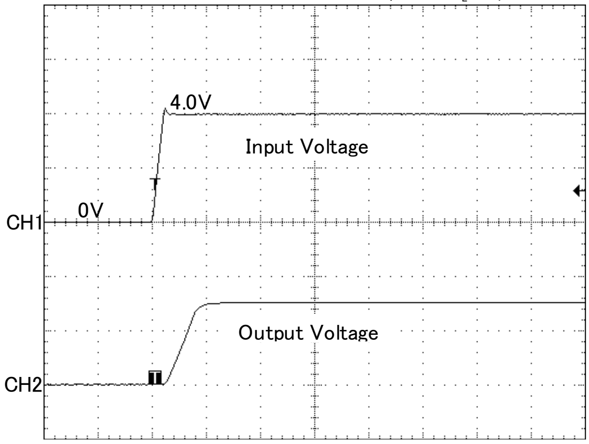
200μs/div
CH1 : 1V/div　CH2 : 500mV/div

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(11) Input Rise Characteristics

XC6220x301

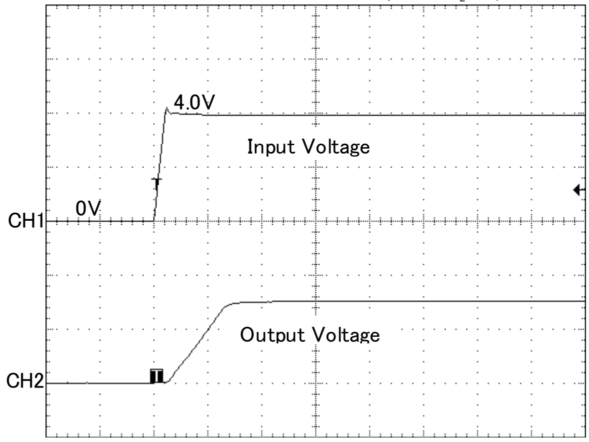
CE=V_{IN}, Tr=5μs, I_{OUT}=0.1mA
Topr=25℃, C_L=4.7μF (ceramic)



200μs/div
CH1 : 2V/div CH2 : 2V/div

XC6220x301

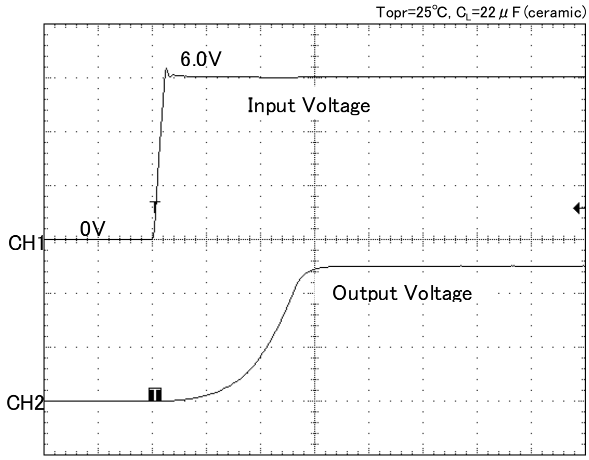
CE=V_{IN}, Tr=5μs, I_{OUT}=300mA
Topr=25℃, C_L=4.7μF (ceramic)



200μs/div
CH1 : 2V/div CH2 : 2V/div

XC6220x501

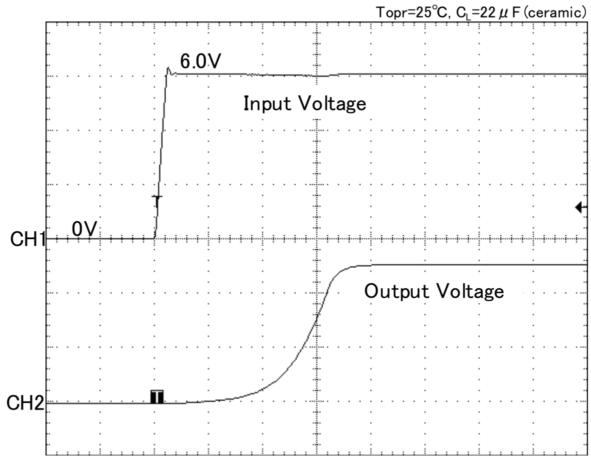
CE=V_{IN}, Tr=5μs, I_{OUT}=0.1mA
Topr=25℃, C_L=22μF (ceramic)



200μs/div
CH1 : 2V/div CH2 : 2V/div

XC6220x501

CE=V_{IN}, Tr=5μs, I_{OUT}=300mA
Topr=25℃, C_L=22μF (ceramic)

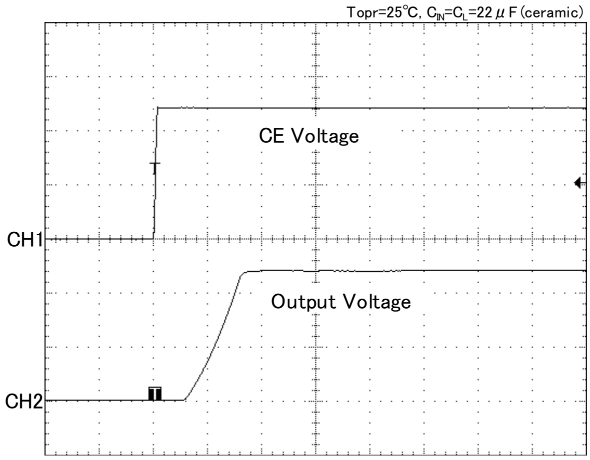


200μs/div
CH1 : 2V/div CH2 : 2V/div

(12) CE Rise Characteristics

XC6220x121

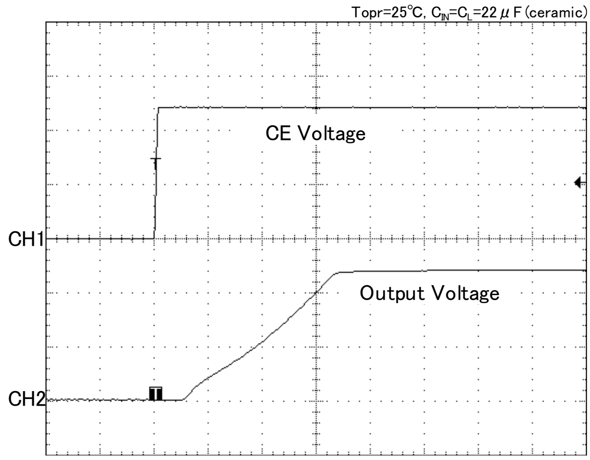
V_{IN}=2.2V, Tr=5μs, I_{OUT}=0.1mA
Topr=25℃, C_{IN}=C_L=22μF (ceramic)



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

XC6220x121

V_{IN}=2.2V, Tr=5μs, I_{OUT}=300mA
Topr=25℃, C_{IN}=C_L=22μF (ceramic)



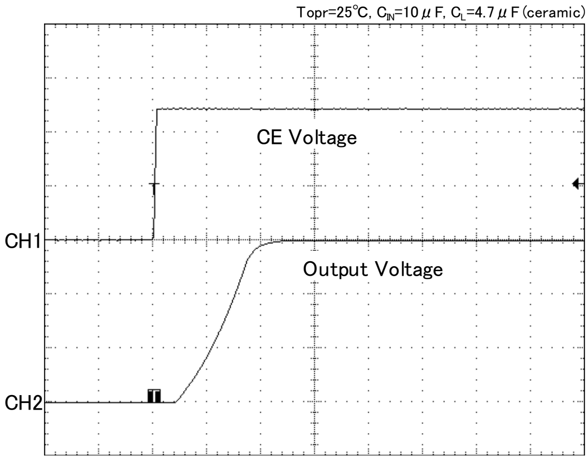
100μs/div
CH1 : 500mV/div CH2 : 500mV/div

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(12) CE Rise Characteristics

XC6220x301

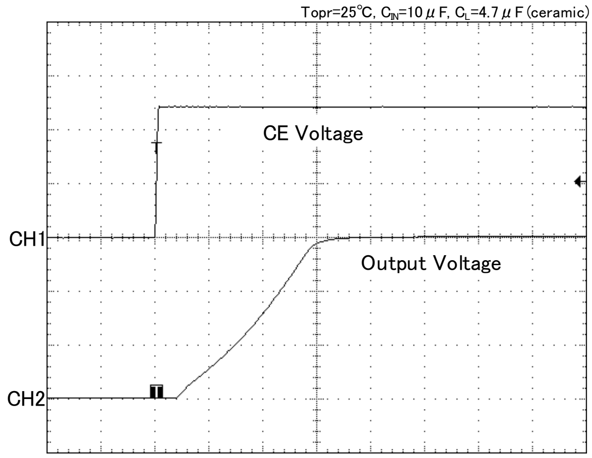
V_{IN}=4.0V, Tr=5 μ s, I_{OUT}=0.1mA
Topr=25℃, C_{IN}=10 μ F, C_L=4.7 μ F (ceramic)



100 μ s/div
CH1 : 500mV/div CH2 : 1V/div

XC6220x301

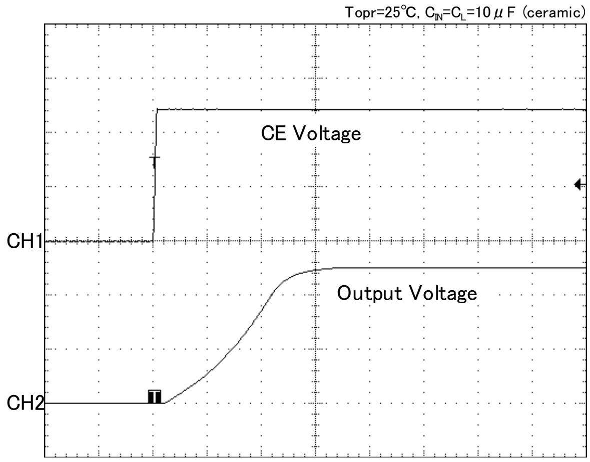
V_{IN}=4.0V, Tr=5 μ s, I_{OUT}=300mA
Topr=25℃, C_{IN}=10 μ F, C_L=4.7 μ F (ceramic)



100 μ s/div
CH1 : 500mV/div CH2 : 1V/div

XC6220x501

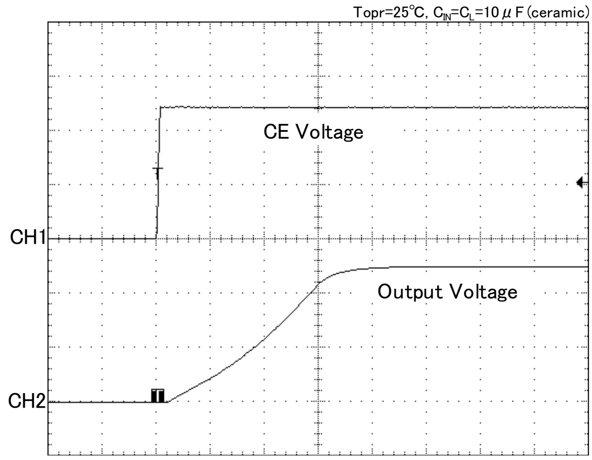
V_{IN}=6.0V, Tr=5 μ s, I_{OUT}=0.1mA
Topr=25℃, C_{IN}=C_L=10 μ F (ceramic)



100 μ s/div
CH1 : 500mV/div CH2 : 2V/div

XC6220x501

V_{IN}=6.0V, Tr=5 μ s, I_{OUT}=300mA
Topr=25℃, C_{IN}=C_L=10 μ F (ceramic)

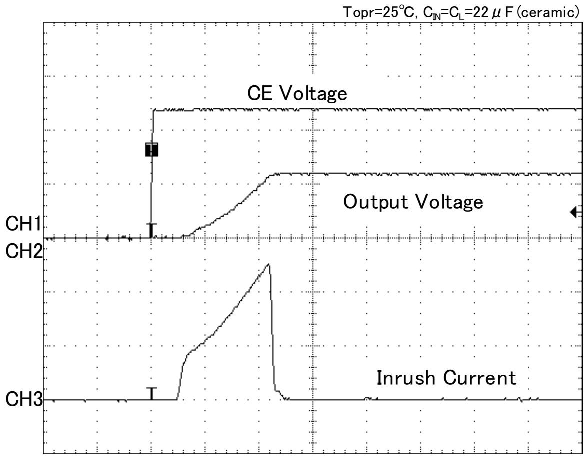


100 μ s/div
CH1 : 500mV/div CH2 : 2V/div

(13) Inrush Current

XC6220x121

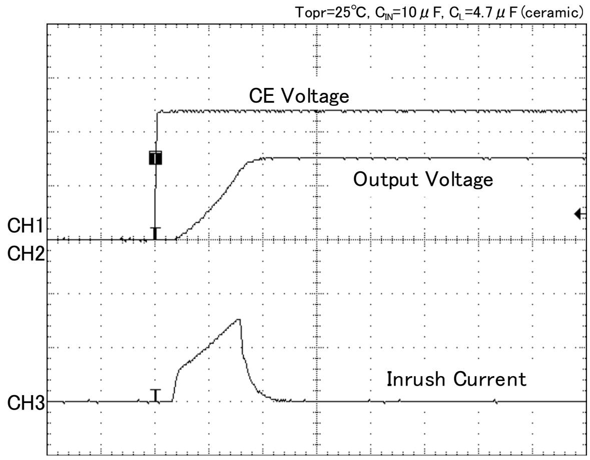
V_{IN}=2.2V, Tr=5 μ s
Topr=25℃, C_{IN}=C_L=22 μ F (ceramic)



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

XC6220x301

V_{IN}=4.0V, Tr=5 μ s
Topr=25℃, C_{IN}=10 μ F, C_L=4.7 μ F (ceramic)



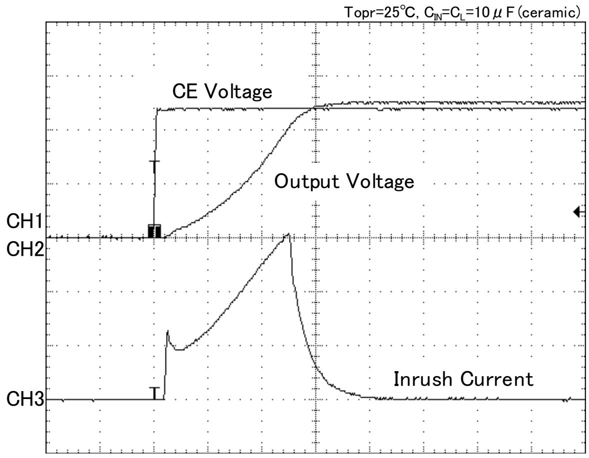
100 μ s/div
CH1 : 500mV/div CH2 : 1V/div CH3 : 100mA/div

■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(13) Inrush Current

XC6220x501

V_{IN}=6.0V, Tr=5 μs
Topr=25℃, C_{IN}=C_L=10 μF (ceramic)

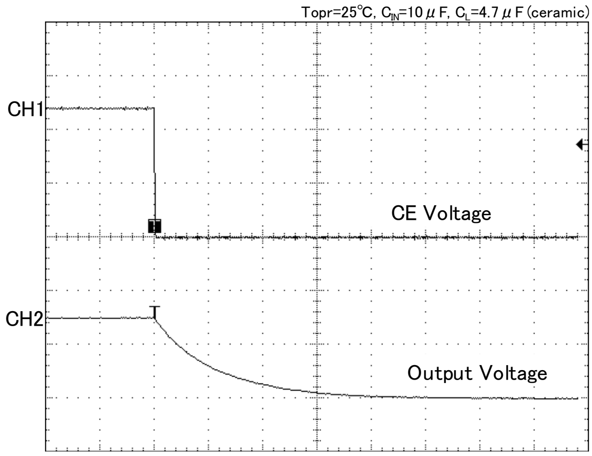


100 μs/div
CH1 : 500mV/div CH2 : 1V/div CH3 : 100mA/div

(14) CL Discharge Time

XC6220x301 (B/D)

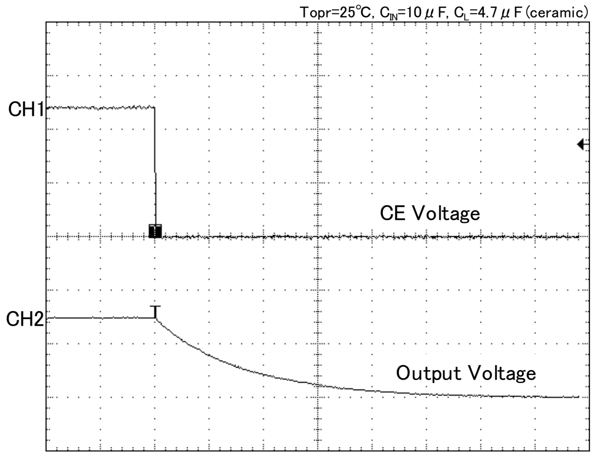
V_{IN}=4.0V, Tf=5 μs, I_{OUT}=0.1mA
Topr=25℃, C_{IN}=10 μF, C_L=4.7 μF (ceramic)



2.0ms/div
CH1 : 500mV/div CH2 : 2V/div

XC6220x301 (A/C)

V_{IN}=4.0V, Tf=5 μs, I_{OUT}=0.1mA
Topr=25℃, C_{IN}=10 μF, C_L=4.7 μF (ceramic)

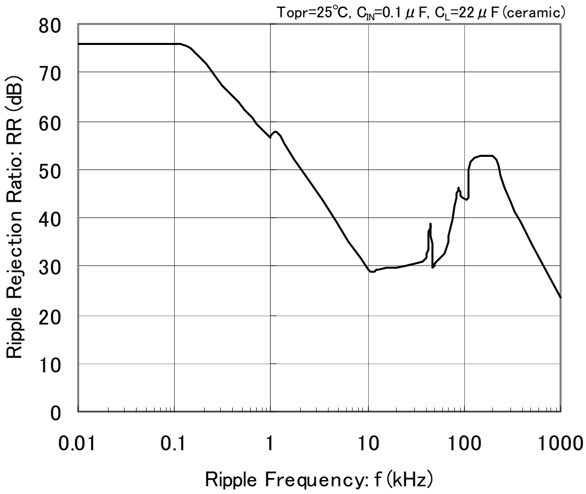


200ms/div
CH1 : 500mV/div CH2 : 2V/div

(15) Ripple Rejection Ratio

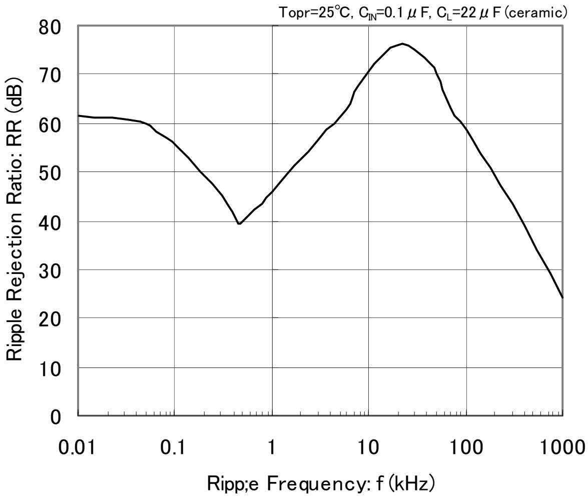
XC6220x121 (HighSpeed mode)

V_{IN}=CE=2.2VDC+0.5Vp-pAC, I_{OUT}=30mA
Topr=25℃, C_{IN}=0.1 μF, C_L=22 μF (ceramic)



XC6220x121 (PowerSave mode)

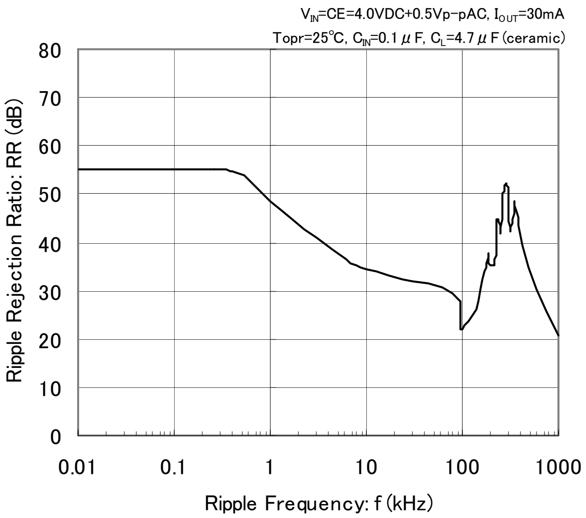
V_{IN}=CE=2.2VDC+0.5Vp-pAC, I_{OUT}=0.1mA
Topr=25℃, C_{IN}=0.1 μF, C_L=22 μF (ceramic)



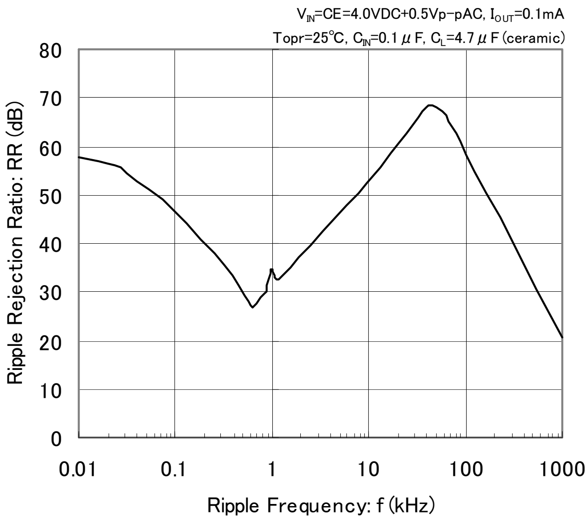
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(15) Ripple Rejection Ratio

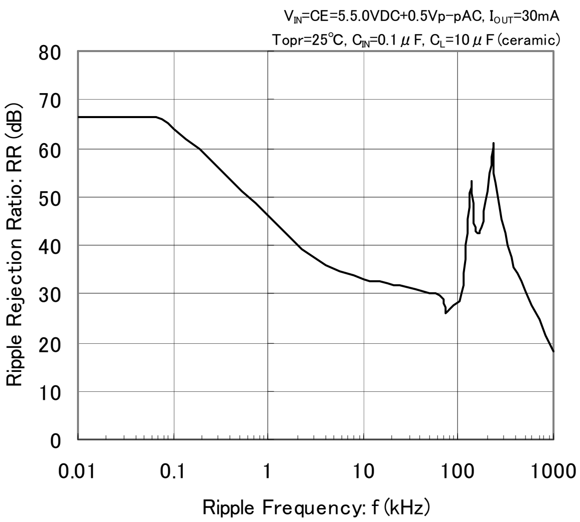
XC6220x301 (HighSpeed mode)



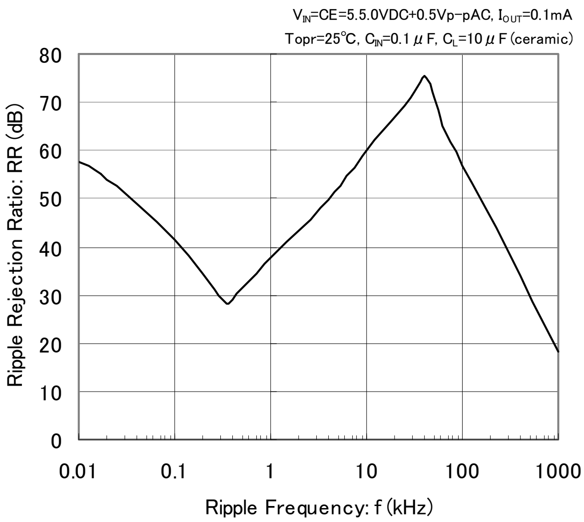
XC6220x301 (PowerSave mode)



XC6220x501 (HighSpeed mode)

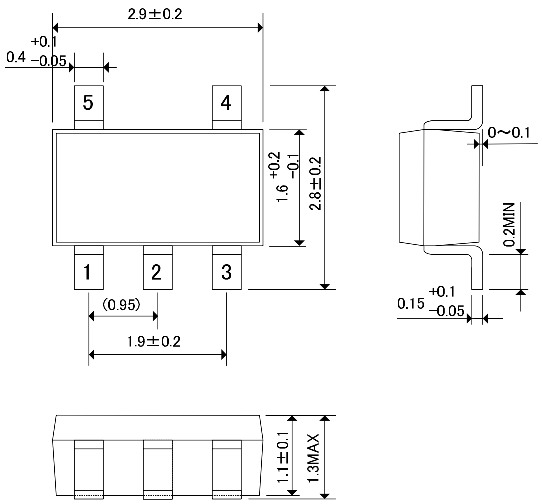


XC6220x501 (PowerSave mode)

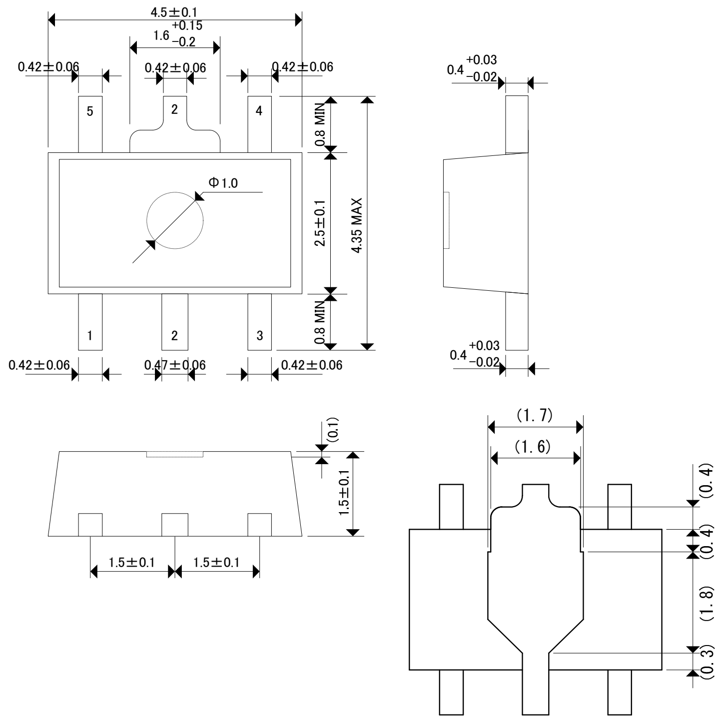


■PACKAGING INFORMATION

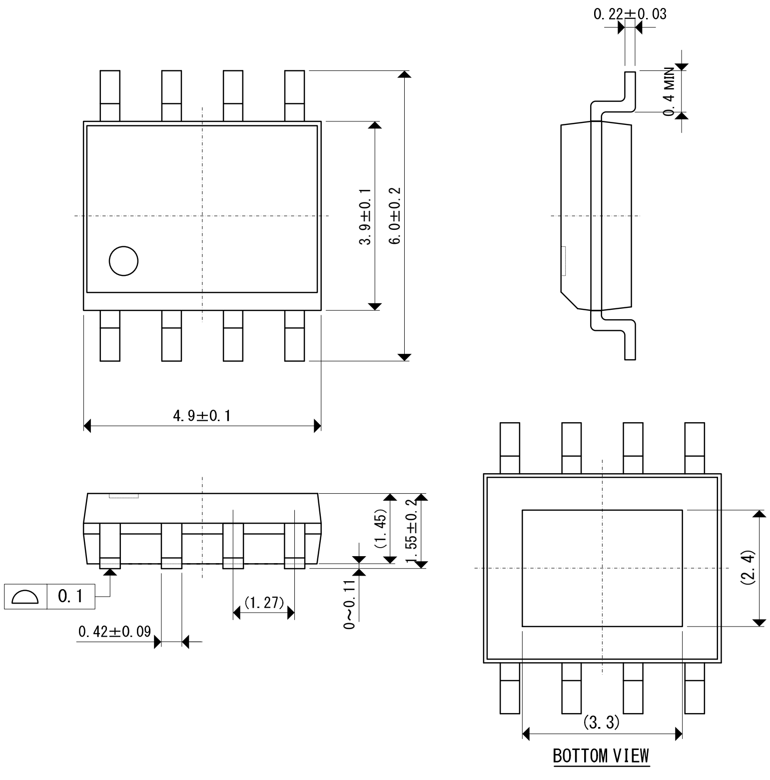
●SOT-25 (unit : mm)



●SOT-89-5 (unit : mm)

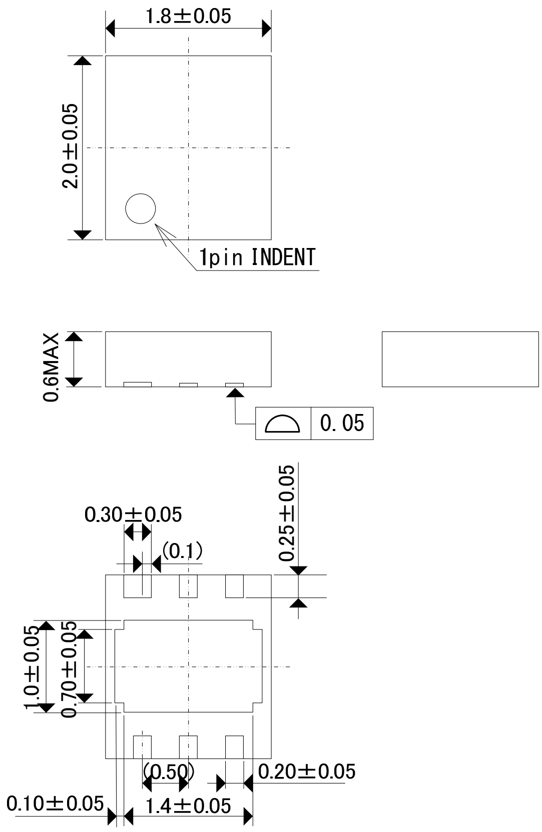


●SOP-8FD (unit : mm)

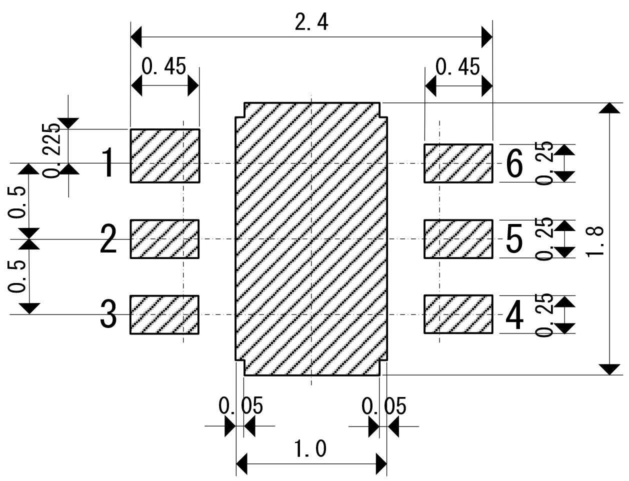


■PACKAGING INFORMATION (Continued)

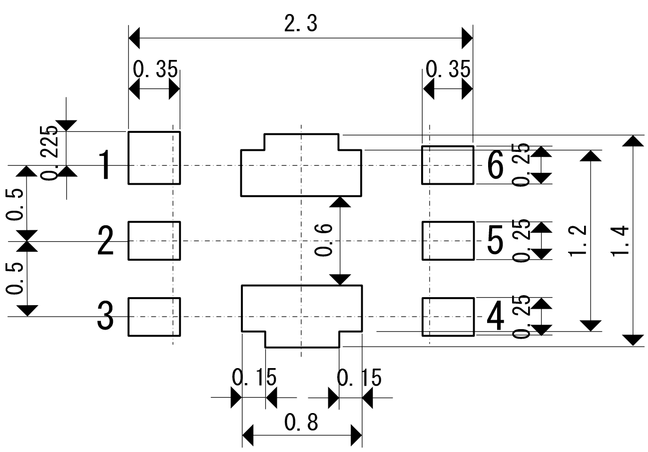
●USP-6C (unit : mm)



●USP-6C Reference Pattern Layout



●USP-6C Reference Metal Mask Design



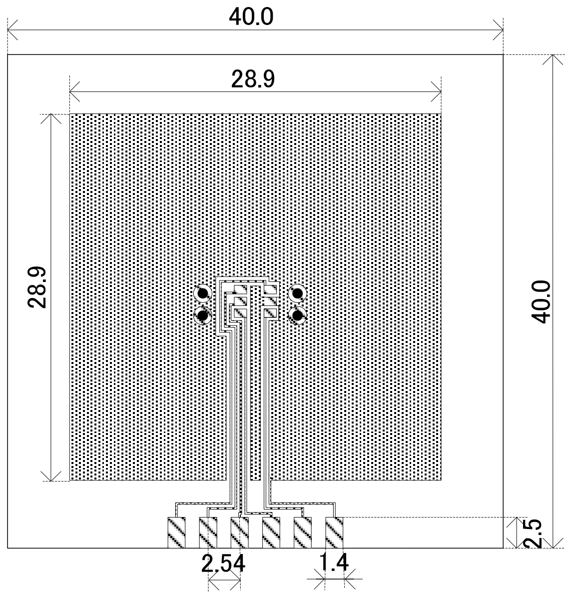
■PACKAGING INFORMATION (Continued)

- SOT-25 Power Dissipation

Power dissipation data for the SOT-25 is shown in this page.
The value of power dissipation varies with the mount board conditions.
Please use this data as one of reference data taken in the described condition.

1. Measurement Condition (Reference data)

Condition: Mount on a board
Ambient: Natural convection
Soldering: Lead (Pb) free
Board: Dimensions 40 x 40 mm (1600 mm^2 in one side)
Copper (Cu) traces occupy 50% of the board area
In top and back faces
Package heat-sink is tied to the copper traces
(Board of SOT-26 is used.)
Material: Glass Epoxy (FR-4)
Thickness: 1.6 mm
Through-hole: 4 x 0.8 Diameter

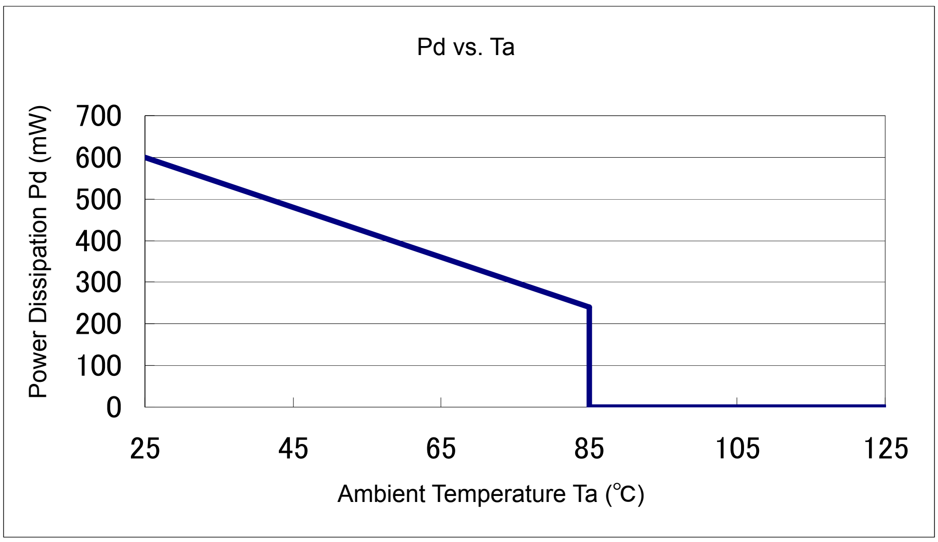


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient temperature

Board Mount (Tj max = 125℃)

Ambient Temperature (℃)	Power Dissipation Pd (mW)	Thermal Resistance (℃/W)
25	600	166.67
85	240	

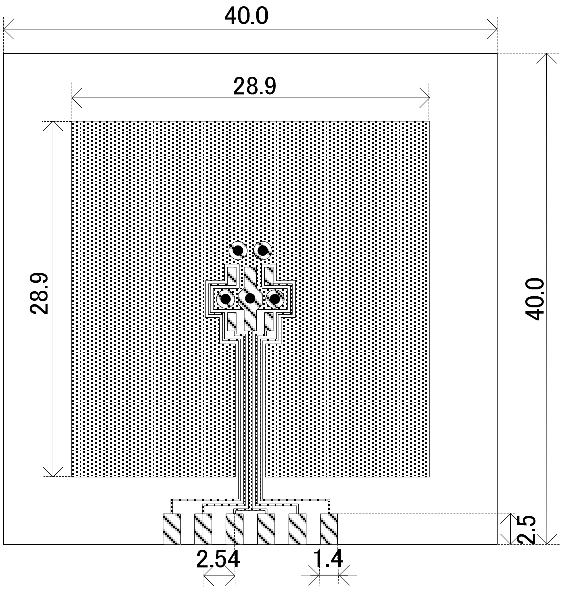


■PACKAGING INFORMATION (Continued)

● SOT-89-5 Power Dissipation

Power dissipation data for the SOT-89-5 is shown in this page.
The value of power dissipation varies with the mount board conditions.
Please use this data as one of reference data taken in the described condition.

1. Measurement Condition (Reference data)
   Condition: Mount on a board
   Ambient: Natural convection
   Soldering: Lead (Pb) free
   Board: Dimensions 40 x 40 mm (1600 mm^2 in one side)
   Copper (Cu) traces occupy 50% of the board area
   In top and back faces
   Package heat-sink is tied to the copper traces
   Material: Glass Epoxy (FR-4)
   Thickness: 1.6 mm
   Through-hole: 5 x 0.8 Diameter

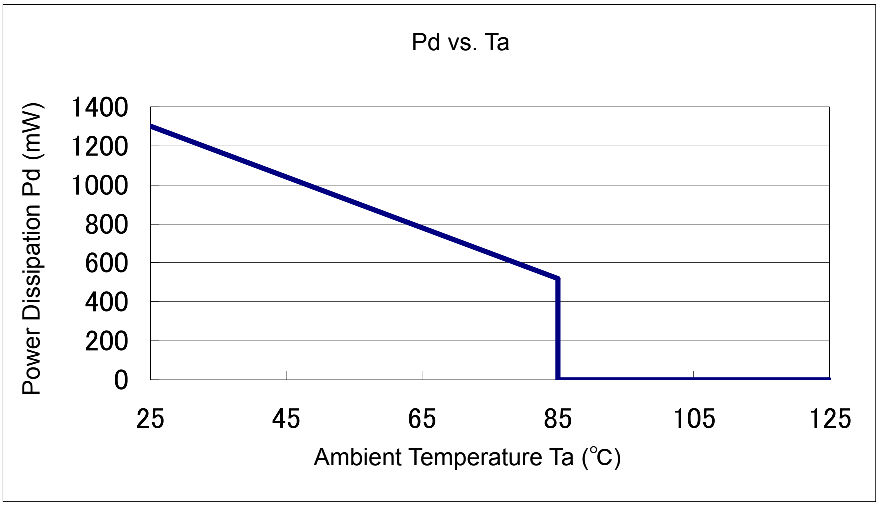


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient temperature

Board Mount (Tj max = 125℃)

Ambient Temperature (℃)	Power Dissipation Pd (mW)	Thermal Resistance (℃/W)
25	1300	76.92
85	520	



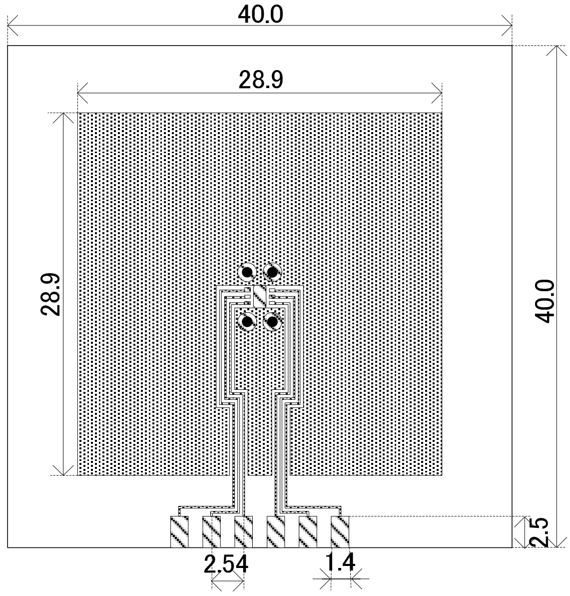
■PACKAGING INFORMATION (Continued)

● USP-6C Power Dissipation

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

1. Measurement Condition (Reference data)

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

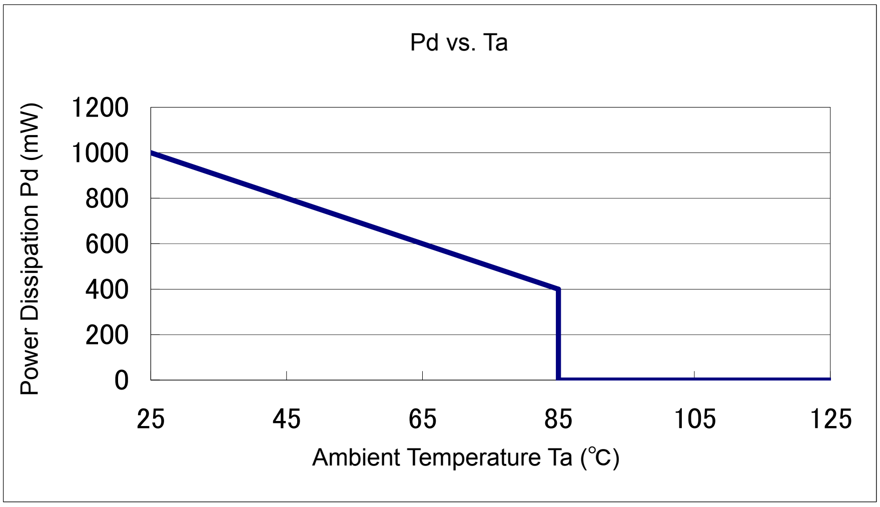


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient temperature

Board Mount (Tj max = 125℃)

Ambient Temperature (℃)	Power Dissipation Pd (mW)	Thermal Resistance (℃/W)
25	1000	100.00
85	400	

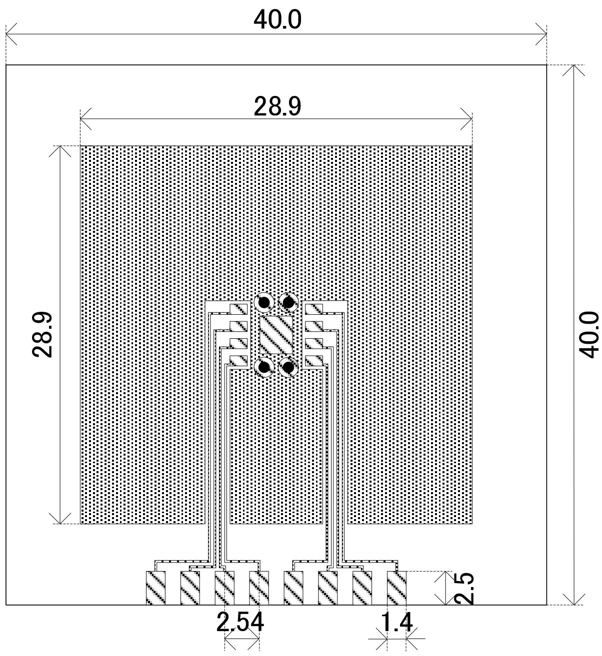


■PACKAGING INFORMATION (Continued)

● SOP-8FD Power Dissipation

Power dissipation data for the SOP-8FD is shown in this page.
The value of power dissipation varies with the mount board conditions.
Please use this data as one of reference data taken in the described condition.

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

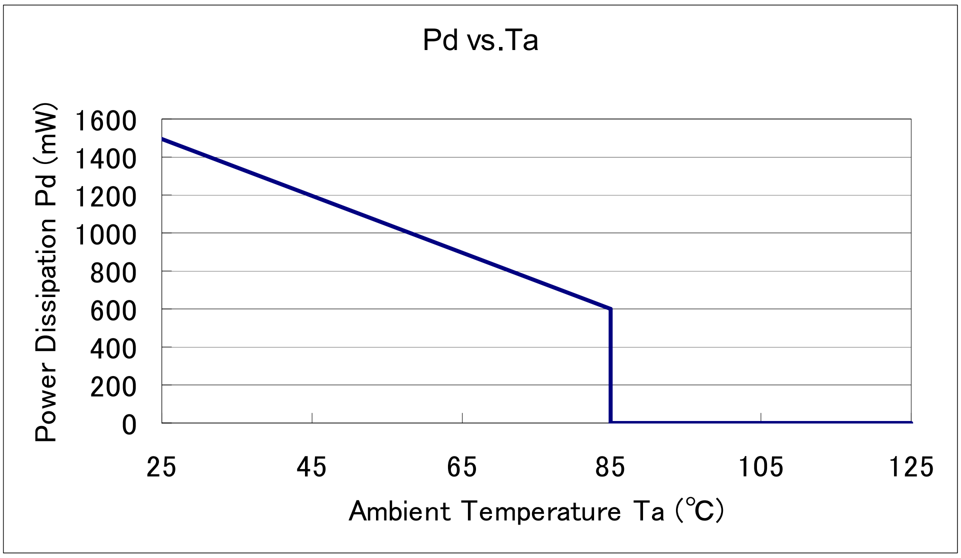


Evaluation Board (Unit: mm)

2. Power Dissipation vs. Ambient temperature

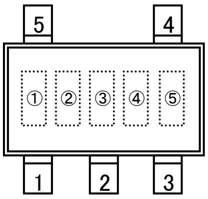
Board Mount (Tj max = 125℃)

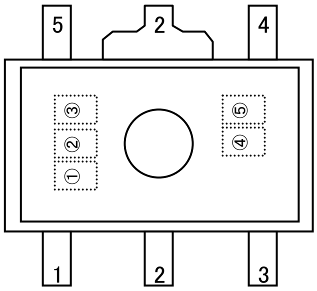
Ambient Temperature (℃)	Power Dissipation Pd (mW)	Thermal Resistance (℃/W)
25	1500	66.67
85	600	

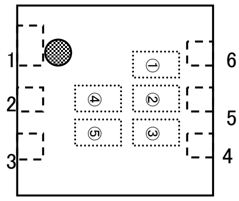


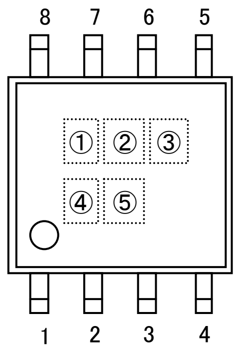
■MARKING RULE

●SOT-25, SOT-89-5,USP6C, SOP-8FD

SOT25


SOT89-5


USP6C


SOP-8FD


① represents product series

MARK	PRODUCT SERIES
H	XC6220******

② represents type of CE, voltage range, and accuracy

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

③ represents output voltage

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

④,⑤ represents production lot number
01～09、0A～0Z、11･･･9Z、A1～A9、AA･･･Z9、ZA～ZZ repeated
(G, I, J, O, Q, W excluded)
*No character inversion used.