ETR0342-005

30mA High Speed LDO Regulator

■GENERAL DESCRIPTION

The XC6225 series is a high accuracy, low noise, and low dropout CMOS LDO regulator. The series includes a reference voltage source, an error amplifier, a driver transistor, a current limiter, and a phase compensation circuit. The CE function enables the entire circuit to be turned off by a low level input signal to the CE pin. In this stand-by state, the XC6225B series can discharge the electric charge stored at the output capacitor through the internal auto-discharge switch, and as a result the Vout pin quickly returns to the Vss level. The output stabilization capacitor (CL) is also compatible with low ESR ceramic capacitors. Output voltage is selectable in 0.05V increments within a range of 0.8V~5.0V. The current limit fold-back circuit works as a short circuit protection as well as the output current limiter. The series achieves a fast response with only $25\,\mu$ A of low power consumption. The current limit is set to 50mA (TYP.) so that the device is optimized to protect the circuit from over-current. It is ideally suited for applications requiring 30 mA or less.

A small USP-4 package makes high density mounting possible.

APPLICATIONS

- Smart phones / Mobile phones
- Portable games
- Digital still cameras / Camcorders
- Digital audio equipment
- Mobile devices / terminals

■FEATURES

Output Current : 30mA <50mA (TYP.) Limit>
Dropout Voltage : 70mV@ louT=30mA, VouT=3.2V

Operating Voltage Range : 2.5V ~ 6.0V

Output Voltage Range : 0.8V~5.0V (0.05V increments)

Accuracy : ±2% (Vout≥1.5V)

±0.03V (VouT≦1.45V)

Low Power Consumption: 25μ A (TYP.)Stand-by Current: Less than 0.1μ A

High Ripple Rejection : 70dB @ 1kHz
Operating Ambient : -40°C~+85°C

Temperature

Output Capacitor : 1.0μ F ceramic capacitor

C_L High-Speed Auto-Discharge (XC6225B)

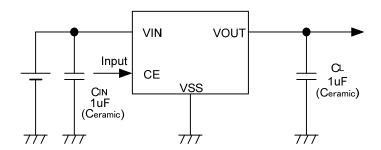
Low Output Noise

Packages : USP-4, SOT-25

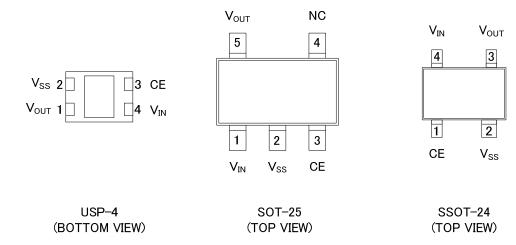
SSOT-24

Environmentally Friendly: EU RoHS Compliant, Pb Free

■TYPICAL APPLICATION CIRCUIT



■PIN CONFIGURATION



^{*}The heat sink pad of the USP-4 is reference to be soldered to enhance the strength. Please refer to the reference mount pattern and metal mask pattern. This pad should be electrically opened or connected to the Vss (No.2) pin.

■PIN ASSIGNMENT

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

■PIN FUNCTION ASSIGNMENT

PIN NAME	SIGNAL	STATUS
	L	Operation OFF
CE	Н	Operation ON
	OPEN	Undefined state

^{*}CE pin should not be left open. Each should have a certain voltage.

■PRODUCT CLASSIFICATION

Ordering Information

XC6225(1)(2)(3)(4)(5)(6)-(7)^(*1)

DESIGNATOR	ITEM	SYMBOL	DESCRIPTION
1)	Type of Regulator	Α	CE High Active, Without C _L discharge function
U	Type of Regulator	В	CE High Active, With C _L discharge function
2 3	Output Voltage	08~50	e.g. 3.0V → ①=3, ②=0
4	Output Voltage Accuracy	2	Output voltage is { x.x0V } (the 2 nd decimal place is "0") 2% (V _{OUT(T)} ≥1.5V), Within ±0.03V (V _{OUT(T)} ≤1.40V)
		А	Output voltage is { x.x5V } (the 2^{nd} decimal place is "5") $\pm 2\%$ (V _{OUT} ≥ 1.55 V), Within ± 0.03 V (V _{OUT} ≤ 1.45 V)
	Packages	GR-G	USP-4 (3,000/Reel)
56-7	Packages (Order Unit)	MR-G	SOT-25 (3,000/Reel)
	(Order Unit)	NR-G	SSOT-24 (3,000/Reel)

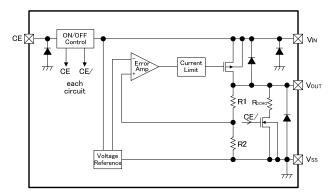
 $^{^{(^{\}circ}1)}$ The "-G" suffix denotes Halogen and Antimony free as well as being fully EU RoHS compliant.

■BLOCK DIAGRAMS

●XC6225 Series TypeA

CE ON/OFF Control T/// CE CE/ each circuit Voltage Reference R1 Voltage Reference

●XC6225 Series TypeB



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

■ ABSOLUTE MAXIMUM RATINGS

Ta=25°C

PARAN	METER	SYMBOL	RATINGS	UNITS
Input V	/oltage	V _{IN}	V _{SS} -0.3~V _{SS} +6.5	V
Output	Current	l _{out}	400 (*1)	mA
Output '	Voltage	V _{OUT}	V_{SS} -0.3 \sim V_{IN} +0.3	V
CE Input	CE Input Voltage		V _{SS} -0.3∼V _{SS} +6.5	V
	USP-4		120	
Power Dissipation	SOT-25	Pd	250	mW
	SSOT-24		150	
Operating Ambient Temperature		Topr	-40~+85	°C
Storage Te	mperature	Tstg	-55 ~ +125	°C

 $^{^{(^{*}1)}}$ $I_{OUT}~\leq~Pd$ / $(V_{IN}\text{-}V_{OUT})$

■ ELECTRICAL CHARACTERISTICS

●XC6225 Series Ta=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
Output Voltage	V _{OUT(E)} (*2)	V _{OUT(T)} ≧1.50V V _{CE} =V _{IN} , I _{OUT} =10mA	V _{OUT(T)} ×0.980	V _{OUT(T)}	V _{OUT(T)} ×1.020	V	①
Calput Voltage	* OUT(E)	V _{OUT(T)} ≦1.45V V _{CE} =V _{IN} , I _{OUT} =10mA	V _{OUT(T)} -0.030	(*3)``	V _{OUT(T)} +0.030	WNITS V mA mV μA μA %/V V ppm/°C	
Output Current	Гоитмах	$V_{CE}=V_{IN}$ $V_{IN}=V_{OUT(T)}+1.0V$ $1.5V \le V_{OUT(T)} \le 5.0V$ $V_{CE}=V_{IN}$ $V_{IN}=2.5V$ $0.8V \le V_{OUT(T)} \le 1.45V$	30	50	-	mA	①
Load Regulation	ΔV _{OUT}	V _{CE} =V _{IN} 0.1mA≦I _{OUT} ≦30mA	-	5	12	mV	1
Dropout Voltage (*4)	Vdif	I _{OUT} =30mA, V _{CE} =V _{IN}		[E-2]		mV	1
Supply Current	I _{SS}	V _{IN} =V _{OUT(T)} +1.0V, I _{OUT} =0mA	-	25	50	μΑ	2
Stand-by Current	I _{STB}	V _{IN} =6.0V, V _{CE} =V _{SS}	-	0.01	0.1	μΑ	2
Line Regulation	ΔV _{OUT} /	$V_{OUT(T)}$ +0.5 $V \le V_{IN} \le 6.0V$ $V_{OUT(T)} \ge 2.0V$, V_{CE} = V_{IN} , I_{OUT} =10mA		0.01	0.20	0/ 0 /	(1)
Line Regulation ((ΔV _{IN} •V _{OUT})	2.5V≦V _{IN} ≦6.0V V _{OUT(T)} ≦1.95V V _{CE} =V _{IN} , I _{OUT} =10mA		0.01	0.20	707 \$)
Input Voltage	V _{IN}		2.5	-	6.0	V	1
Output Voltage Temperature Characteristics	ΔV _{OUT} / (ΔTopr•V _{OUT})	V _{CE} =V _{IN} , I _{OUT} =30mA -40°C≦Topr≦85°C	-	±100	-	ppm/°C	1

■ ELECTRICAL CHARACTERISTICS (Continued)

●XC6225 Series (Continued) Ta=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
Disale Deienting		$\begin{aligned} &V_{\text{IN}} = 5.75 V_{\text{DC}} + 0.5 Vp\text{-pAC} \\ &5.0 V \geqq V_{\text{OUT}(T)} \geqq 4.8 V \\ &V_{\text{CE}} = V_{\text{IN}}, I_{\text{OUT}} = 30 \text{mA}, f = 1 \text{kHz} \end{aligned}$ $\begin{aligned} &V_{\text{IN}} = \{V_{\text{OUT}(T)} + 1.0\} V_{\text{DC}} + 0.5 Vp\text{-pAC} \\ &4.75 V \geqq V_{\text{OUT}(T)} \geqq 4.05 V \end{aligned}$		60	-		
Ripple Rejection Ratio	PSRR	$\begin{split} &V_{CE} = V_{IN}, \ I_{OUT} = 30 \text{mA}, \ f = 1 \text{kHz} \\ &V_{IN} = \{V_{OUT(T)} + 1.0\} \ VDC + 0.5 \ Vp - pAC \\ &4.0 \ V \ge V_{OUT(T)} \ge 1.75 \ V \\ &V_{CE} = V_{IN}, \ I_{OUT} = 30 \text{mA}, \ f = 1 \text{kHz} \\ &V_{IN} = 2.75 \ V_{DC} + 0.5 \ Vp - pAC \\ &1.7 \ V \ge V_{OUT(T)} \ge 0.8 \ V \\ &V_{CE} = V_{IN}, \ I_{OUT} = 30 \text{mA}, \ f = 1 \text{kHz} \end{split}$		70	-	_ dB	3
Limit Current1 ^(*8)	I _{LIM1}	V_{IN} =6.0V, V_{CE} = V_{IN} 5.0V \geq $V_{OUT(T)}$ \geq 0.8V	30	50	70		
Limit Current2 ^(*8) (*9)	I _{LIM 2}	$V_{IN}=V_{OUT(T)}+1.0V, V_{CE}=V_{IN}$ $5.0V \ge V_{OUT(T)} \ge 1.55V$	30	50	70	mA	1
		V_{IN} =2.5V 1.50V \ge V _{OUT(T)} \ge 0.8V					
Limit Current3 ^(*8) (*9)	I _{LIM 3}	$V_{IN}=V_{OUT(T)}+0.1V$ $5.0V \ge V_{OUT(T)} \ge 2.4V$ $V_{IN}=2.5V$ $2.35V \ge V_{OUT(T)} \ge 1.55V$		50	70		
Short Current	I _{SHORT}	$V_{\text{CE}} = V_{\text{IN}}$ V_{OUT} is short-circuited at the V_{SS} level	-	15	-	mA	1
CE High Level Voltage	V_{CEH}		1.2	-	6.0	V	4
CE Low Level Voltage	V_{CEL}		-	-	0.3	V	4
CE High Level Current	I _{CEH}	V _{CE} =V _{IN}	-0.1	-	0.1	μΑ	4
CE Low Level Current	I _{CEL}	V _{CE} =V _{SS}	-0.1	-	0.1	μΑ	4
C _L Auto-Discharge Resistance (*7)	R _{DCHG}	V _{IN} =6.0V, V _{OUT} =4.0V, V _{CE} = V _{SS}	-	780	-	Ω	1

NOTE:

- * 1: Unless otherwise stated regarding input voltage conditions, 1.5V≦V_{OUT(I)}≦5.0V is V_{IN}=V_{OUT(I)}+1.0V, and 0.8V≦V_{OUT(I)}≦1.45V is V_{IN}=2.5V.
- * 2: Vout (E) = Effective output voltage (Refer to the voltage chart)
 - (I.e. the output voltage when stabilized "Vout (T) + 1.0V" is provided at the Vin pin while maintaining a certain lout value.)
- * 3: Vout (T) = Nominal output voltage
- * 4: Vdif ={VIN1(*6)-VOUT1(*5)}
- * 5: Vout1=A voltage equal to 98% of the output voltage when an amply stabilized {Vout (T) +1.0V} is input.
- * 6: VIN1= The input voltage when Vout1 appears at the Vout pin while input voltage is gradually decreased.
- * 7: For the XC6225 series type B only. The XC6225 series type A discharges by using the two resistors R1 and R2 shown in the block diagram.
- * 8: Limit current is defined as the output current when V_{OUT(E)} x 0.95 is impressed at the V_{OUT} pin.
- * 9: The device may not satisfy the specification values when it is used with the input voltages lower than the conditions of I_{LIM3}.

■OUTPUT VOLTAGE CHART

●Voltage Table1

Ta=25°C

SYMBOL Color Co	●Voltage Table1					
OUTPUT VOLTAGE (V) VOUT(E) VOIT (mV) Voiff Vout(t) MIN. MAX. TYP. MAX. 0.80 0.7700 0.8300 325 1700 0.85 0.8200 0.8800 325 1660 0.90 0.8700 0.9300 235 1550 1.00 0.9700 1.0300 160 1500 1.05 1.0200 1.0800 1450 1450 1.10 1.0700 1.1300 115 1400 1.15 1.1200 1.1800 115 1350 1.20 1.1700 1.2300 1300 1250 1.30 1.2700 1.3300 1250 1250 1.33 1.3200 1.3300 1150 1150 1.40 1.3700 1.4300 1100 1100 1.45 1.4200 1.4800 1050 150 1.60 1.5680 1.6320 160 850 1.65 1.6170	SYMBOL	Е	E-1	E	E-2	
OUTHOT VOLTAGE (V) VOLTAGE (V) VOLTAGE (V) Voutif Voutif Votif Vout(t) MIN. MAX. TYP. MAX. 0.80 0.7700 0.8300 325 1700 0.85 0.8200 0.8800 325 1650 0.90 0.8700 0.9300 235 1550 1.00 0.9700 1.0300 160 1500 1.05 1.0200 1.0800 1450 1450 1.10 1.0700 1.1300 115 1400 1.15 1.1200 1.1800 115 1350 1.20 1.1700 1.2300 1300 1250 1.33 1.2700 1.3300 1300 1250 1.35 1.3200 1.3800 1150 1150 1.40 1.3700 1.4300 1100 1100 1.45 1.4200 1.4800 1050 1550 1.55 1.5190 1.5810 950 1000 <t< td=""><td>NOMINAL</td><td>OL I</td><td>TDLIT</td><td>DROPOU</td><td>T VOLTAGE</td></t<>	NOMINAL	OL I	TDLIT	DROPOU	T VOLTAGE	
VOLTAGE (MV) Vout(T) WIN. MAX. TYP. MAX. 0.80 0.7700 0.8300 325 1700 0.85 0.8200 0.8800 325 1650 0.90 0.8700 0.9300 235 1600 0.95 0.9200 0.9800 1550 1550 1.00 0.9700 1.0300 160 1450 1.01 1.0700 1.1300 115 1400 1.15 1.1200 1.1800 115 1350 1.20 1.1700 1.2300 1300 1350 1.25 1.2200 1.2800 1300 1250 1.33 1.3200 1.3300 1300 1250 1.35 1.3200 1.3300 1300 1150 1.44 1.3700 1.4300 1100 1050 1.55 1.5190 1.5810 1000 1050 1.55 1.5190 1.5810 950 900	OUTPUT			I _{OUT} =	=30mA	
Vour(f) MIN. MAX. TYP. MAX. 0.80 0.7700 0.8300 325 1700 0.85 0.8200 0.8800 325 1650 0.90 0.8700 0.9300 235 1600 0.95 0.9200 0.9800 235 1550 1.00 0.9700 1.0300 160 1450 1.05 1.0200 1.0800 1450 1400 1.10 1.0700 1.1300 115 1400 1.15 1.1200 1.1800 115 1350 1.20 1.1700 1.2300 1300 1250 1.33 1.2700 1.3300 1250 1250 1.33 1.2700 1.3800 1150 1150 1.44 1.3700 1.4800 1050 1.45 1.4200 1.4800 1050 1.55 1.5190 1.5810 1000 1.55 1.5190 1.5810 850		VOLI	AGE(V)	1)	mV)	
0.80 0.7700 0.8300 325 1700 0.85 0.8200 0.8800 325 1650 0.90 0.8700 0.9300 235 1600 0.95 0.9200 0.9800 1550 1.00 0.9700 1.0300 160 1450 1.05 1.0200 1.1800 115 1400 1.10 1.0700 1.1300 115 1400 1.15 1.1200 1.1800 1350 1350 1.20 1.1700 1.2300 1300 1250 1.25 1.2200 1.2800 1250 1250 1.30 1.2700 1.3300 1250 1250 1.35 1.3200 1.3800 1150 1250 1.40 1.3700 1.4300 1100 1100 1.45 1.4200 1.4800 1050 1100 1.55 1.5190 1.5810 1000 1050 1.66 1.6170 1.6830 <td>(V)</td> <td>Vo</td> <td>OUT(E)</td> <td>\</td> <td>/dif</td>	(V)	Vo	OUT(E)	\	/dif	
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0.95 0.9200 0.9800 1.550 1.00 0.9700 1.0300 160 1500 1.05 1.0200 1.0800 1450 1450 1.10 1.0700 1.1300 115 1400 1.15 1.1200 1.1800 115 1350 1.20 1.1700 1.2300 1300 1250 1.30 1.2700 1.3300 1250 1250 1.33 1.3200 1.3800 1150 1200 1.35 1.3200 1.3800 1150 1150 1.40 1.3700 1.4300 1100 1150 1.45 1.4200 1.4800 1050 1050 1.50 1.4700 1.5300 1000 1050 1.55 1.5190 1.5810 1000 950 1.65 1.6170 1.6830 1000 850 1.70 1.6660 1.7340 1.75 1.7150 1.7850 750 1.80 <td>0.85</td> <td>0.8200</td> <td>0.8800</td> <td>325</td> <td>1650</td>	0.85	0.8200	0.8800	325	1650	
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1.05 1.0200 1.0800 1450 1.10 1.0700 1.1300 115 1400 1.15 1.1200 1.1800 115 1350 1.20 1.1700 1.2300 1300 1250 1.30 1.2700 1.3300 1250 1250 1.35 1.3200 1.3800 1150 1200 1.35 1.3200 1.3800 1100 1100 1.40 1.3700 1.4300 1100 1100 1.45 1.4200 1.4800 1050 1000 1.50 1.4700 1.5300 1000 1050 1.55 1.5190 1.5810 1000 1000 1.55 1.5190 1.6830 1000 1000 1.65 1.6170 1.6830 850 1000 1.75 1.7150 1.7850 750 180 1.85 1.8130 1.8870 650 650 1.90 1.8620 1.9380	0.95	0.9200	0.9800	235	1550	
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1.25 1.2200 1.2800 1.30 1.2700 1.3300 1.35 1.3200 1.3800 1.40 1.3700 1.4300 1.45 1.4200 1.4800 1.50 1.4700 1.5300 1.55 1.5190 1.5810 1.60 1.5680 1.6320 1.65 1.6170 1.6830 1.70 1.6660 1.7340 1.75 1.7150 1.7850 1.80 1.7640 1.8360 1.90 1.8620 1.9380 1.95 1.9110 1.9890 2.00 1.9600 2.0400 2.05 2.0990 2.0910 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.3460 2.35 2.3030 2.3520 2.45 2.4010 2.4990 2.55 2.4990 2.650 2.55 2.5970 2.7030 <td>1.15</td> <td>1.1200</td> <td>1.1800</td> <td>115</td> <td>1350</td>	1.15	1.1200	1.1800	115	1350	
1.30 1.2700 1.3300 1.350 1.3200 1.3800 1150 1.40 1.3700 1.4300 1100 1100 1150 1100 1.45 1.4200 1.4800 1050 1000 1050 1000 1050 1.50 1.4700 1.5300 1000 1000 1000 1050 1000 1050 1000 1050 1000 1050 1000 1050 1000 1050 1000 1050 1000 1050 1000 1050 1000 1000 1050 1000 1000 1050 1000	1.20	1.1700	1.2300		1300	
1.35 1.3200 1.3800 1150 1.40 1.3700 1.4300 1100 1.45 1.4200 1.4800 1050 1.50 1.4700 1.5300 1000 1.55 1.5190 1.5810 950 1.60 1.5680 1.6320 900 1.65 1.6170 1.6830 850 1.70 1.6660 1.7340 800 1.75 1.7150 1.7850 750 1.80 1.7640 1.8360 700 1.85 1.8130 1.8870 650 1.90 1.8620 1.9380 600 1.95 1.9110 1.9890 550 2.00 1.9600 2.0400 500 2.05 2.0990 2.0910 450 2.15 2.1070 2.1930 350 2.20 2.1560 2.2440 2.25 2.30 2.2540 2.3460 2.0 2.35 2.3030 2.3970 2.40 2.55 2.4990 2.6010 2.540 </td <td>1.25</td> <td>1.2200</td> <td>1.2800</td> <td>ĺ</td> <td>1250</td>	1.25	1.2200	1.2800	ĺ	1250	
1.35 1.3200 1.3800 1150 1.40 1.3700 1.4300 1100 1.45 1.4200 1.4800 1050 1.50 1.4700 1.5300 1000 1.55 1.5190 1.5810 950 1.60 1.5680 1.6320 900 1.65 1.6170 1.6830 850 1.70 1.6660 1.7340 800 1.75 1.7150 1.7850 750 1.80 1.7640 1.8360 700 1.85 1.8130 1.8870 650 1.90 1.8620 1.9380 600 1.95 1.9110 1.9890 550 2.00 1.9600 2.0400 2.0400 2.05 2.0900 2.0910 450 2.10 2.0580 2.1420 2.15 2.1070 2.1930 2.25 2.2050 2.2950 2.33 2.2540 2.3460 2.40 2.3520 2.4480 2.45 2.4010 2.4990	1.30	1.2700	1.3300	0.5	1200	
1.45 1.4200 1.4800 1050 1.50 1.4700 1.5300 1000 1.55 1.5190 1.5810 950 1.60 1.5680 1.6320 900 1.65 1.6170 1.6830 850 1.70 1.6660 1.7340 800 1.75 1.7150 1.7850 750 1.80 1.7640 1.8360 700 1.85 1.8130 1.8870 650 1.90 1.8620 1.9380 600 1.95 1.9110 1.9890 550 2.00 1.9600 2.0400 500 2.15 2.1070 2.1930 350 2.20 2.1560 2.2440 2.25 2.30 2.2540 2.3460 200 2.35 2.3030 2.3970 150 2.40 2.3520 2.4480 2.45 2.45 2.4900 2.5500 2.5500 2.55 2.4990 2.6010 2.665 2.5970 2.7030 2.75 2.69	1.35	1.3200	1.3800	85	1150	
1.50 1.4700 1.5300 1.55 1.5190 1.5810 1.60 1.5680 1.6320 1.65 1.6170 1.6830 1.70 1.6660 1.7340 1.75 1.7150 1.7850 1.80 1.7640 1.8360 1.85 1.8130 1.8870 1.90 1.8620 1.9380 1.95 1.9110 1.9890 2.00 1.9600 2.0400 2.05 2.0990 2.0910 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9580	1.40	1.3700	1.4300	1	1100	
1.55 1.5190 1.5810 1.60 1.5680 1.6320 1.65 1.6170 1.6830 1.70 1.6660 1.7340 1.75 1.7150 1.7850 1.80 1.7640 1.8360 1.85 1.8130 1.8870 1.90 1.8620 1.9380 1.95 1.9110 1.9890 2.00 1.9600 2.0400 2.05 2.0090 2.0910 2.10 2.0580 2.1420 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.85 2.7930 2.9070 2.90 2.8420 2.9580	1.45	1.4200	1.4800	1	1050	
1.60 1.5680 1.6320 1.65 1.6170 1.6830 1.70 1.6660 1.7340 1.75 1.7150 1.7850 1.80 1.7640 1.8360 1.85 1.8130 1.8870 1.90 1.8620 1.9380 1.95 1.9110 1.9890 2.00 1.9600 2.0400 2.05 2.0090 2.0910 2.10 2.0580 2.1420 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.85 2.7930 2.9070 2.90 2.8420 2.9580	1.50	1.4700	1.5300		1000	
1.65 1.6170 1.6830 1.70 1.6660 1.7340 1.75 1.7150 1.7850 1.80 1.7640 1.8360 1.85 1.8130 1.8870 1.90 1.8620 1.9380 1.95 1.9110 1.9890 2.00 1.9600 2.0400 2.10 2.0580 2.1420 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	1.55	1.5190	1.5810	1	950	
1.65 1.6170 1.6830 850 1.70 1.6660 1.7340 800 1.75 1.7150 1.7850 750 1.80 1.7640 1.8360 700 1.85 1.8130 1.8870 650 1.90 1.8620 1.9380 600 1.95 1.9110 1.9890 550 2.00 1.9600 2.0400 500 2.05 2.0990 2.0910 450 2.10 2.0580 2.1420 400 2.15 2.1070 2.1930 350 2.20 2.1560 2.2440 300 2.25 2.2050 2.2950 250 2.30 2.2540 2.3460 200 2.35 2.3030 2.3970 150 2.40 2.3520 2.4480 2.45 2.45 2.4010 2.4990 2.50 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.80 2.7440 2.8560 </td <td>1.60</td> <td>1.5680</td> <td>1.6320</td> <td>50</td> <td>900</td>	1.60	1.5680	1.6320	50	900	
1.75 1.7150 1.7850 750 1.80 1.7640 1.8360 700 1.85 1.8130 1.8870 650 1.90 1.8620 1.9380 600 1.95 1.9110 1.9890 550 2.00 1.9600 2.0400 500 2.05 2.0990 2.0910 450 2.10 2.0580 2.1420 400 2.15 2.1070 2.1930 350 2.20 2.1560 2.2440 300 2.25 2.2050 2.2950 250 2.30 2.2540 2.3460 200 2.35 2.3030 2.3970 150 2.40 2.3520 2.4480 2.45 2.45 2.4010 2.4990 2.50 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.85 2.7930 2.9070 2.90 2.8420 2.9580	1.65	1.6170	1.6830	50	850	
1.80 1.7640 1.8360 700 1.85 1.8130 1.8870 650 1.90 1.8620 1.9380 600 1.95 1.9110 1.9890 550 2.00 1.9600 2.0400 500 2.05 2.0090 2.0910 450 2.10 2.0580 2.1420 400 2.15 2.1070 2.1930 350 2.20 2.1560 2.2440 300 2.25 2.2050 2.2950 250 2.30 2.2540 2.3460 200 2.35 2.3030 2.3970 150 2.40 2.3520 2.4480 2.45 2.45 2.4010 2.4990 2.50 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.60 2.5480 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.8050 2.8050 2.8050 2.85 2.7930 2.9070 2.9070 2.9080 2.9070	1.70	1.6660	1.7340	1	800	
1.85 1.8130 1.8870 1.90 1.8620 1.9380 1.95 1.9110 1.9890 2.00 1.9600 2.0400 2.05 2.0090 2.0910 2.10 2.0580 2.1420 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.5500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.80 2.7440 2.8560 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	1.75	1.7150	1.7850	1	750	
1.90 1.8620 1.9380 600 1.95 1.9110 1.9890 550 2.00 1.9600 2.0400 500 2.05 2.0090 2.0910 450 2.10 2.0580 2.1420 400 2.15 2.1070 2.1930 350 2.20 2.1560 2.2440 300 2.25 2.2050 2.2950 250 2.30 2.2540 2.3460 200 2.35 2.3030 2.3970 150 2.40 2.3520 2.4480 2.4990 2.50 2.4500 2.5500 2.5500 2.55 2.4990 2.6010 2.6520 2.65 2.5970 2.7030 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	1.80	1.7640	1.8360		700	
1.95 1.9110 1.9890 2.00 1.9600 2.0400 2.05 2.0090 2.0910 2.10 2.0580 2.1420 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.5500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	1.85	1.8130	1.8870		650	
2.00 1.9600 2.0400 2.05 2.0090 2.0910 2.10 2.0580 2.1420 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.5400 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	1.90	1.8620	1.9380		600	
2.05 2.0090 2.0910 2.10 2.0580 2.1420 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.550 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.70 2.6460 2.7540 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	1.95	1.9110	1.9890		550	
2.10 2.0580 2.1420 2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.4500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.70 2.6460 2.7540 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.00	1.9600	2.0400]	500	
2.15 2.1070 2.1930 2.20 2.1560 2.2440 2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.4500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.05	2.0090	2.0910]	450	
2.15 2.1070 2.1930 350 2.20 2.1560 2.2440 300 2.25 2.2050 2.2950 250 2.30 2.2540 2.3460 200 2.35 2.3030 2.3970 150 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.4500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.10	2.0580	2.1420	40	400	
2.25 2.2050 2.2950 2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.4500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.15	2.1070	2.1930	40	350	
2.30 2.2540 2.3460 2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.4500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.20	2.1560	2.2440	Ī	300	
2.35 2.3030 2.3970 2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.4500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.25		2.2950]	250	
2.40 2.3520 2.4480 2.45 2.4010 2.4990 2.50 2.4500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.30	2.2540	2.3460]	200	
2.45 2.4010 2.4990 2.50 2.4500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.35	2.3030	2.3970		150	
2.50 2.4500 2.5500 2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.40	2.3520	2.4480			
2.55 2.4990 2.6010 2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.45	2.4010	2.4990	1		
2.60 2.5480 2.6520 2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.50	2.4500	2.5500		1	
2.65 2.5970 2.7030 2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.55	2.4990	2.6010			
2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.60	2.5480	2.6520			
2.70 2.6460 2.7540 2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.65	2.5970	2.7030		120	
2.75 2.6950 2.8050 2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.70	2.6460	2.7540	70	120	
2.80 2.7440 2.8560 2.85 2.7930 2.9070 2.90 2.8420 2.9580	2.75	2.6950	2.8050	1 /0		
2.90 2.8420 2.9580	2.80	2.7440]		
 	2.85	2.7930	2.9070	1		
2.95 2.8910 3.0090	2.90	2.8420	2.9580	1		
	2.95	2.8910	3.0090	1		

■OUTPUT VOLTAGE CHART (Continued)

●Voltage Table2

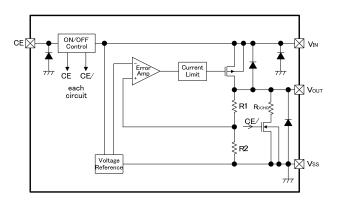
Ta=25°C

SYMBOL	E	-1	E-2			
NOMINAL	OUTPUT		DROPOUT	VOLTAGE		
OUTPUT	VOLTAGE(V)		I _{OUT} =3	80mA		
VOLTAGE	VOLIZ	(V)	(m	ıV)		
(V)		JT(E)	Vdif TYP. MAX.			
$V_{OUT(T)}$	MIN.	MAX.	TYP.	MAX.		
3.00	2.9400	3.0600				
3.05	2.9890	3.1110				
3.10	3.0380	3.1620	70	120		
3.15	3.0870	3.2130				
3.20	3.1360	3.2640				
3.25	3.1850	3.3150				
3.30	3.2340	3.3660				
3.35	3.2830	3.4170				
3.40	3.3320	3.4680				
3.45	3.3810	3.5190				
3.50	3.4300	3.5700				
3.55	3.4790	3.6210				
3.60	3.5280	3.6720				
3.65	3.5770	3.7230				
3.70	3.6260	3.7740				
3.75	3.6750	3.8250				
3.80	3.7240	3.8760				
3.85	3.7730	3.9270				
3.90	3.8220	3.9780				
3.95	3.8710	4.0290				
4.00	3.9200	4.0800				
4.05	3.9690	4.1310				
4.10	4.0180	4.1820	95	170		
4.15	4.0670	4.2330				
4.20	4.1160	4.2840				
4.25	4.1650	4.3350				
4.30	4.2140	4.3860				
4.35	4.2630	4.4370				
4.40	4.3120	4.4880				
4.45	4.3610	4.5390				
4.50	4.4100	4.5900				
4.55	4.4590	4.6410				
4.60	4.5080	4.6920				
4.65	4.5570	4.7430				
4.70	4.6060	4.7940				
4.75	4.6550	4.8450				
4.80	4.7040	4.8960				
4.85	4.7530	4.9470				
4.90	4.8020	4.9980				
4.95	4.8510	5.0490				
5.00	4.9000	5.1000				

■ OPERATIONAL EXPLANATION

The voltage divided by resistors R1 & R2 is compared with the internal reference voltage by the error amplifier. The P-channel MOSFET connected to the Vout pin, is then driven by the subsequent control signal. The output voltage at the Vout pin is controlled and stabilized by a system of negative feedback. The current limit circuit and short-circuit protection circuit operate in relation to the level of output current. Further, the IC's entire circuitry is turned off by the input signal to the CE pin.

BLOCK DIAGRAM



<Input and Output Capacitors>

The XC6225 needs an output capacitor C_L for phase compensation. Values required for the phase compensation are shown in the chart below. If a loss of the capacitance happens, the stable phase compensation may not be obtained. Please ensure to use a capacitor which does not depend on bias or temperature too much. For a stable power input, please connect an input capacitor C_{IN} of 1.0 μ F between the V_{IN} pin and the V_{SS} pin.

OUTPUT VOLTAGE	OUTPUT CAPACITOR
0.8V~1.15V	More than C_L =4.7 μ F
1.2V~1.35V	More than $C_L=2.2 \mu F$
1.4V~4.0V	More than $C_L=1.0 \mu F$
4.05V~5.0V	More than C _L =2.2 μ F

<CL Auto-Discharge Function>

XC6225 series Type B can discharge the electric charge in the output capacitor (CL), when a low signal to the CE pin, which enables the whole IC circuit to be turned off, is inputted via the N-channel transistor and C_L discharge resistance(R_{DCHG}) located between the VouT pin and the Vss pin (refer to BLOCK DIAGRAM). The C_L auto-discharge resistance value is set at 780 Ω (VouT=4.0V @ VIN=6.0V at TYP.). The discharge time of the output capacitor (CL) is set by the C_L auto-discharge resistance (R_{DCHG}) and the output capacitor (CL). By setting the time constant of the C_L auto-discharge resistance(R_{DCHG}) value [R_{DCHG}] and the output capacitor value (CL) as τ (τ =C x R_{DCHG}), the output voltage after discharge via is calculated by the following formula.

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

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

■ OPERATIONAL EXPLANATION (Continued)

< Current Limiter, Short-Circuit Protection>

The XC6225 series' fold-back circuit operates as an output current limiter and a short protection circuit for the output pin. When the load current reaches the current limit level, the fixed current limiter circuit operates and output voltage drops. When the output pin is short-circuited to the Vss pin, the current falls and reaches about 15mA.

<CE Pin>

The IC's internal circuitry can be shutdown via the signal from the CE pin with the XC6225 series. In the shutdown state, output at the VouT pin will be pulled down to the Vss level via R1 & R2. However, with the XC6225 series type B, the C_L auto-discharge (R_{DCHG}) N-channel transistor switch is connected in parallel to R1 and R2 while the power supply is applied to the V_{IN} pin.

The output voltage is in an undefined state when the CE pin is left open. If this IC is used with the correct voltage for the CE pin, the logic is fixed and the IC will operate normally. However, the supply current may increase as a result of shoot-through current in the IC's internal circuitry when a medium voltage is input.

■NOTES ON USE

- 1. 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. Capacitances of these capacitors (C_{IN} , C_{L}) are decreased by the influences of bias voltage and ambient temperature. Care shall be

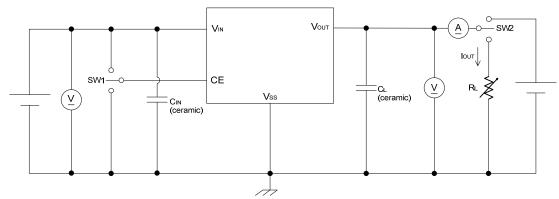
taken for capacitor selection to ensure stability of phase compensation from the point of ESR influence.

- 5. When it is used in a quite small input / output dropout voltage, output may go into unstable operation. Please test it thoroughly before using it in production.
- 6. Torex places an importance on improving our products and their reliability.

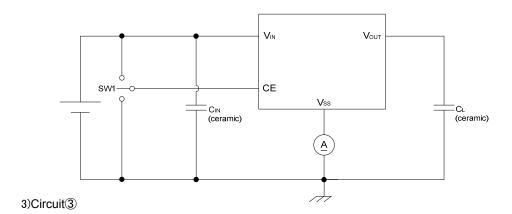
We request that users incorporate fail-safe designs and post-aging protection treatment when using Torex products in their systems.

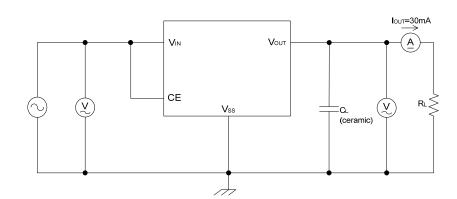
■TEST CIRCUITS



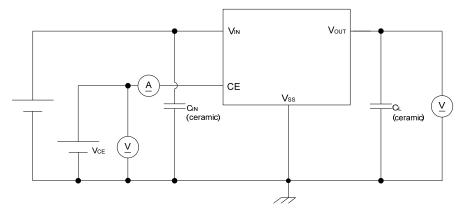


2)Circuit②



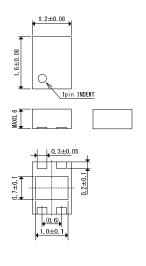


4)Circuit4



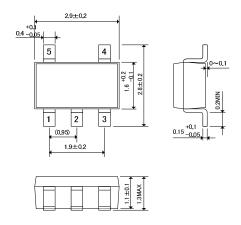
■PACKAGING INFORMATION

●USP-4 (unit: mm)

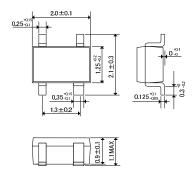


USP-4 Package

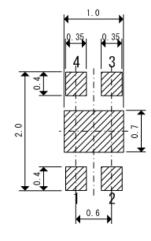
●SOT-25 (unit: mm)



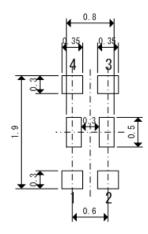
●SSOT-24 (unit: mm)



●USP-4 Reference Pattern Layout

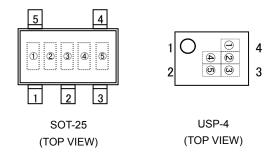


●USP-4 Reference Metal Mask Design



■MARKING RULE

●SOT-25, USP-4



① represents product number

MARK	PRODUCT SERIES
F	XC6225*****-G

2 represents type of regulator

	MA			
100mV increments		50mV increments		
OUTPUT	OUTPUT	OUTPUT	OUTPUT	PRODUCT SERIES
VOLTAGE	VOLTAGE VOLTAGE		VOLTAGE	
=0.8~3.5V	=3.6~5.0V	=0.85~3.55V	=3.65~4.95V	
V	Α	Е	L	XC6225A****-G
X	В	F	М	XC6225B****-G

③ represents output voltage

MARK	OUT	PUT V	OLTAG	E(V)	MARK	OUT	TPUT V	OLTAG	E(V)
0	-	3.6	-	3.65	F	2.1	-	2.15	-
1	-	3.7	-	3.75	Н	2.2	-	2.25	-
2	8.0	3.8	0.85	3.85	K	2.3	-	2.35	-
3	0.9	3.9	0.95	3.95	L	2.4	-	2.45	-
4	1.0	4.0	1.05	4.05	М	2.5	-	2.55	-
5	1.1	4.1	1.15	4.15	N	2.6	-	2.65	-
6	1.2	4.2	1.25	4.25	Р	2.7	-	2.75	-
7	1.3	4.3	1.35	4.35	R	2.8	-	2.85	-
8	1.4	4.4	1.45	4.45	S	2.9	-	2.95	-
9	1.5	4.5	1.55	4.55	Т	3.0	-	3.05	-
Α	1.6	4.6	1.65	4.65	U	3.1	-	3.15	-
В	1.7	4.7	1.75	4.75	V	3.2	-	3.25	-
С	1.8	4.8	1.85	4.85	Х	3.3	_	3.35	_
D	1.9	4.9	1.95	4.95	Y	3.4	-	3.45	-
E	2.0	5.0	2.05	-	Z	3.5	-	3.55	-

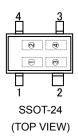
45 represents production lot number

01 to 09, 0A to 0Z, 11 to 9Z, A1 to A9, AA to Z9, ZA to ZZ in order.

(G, I, J, O, Q, W excluded. No character inversion used.)

■MARKING RULE (Continued)

●SSOT-24



① represents type of regulator and output voltage range

OUTPUT VOLTAGE =0.8~1.2V	OUTPUT VOLTAGE =1.25~1.7V	OUTPUT VOLTAGE =1.75~2.2V	OUTPUT VOLTAGE =2.25~2.7V	OUTPUT VOLTAGE =2.75~3.2V	PRODUCT SERIES	
L	0	М	Т	V	XC6225A****-G	
N	K	S	U	X	XC6225B****-G	
OUTPUT VOLTAGE =3.25~3.7V	OUTPUT VOLTAGE =3.75~4.05V	OUTPUT VOLTAGE =4.1~4.4V	OUTPUT VOLTAGE =4.45~4.75V	OUTPUT VOLTAGE =4.8~5.0V	PRODUCT SERIES	
Y	1	3	9	В	XC6225A****-G	
Z	2	4	Α	С	XC6225B****-G	

2 represents output voltage

MARK	OUTPUT VOLTAGE (V)
Р	0.8
R	0.85
S	0.9
Т	0.95
U	1.0
V	1.05
Х	1.1
Υ	1.15
Z	1.2

MARK	OUTPUT VOLTAGE (V)					
0	1.25	1.75	2.25	2.75	3.25	
1	1.3	1.8	2.3	2.8	3.3	
2	1.35	1.85	2.35	2.85	3.35	
3	1.4	1.9	2.4	2.9	3.4	
4	1.45	1.95	2.45	2.95	3.45	
5	1.5	2.0	2.5	3.0	3.5	
6	1.55	2.05	2.55	3.05	3.55	
7	1.6	2.1	2.6	3.1	3.6	
8	1.65	2.15	2.65	3.15	3.65	
9	1.7	2.2	2.7	3.2	3.7	

MARK	OUTPUT VOLTAGE (V)				
0	3.75	4.1	4.45	4.8	
1	3.8	4.15	4.5	4.85	
2	3.85	4.2	4.55	4.9	
3	3.9	4.25	4.6	4.95	
4	3.95	4.3	4.65	5.0	
5	4.0	4.35	4.7	=	
6	4.05	4.4	4.75	=	

34 represents production lot number

01 to 09, 0A to 0Z, 11 to 9Z, A1 to A9, AA to Z9, ZA to ZZ in order.

(G, I, J, O, Q, W excluded. No character inversion used.)

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