APPLICATION MANUAL

Negative-input Negative-output Regulator IC
TK721xxCS

CONTENTS

Negative-input Negative-output Regulator IC
TK721xxCS

1. DESCRIPTION

TK721xxCS series is a negative-input negative-output regulator IC using silicon monolithic bipolar structure which can supply 150mA output current.
The output voltage can be set from -2.0 to -9.5V, which is trimmed in high accuracy.
TK721xxCS is supplied with ON/OFF terminal and noise reduction terminal. The ON/OFF control can be controlled directly with positive logic or CPU.
Moreover, TK721xxCS is provided with short-circuit protection and thermal shutdown.

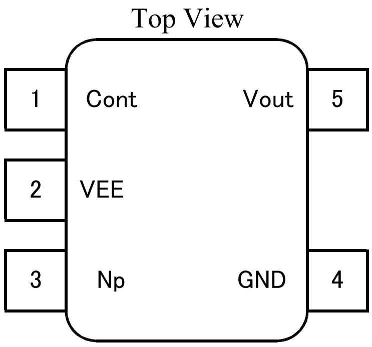
2. FEATURES

- High Output Voltage Accuracy(±2.0% or ±60 mV)
- ON/OFF control available (High OFF)
- Built-in short-circuit protection and thermal shutdown.
- Guarantee 150mA output current(200mA peak)
- Ceramic capacitor available for application

3. APPLICATIONS

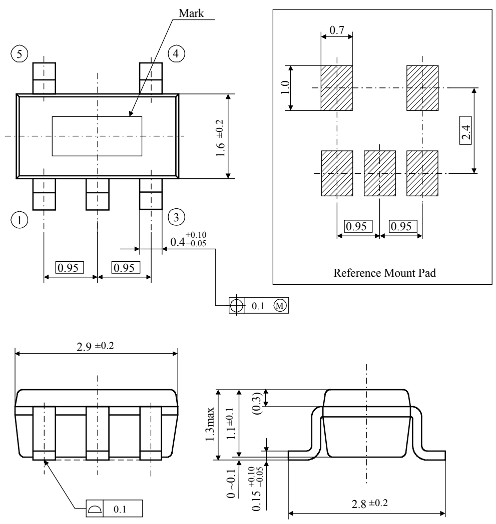
- Battery Powered Systems
- DSC, CCD bias, GaAs bias.

4. PIN CONFIGURATION

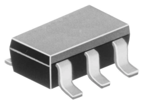


5. PACKAGE OUTLINE

- SOT23-5

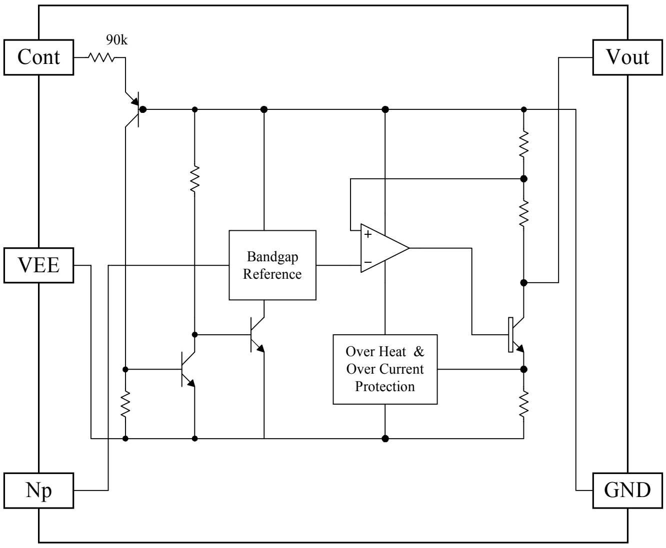


5. ORDERING INFORMATION

Package	Vout	Part Number	Marking
	-2.0	TK72120CS	K20
	-2.5	TK72125CS	K25
	-3.0	TK72130CS	K30
	-3.5	TK72135CS	K35
	-4.0	TK72140CS	K40
	-4.5	TK72145CS	K45
SOT23-5	-5.0	TK72150CS	K50
	-5.5	TK72155CS	K55
	-6.0	TK72160CS	K60
	-6.5	TK72165CS	K65
	-7.0	TK72170CS	K70
	-7.5	TK72175CS	K75
	-8.0	TK72180CS	K80
	-8.5	TK72185CS	K85
	-9.0	TK72190CS	K90
	-9.5	TK72195CS	K95

For other voltages, please contact the TOKO sales office.

6. BLOCK DIAGRAM



Control:Low Level On

7. ABSOLUTE MAXIMUM RATINGS

T_a=25°C

Parameter	Symbol	Rating	Units	Conditions
Supply Voltage	Vin	-20	V	|Vin|+|Vcont|≤20V
Control pin Voltage	Vcont	-0.4 ~ +5	V	|Vin|+|Vcont|≤19V
Power Dissipation				
(SOT23-5 Simple substance)	P_D	500	mW	P_D must be decreased at the rate of 4mW/°C for operation above 25°C.
Storage Temperature Range	T_{stg}	-55 ~ +150	°C	
Operating Temperature Range	T_{OP}	-40 ~ 85	°C	
Operating Voltage Range	V_{OP}	-19	V	|Vin|+|Vcont|≤19V
Output short-circuit current	Ishort	300	mA	Over Current Protection

Absolute maximum ratings are limits beyond which damage to the device may occur.
When the operation exceeds this standard, quality can not be guaranteed.

8. ELECTRICAL CHARACTERISTICS

Vin=Vout$_{TYP}$-1.5V, Ta=25°C

Parameter	Symbol	Value MIN	Value TYP	Value MAX	Unit	Condition
Vout	Vout	Refer to TABLE 1			V	Iout=5mA
Line Regulation	LinReg		1	5	mV	ΔVin=5V
Load Regulation	LoaReg	Refer to TABLE 1			mV	Iout=5mA~50mA
		Refer to TABLE 1			mV	Iout=5mA~100mA
		Refer to TABLE 1			mV	Iout=5mA~150mA
Dropout Voltage *1	Vdrop		0.29	0.50	V	Iout=50mA
			0.48	0.80	V	Iout=100mA
			0.66	1.10	V	Iout=150mA
Supply Current	Icc		155	250	µA	Iout=0mA
Standby Current	Istandby		20	60	µA	Vout Off State
Peak Output Current	Iout$_{PEAK}$	200	280		mA	When Vout drops 10%
Control Current	Icont		12	30	µA	Vcont=+1.8V
Control Voltage	Vcont	0		0.3	V	Vout ON State
		1.5			V	Vout OFF State

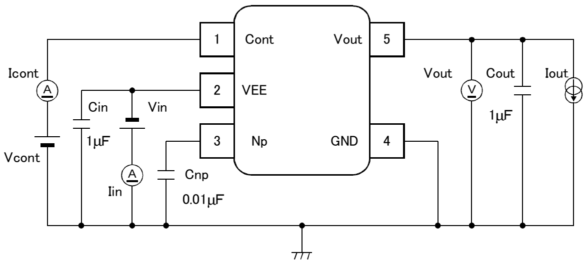
*1 For Vout≥-3.0 no regulations

TABLE 1

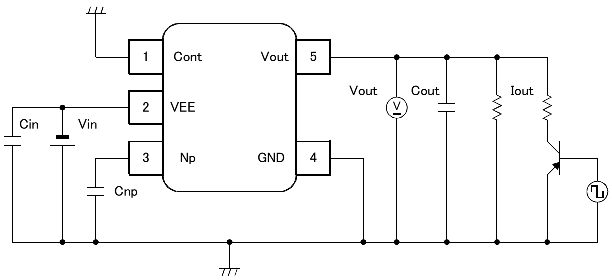
Part Number	Vout			LoaReg Iout=50mA		LoaReg Iout=100mA		LoaReg Iout=150mA	
	MIN	TYP	MAX	TYP	MAX	TYP	MAX	TYP	MAX
TK72120CS	-2.060	-2.000	-1.940	9	24	15	39	24	60
TK72125CS	-2.560	-2.500	-2.440	9	24	15	39	24	60
TK72130CS	-3.060	-3.000	-2.940	9	24	15	39	24	60
TK72135CS	-3.570	-3.500	-3.430	11	28	18	46	28	70
TK72140CS	-4.080	-4.000	-3.920	12	30	20	52	32	80
TK72145CS	-4.590	-4.500	-4.410	14	34	23	59	36	90
TK72150CS	-5.100	-5.000	-4.900	15	38	25	65	40	100
TK72155CS	-5.610	-5.500	-5.390	17	41	28	72	44	110
TK72160CS	-6.120	-6.000	-5.880	18	45	30	78	48	120
TK72165CS	-6.630	-6.500	-6.370	20	49	33	85	52	130
TK72170CS	-7.140	-7.000	-6.860	21	53	35	91	56	140
TK72175CS	-7.650	-7.500	-7.350	23	56	38	98	60	150
TK72180CS	-8.160	-8.000	-7.840	24	60	40	104	64	160
TK72185CS	-8.670	-8.500	-8.330	26	64	43	111	68	170
TK72190CS	-9.180	-9.000	-8.820	27	68	45	117	72	180
TK72195CS	-9.690	-9.500	-9.310	29	71	48	124	76	190

9. TEST CIRCUIT

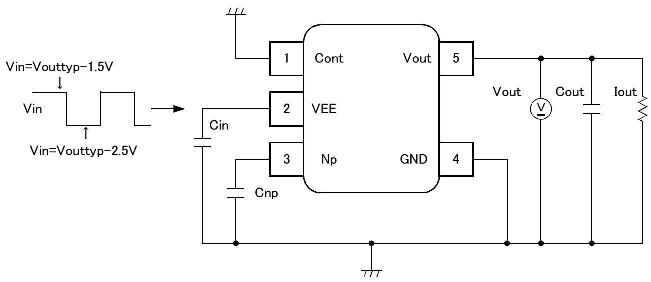
■ DC



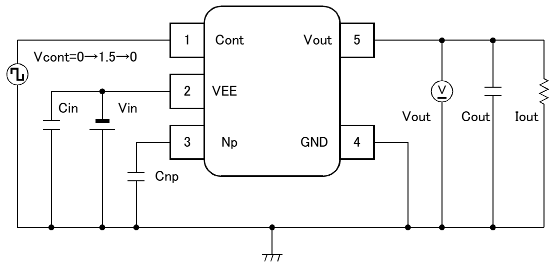
■ Load Transient



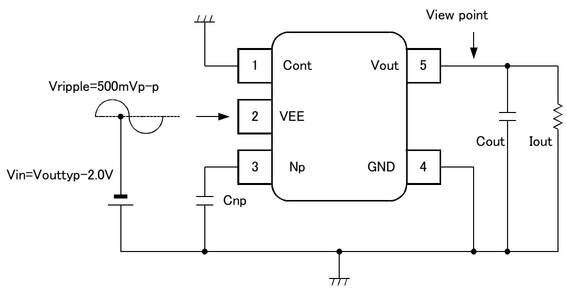
■ Line Transient



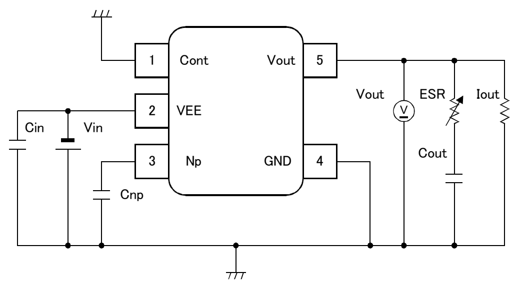
■ ON/OFF Transient



■ Ripple Rejection



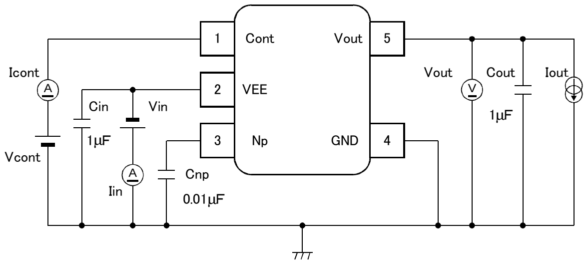
■ ESR Stability



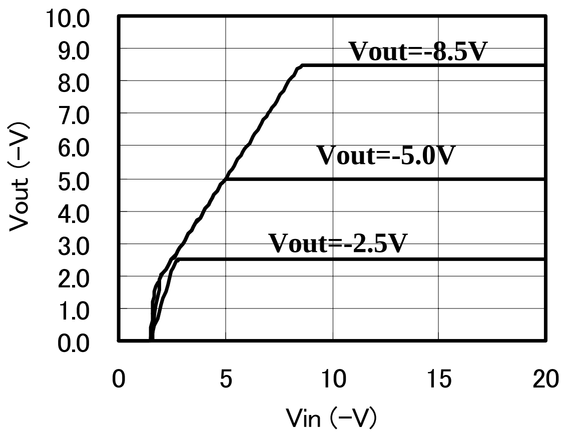
10. TYPICAL CHARACTERISTICS

10-1 DC CHARACTERISTICS

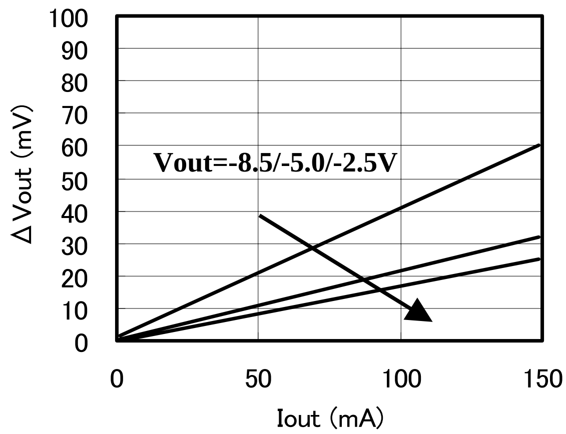
Unless otherwise specified Vin=Vout$_{TYP}$-1.5V,Vcont=0V,Cin=1.0uF(MLCC),Cout=1.0uF(MLCC),Cnp=0.01uF
Ta=25°C



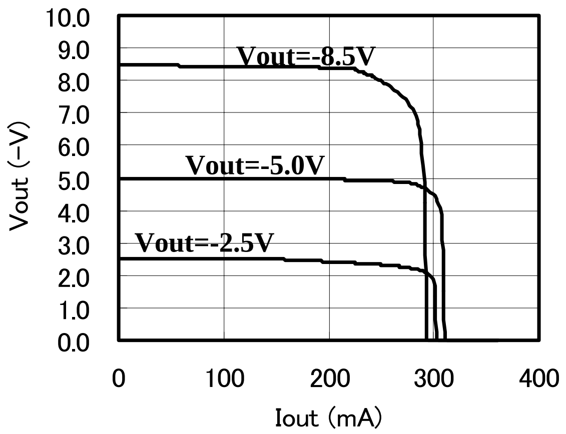
■ **Line Regulation**



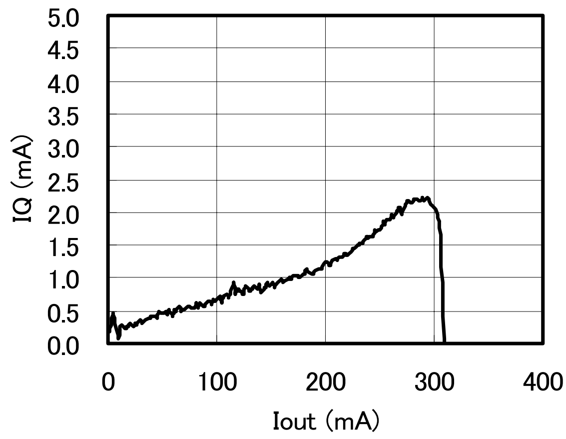
■ **Load Regulation**



■ **Iout$_{PEAK}$**

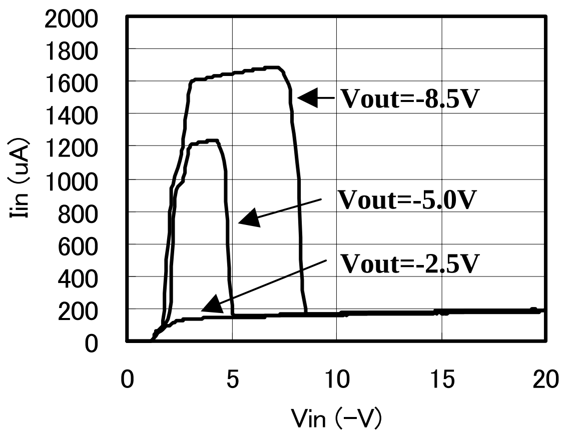


■ **IQ**

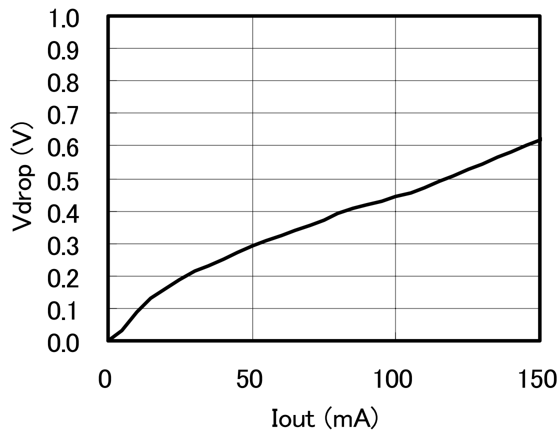


Unless otherwise specified Vin=Vout$_{TYP}$-1.5V,Vcont=0V,Cin=1.0uF(MLCC),Cout=1.0uF(MLCC),Cnp=0.01uF
Ta=25°C

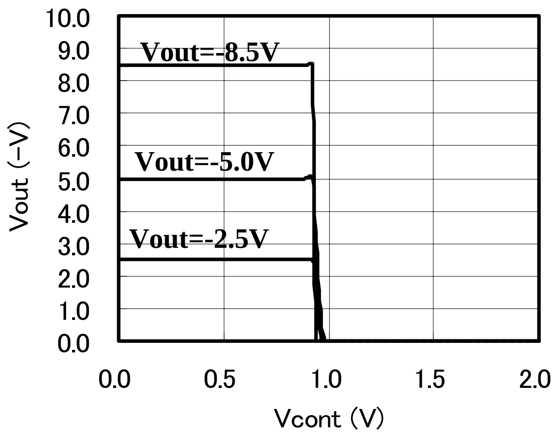
■ **Iin (Iout=0mA)**



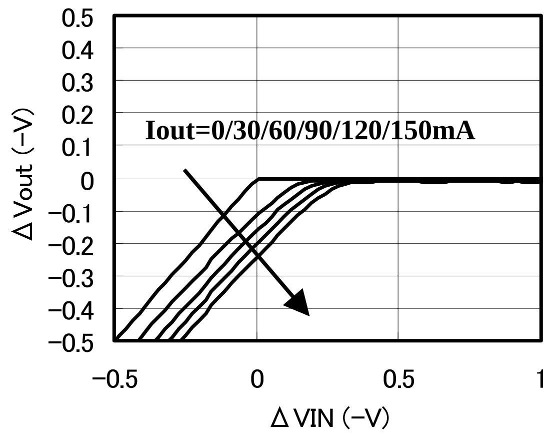
■ **Dropout Voltage**



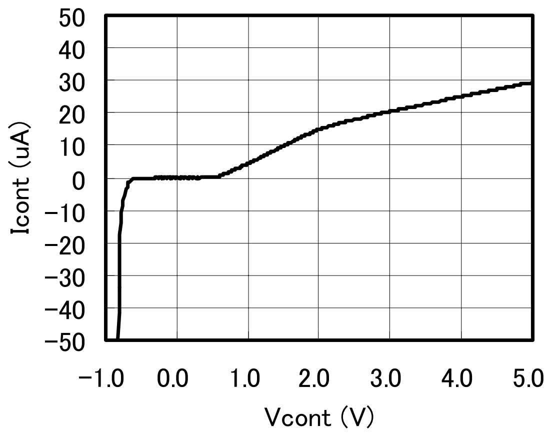
■ **Vout VS Vcont**



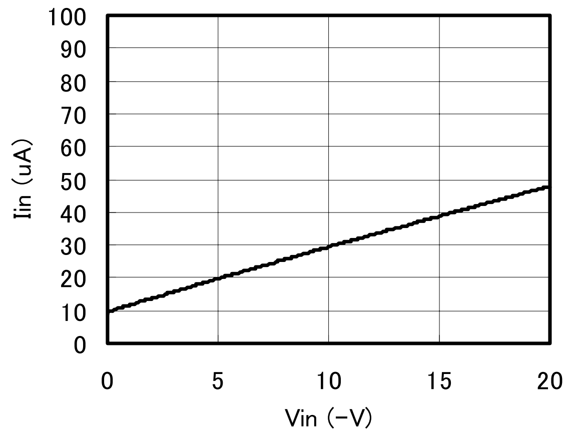
■ **Vout VS VIN**



■ **Icont VS Vcont (Iout=1mA)**

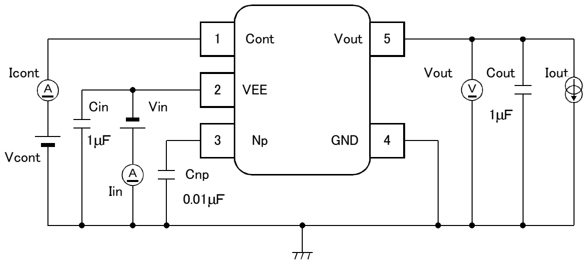


■ **Icc Off Mode (Vcont=1.5V,Iout=0mA)**

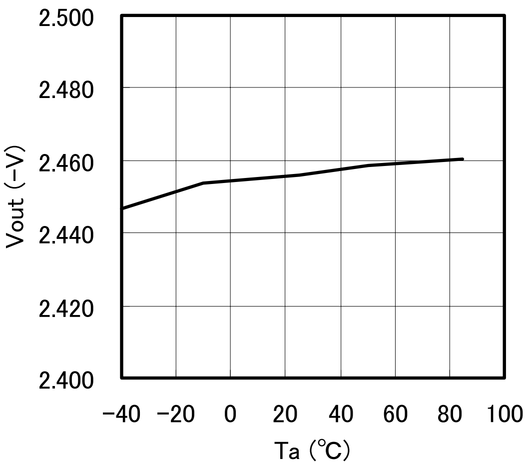


10-2 Temperature characteristic

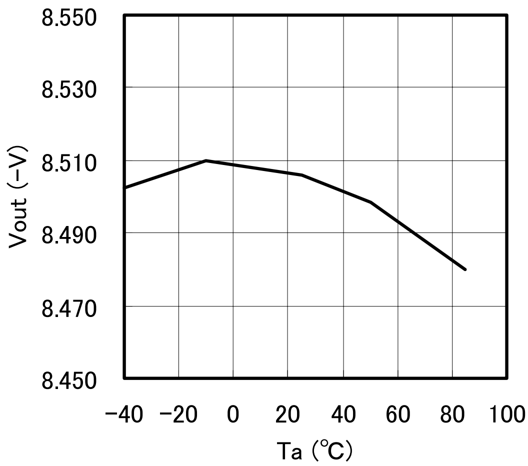
Unless otherwise specified Vin=-Vout$_{TYP}$-1.5V,Vcont=0V,Cin=1.0uF(MLCC),Cout=1.0uF(MLCC),Cnp=0.01uF



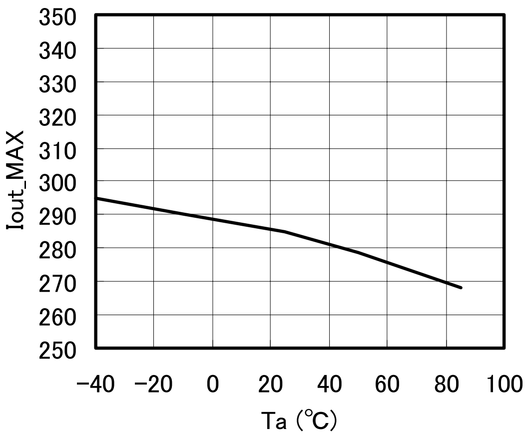
■ **TK72125CS Vout**



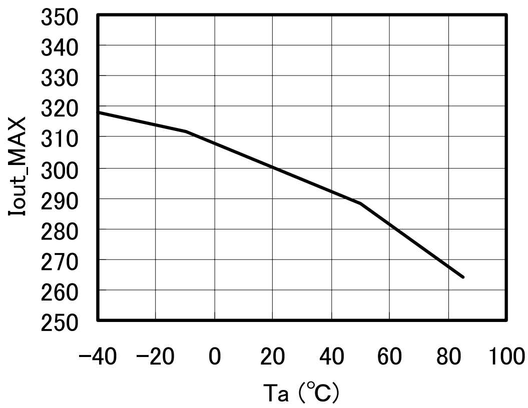
■ **TK72185CS Vout**



■ **TK72125CS Iout$_{PEAK}$**

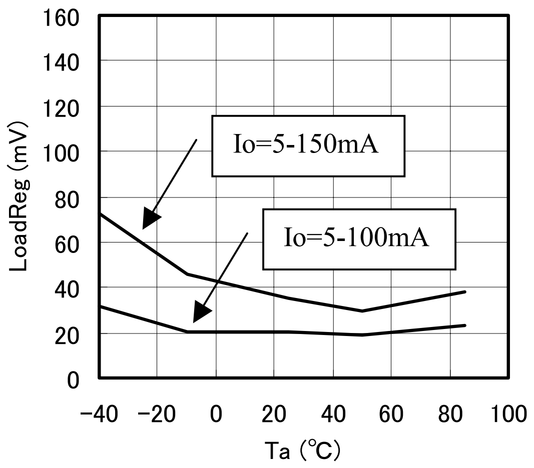


■ **TK72185CS Iout$_{PEAK}$**

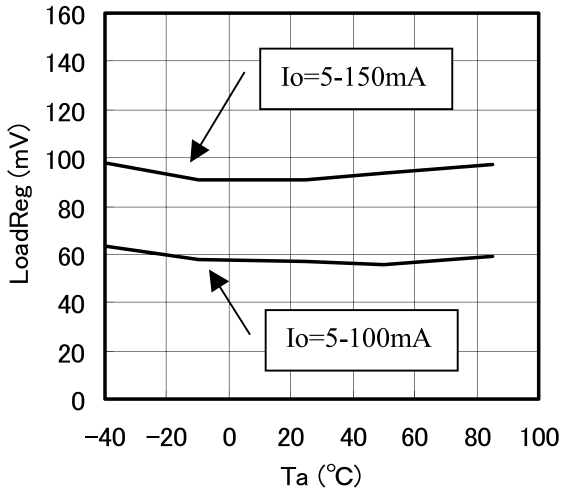


Unless otherwise specified Vin=-$Vout_{TYP}$-1.5V,Vcont=0V,Cin=1.0uF(MLCC),Cout=1.0uF(MLCC),Cnp=0.01uF

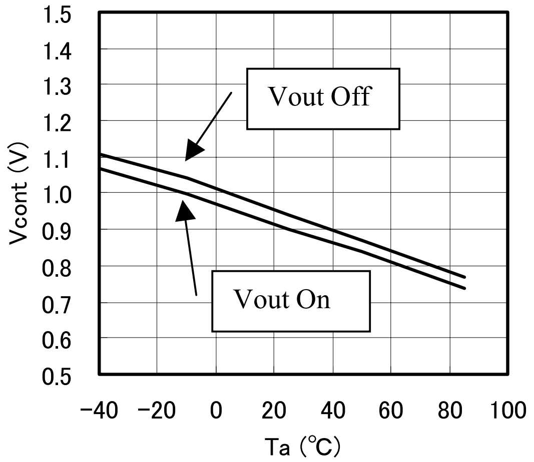
■ **TK72125CS LoadReg**



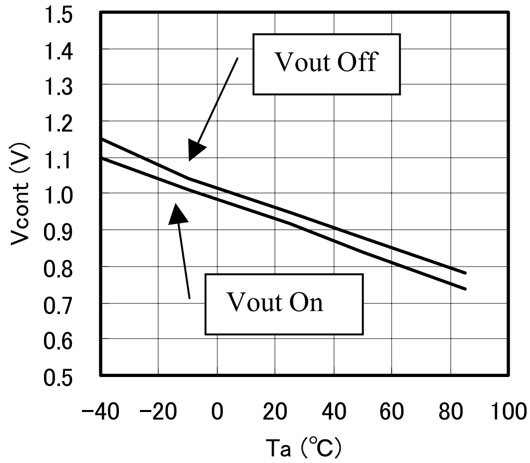
■ **TK72185CS LoadReg**



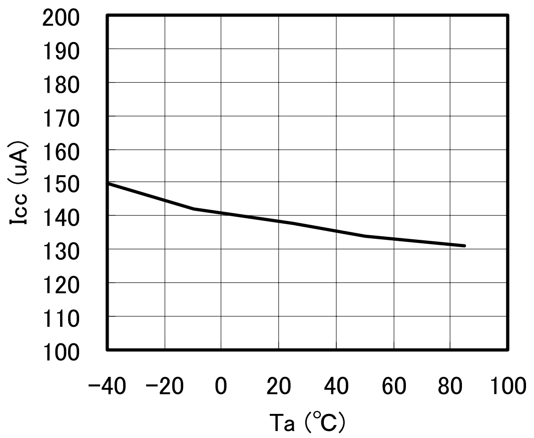
■ **TK72125CS ON/OFF**



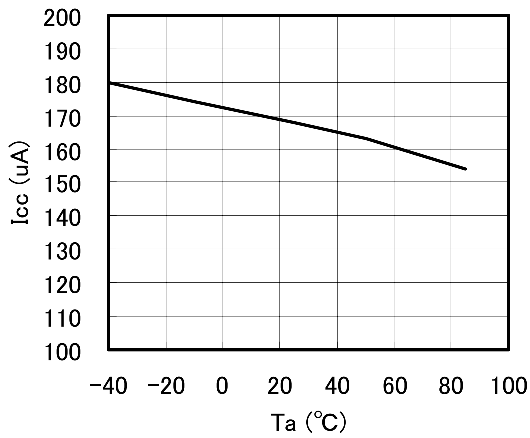
■ **TK72185CS ON/OFF**



■ **TK72125CS Iin(Iout=0mA)**

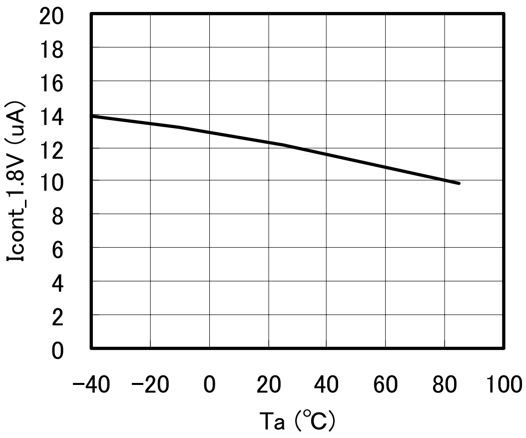


■ **TK72185CS Iin(Iout=0mA)**

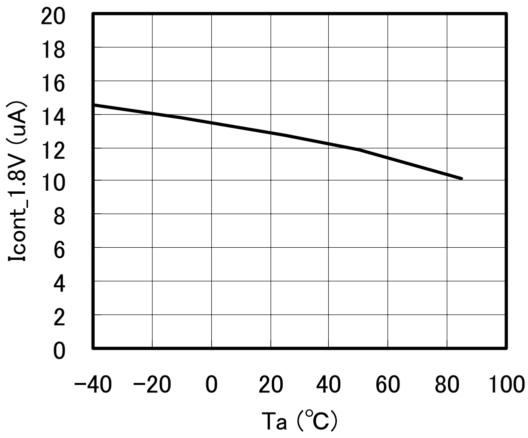


Unless otherwise specified Vin=-Vout$_{TYP}$-1.5V,Vcont=0V,Cin=1.0uF(MLCC),Cout=1.0uF(MLCC),Cnp=0.01uF

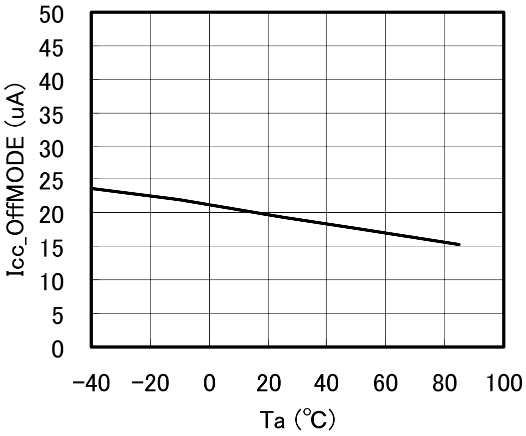
■ **TK72125CS Icont**



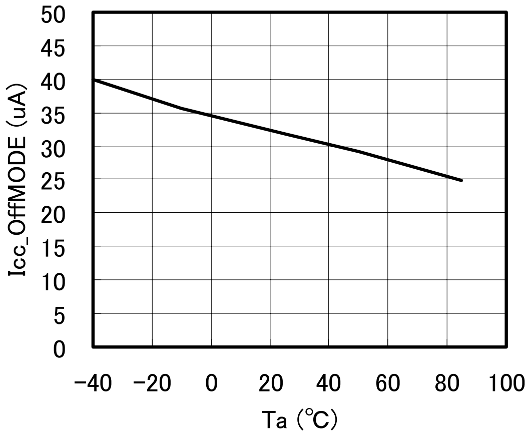
■ **TK72185CS Icont**



■ **TK72125CS Icc_OFFMode**



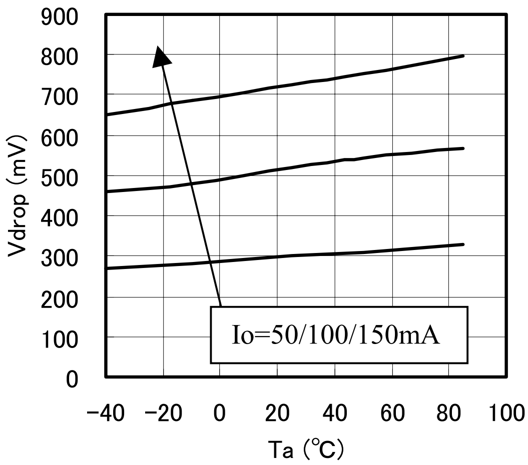
■ **TK72185CS Icc_OFFMode**



■ **TK72125CS Vdrop**

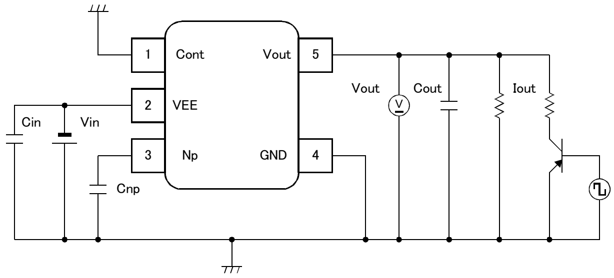
For Vout≥-2.0V, no regulations

■ **TK72185CS Vdrop**



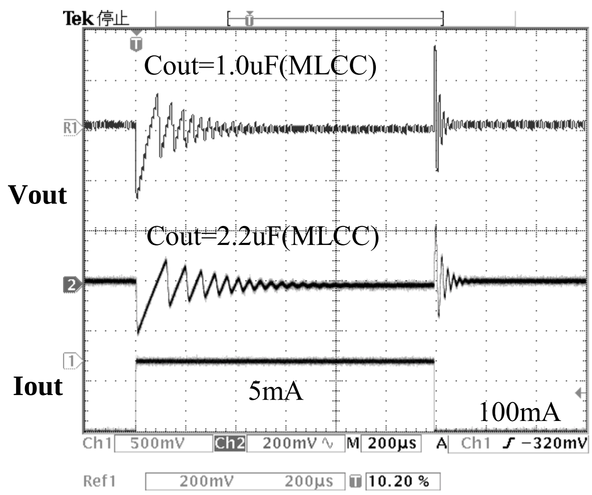
10-3 Load Transient

Unless otherwise specified Vin=Vout$_{TYP}$-1.5V,Cin=1.0uF(MLCC),Cnp=0.01uF



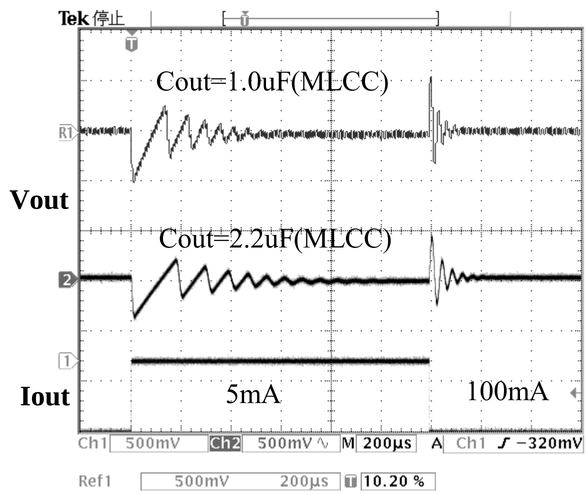
■TK72125CS

Vout:200mV/div Time:200usec/div



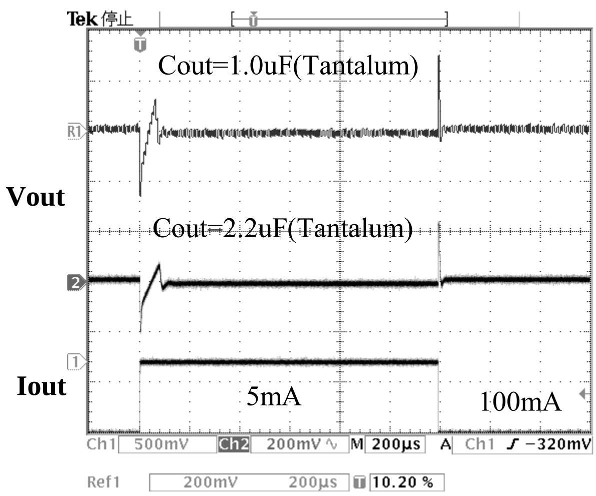
■TK72185CS

Vout:200mV/div Time:200usec/div



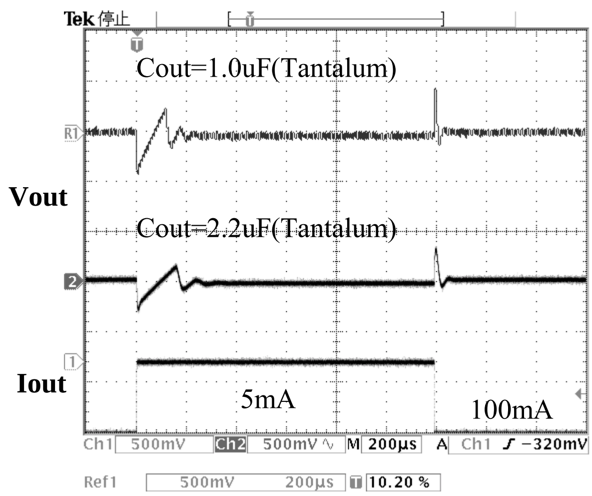
■TK72125CS

Vout:200mV/div Time:200usec/div



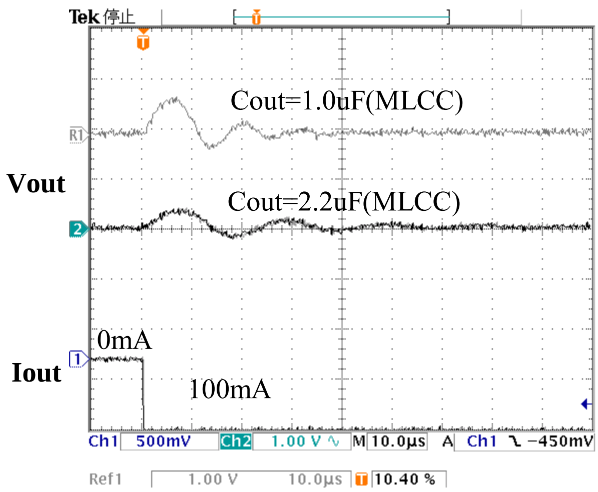
■TK72185CS

Vout:200mV/div Time:200usec/div

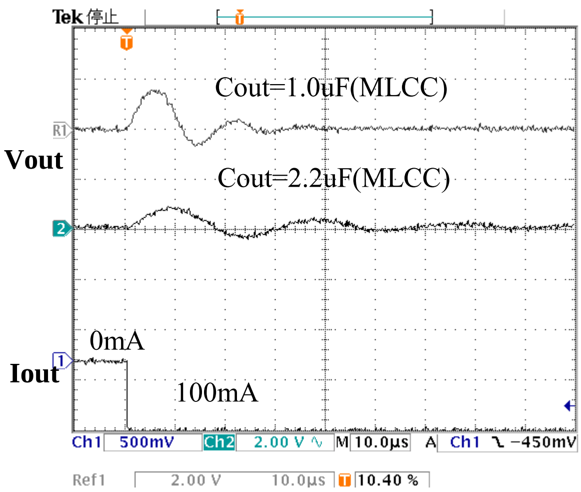


Unless otherwise specified Vin=$Vout_{TYP}$-1.5V,Cin=1.0uF(MLCC),Cnp=0.01uF

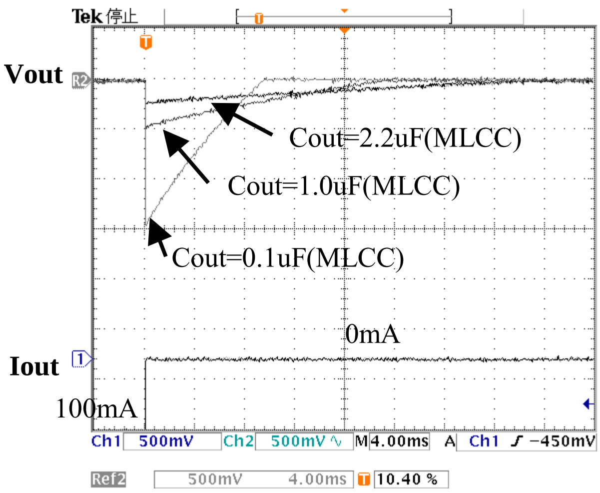
■TK72125CS
Vout:1V/div Time:10usec/div



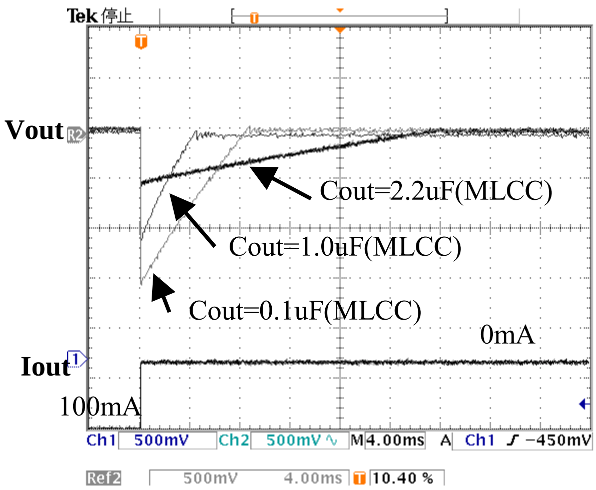
■TK72185CS
Vout:2V/div Time:10usec/div



■TK72125CS
Vout:500mV/div Time:4msec/div

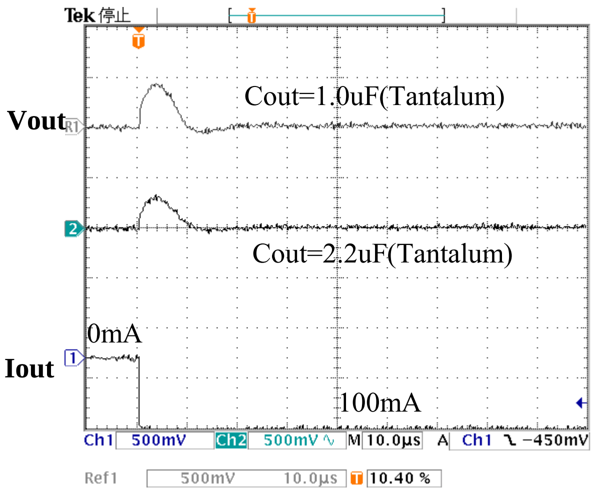


■TK72185CS
Vout:500mV/div Time:4msec/div

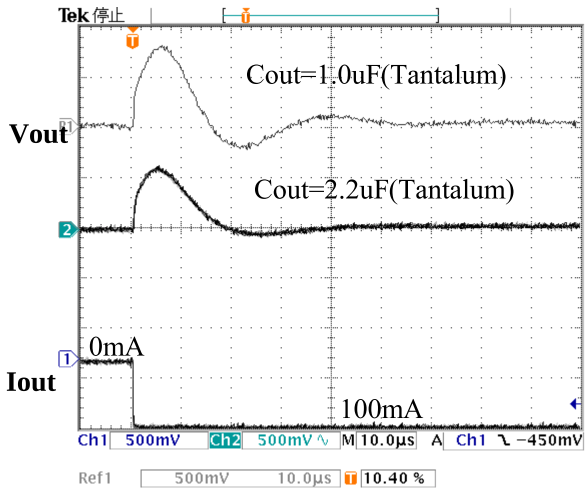


Unless otherwise specified Vin=Vout$_{TYP}$-1.5V,Cin=1.0uF(MLCC),Cnp=0.01uF

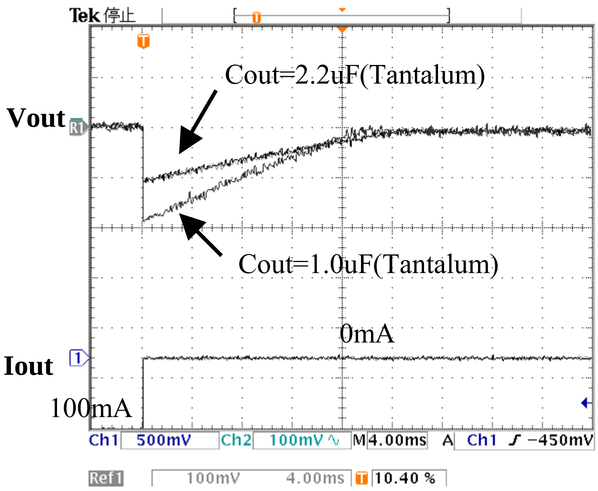
■**TK72125CS**
Vout:500mV/div Time:10usec/div



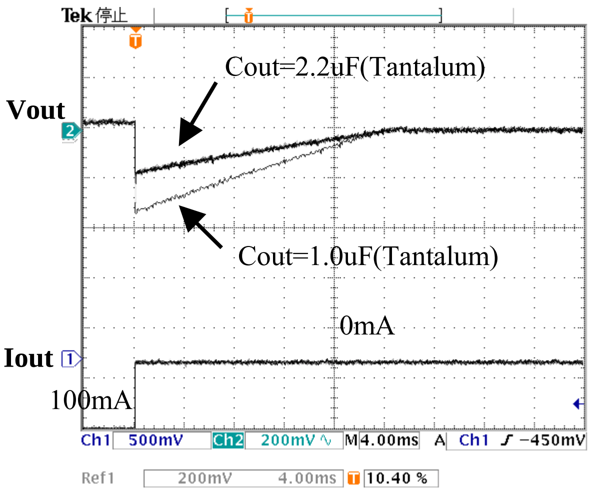
■**TK72185CS**
Vout:500mV/div Time:10usec/div



■**TK72125CS**
Vout:100mV/div Time:4msec/div

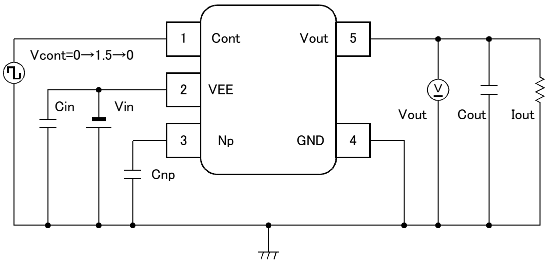


■**TK72185CS**
Vout:100mV/div Time:4msec/div

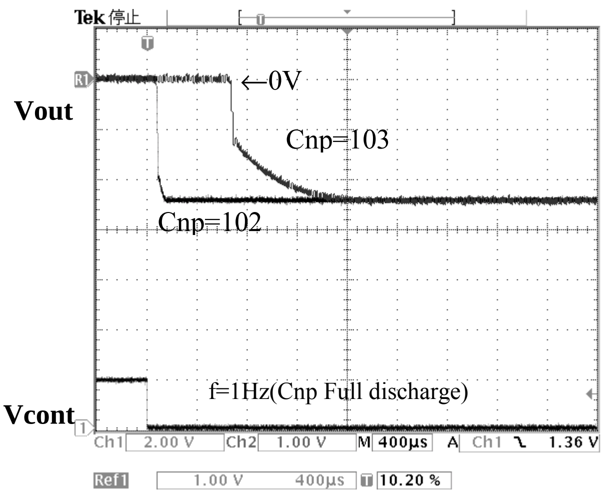


10-4 ON/OFF Transient

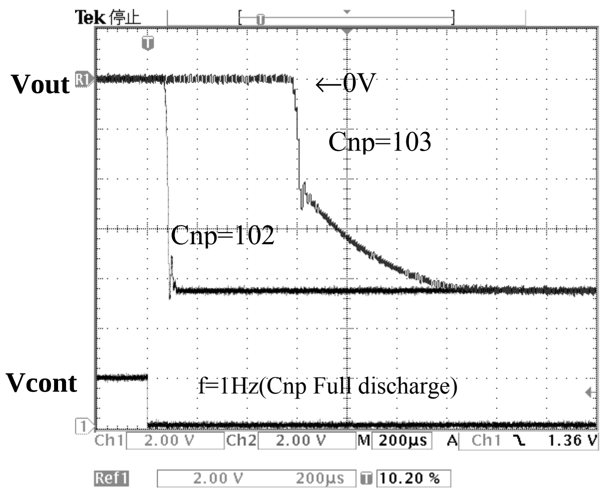
Vin=Vout$_{TYP}$-1.5V,Cin=1.0uF(MLCC),Iout=100mA



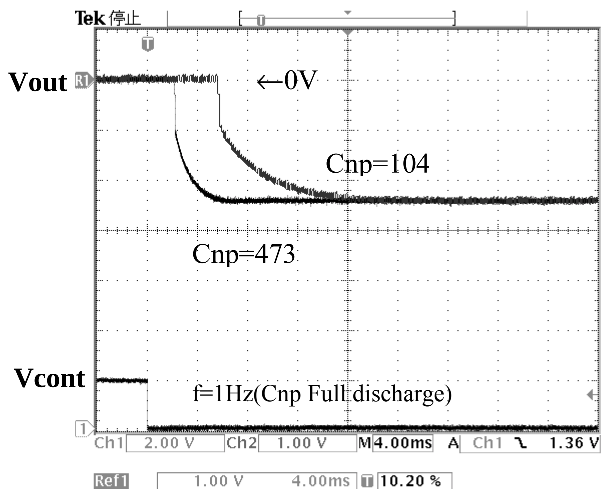
■**TK72125CS** Cout=1.0uF(MLCC)
Vout:1V/div Vcont:2V/div Time:400usec/div



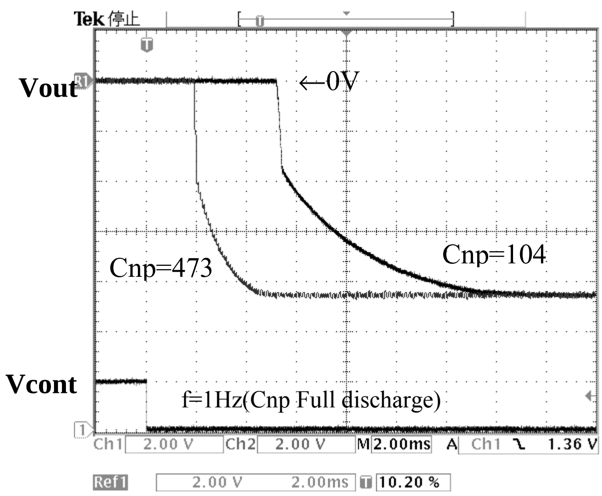
■**TK72185CS** Cout=1.0uF(MLCC)
Vout:2V/div Vcont:2V/div Time:200usec/div



■**TK72125CS** Cout=1.0uF(MLCC)
Vout:1V/div Vcont:2V/div Time:4msec/div

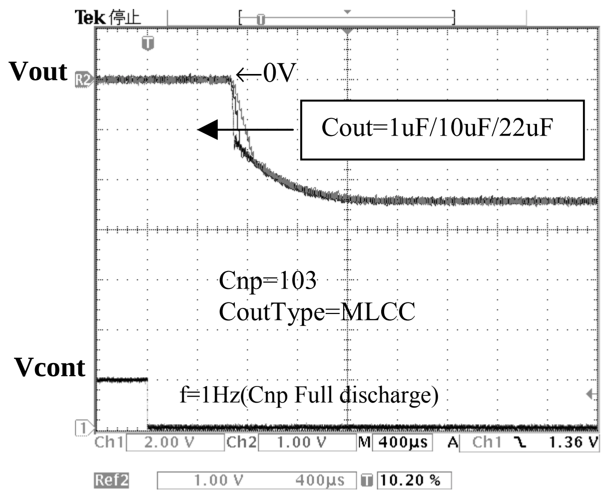


■**TK72185CS** Cout=1.0uF(MLCC)
Vout:2V/div Vcont:2V/div Time:2msec/div

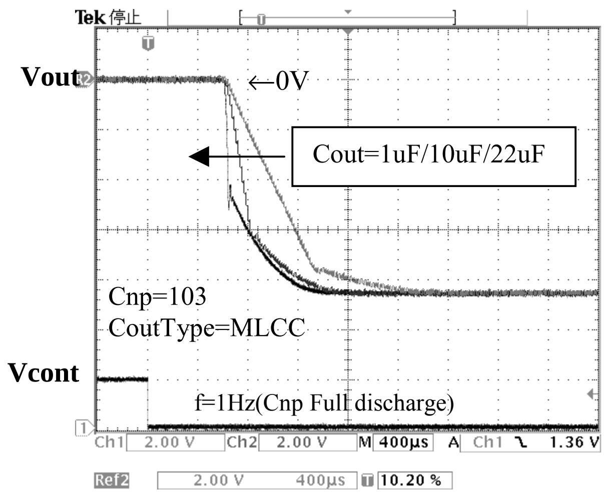


Vin=-$Vout_{TYP}$-1.5V,Cin=1.0uF(MLCC),Iout=100mA

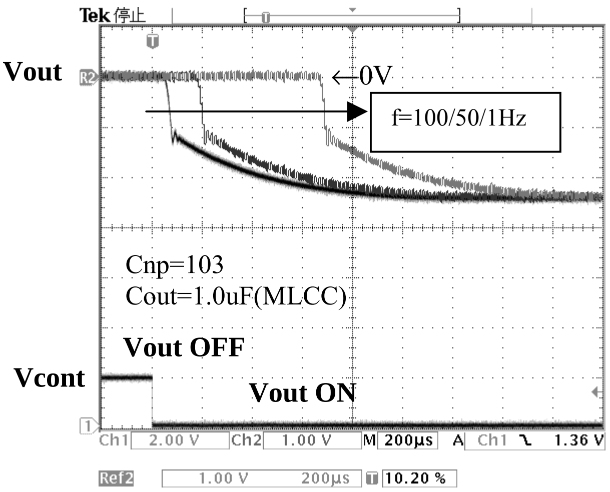
■TK72125CS
Vout:1V/div Vcont:2V/div Time:400usec/div



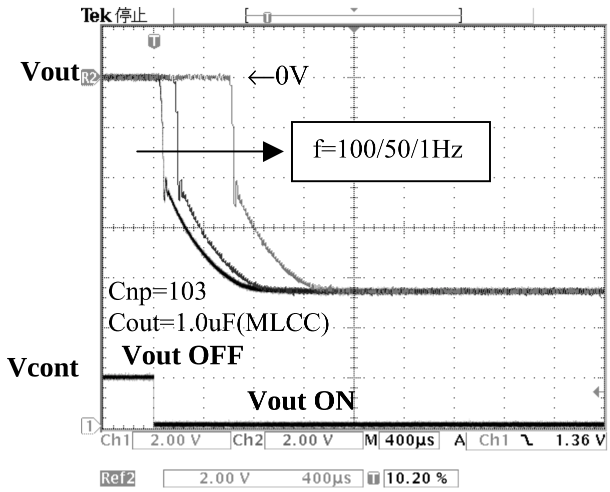
■TK72185CS
Vout:2V/div Vcont:2V/div Time:400usec/div



■TK72125CS
Control frequency variable
Vout:1V/div Vcont:2V/div Time:200usec/div



■TK72185CS
Control frequency variable
Vout:2V/div Vcont:2V/div Time:400usec/div

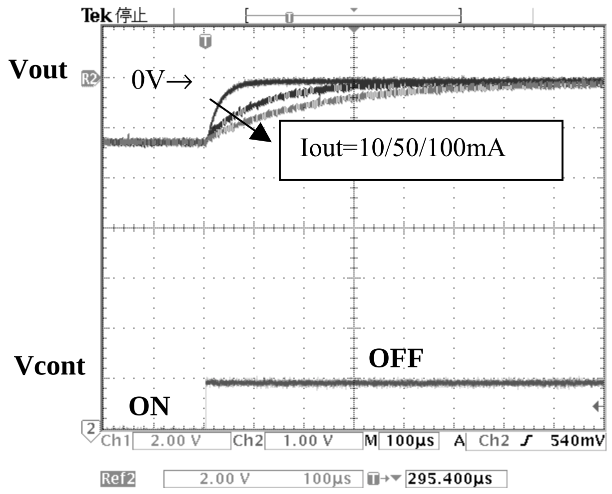


Rise-time of the output voltage. changes by Cout and Cnp.
Moreover, the rise-time changes by the charge situation of Cnp. Standing up from the state that the charge came off completely slows most.

Vin=-Vout$_{TYP}$-1.5V,Cin=1.0uF(MLCC),Cout=1.0uF(MLCC),Cnp=0.01uF,Iout=100mA

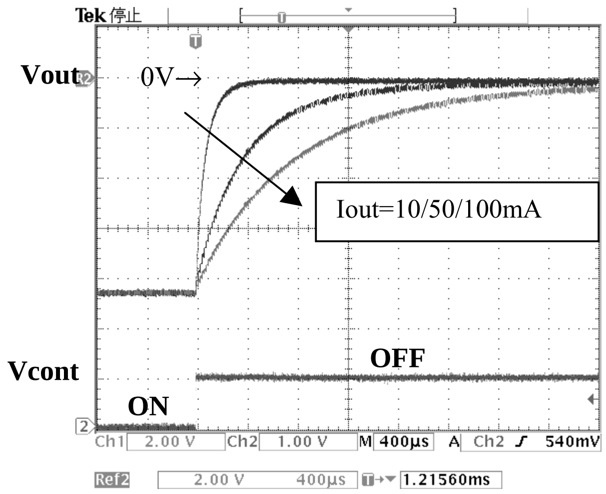
■**TK72125CS**

Vout:2V/div Vcont:1V/div Time:100usec/div



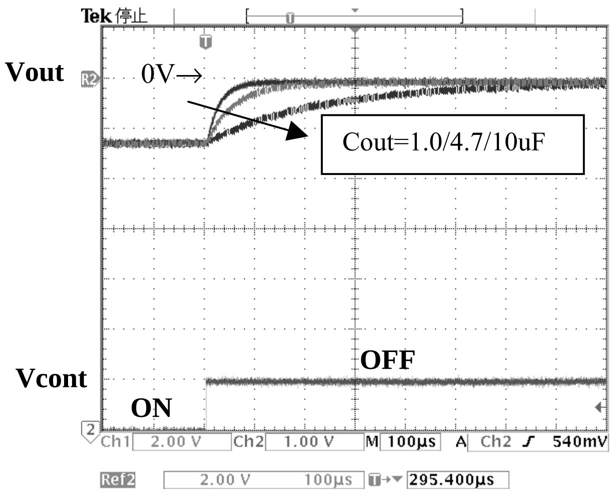
■**TK72185CS**

Vout:2V/div Vcont:1 V/div Time:400usec/div



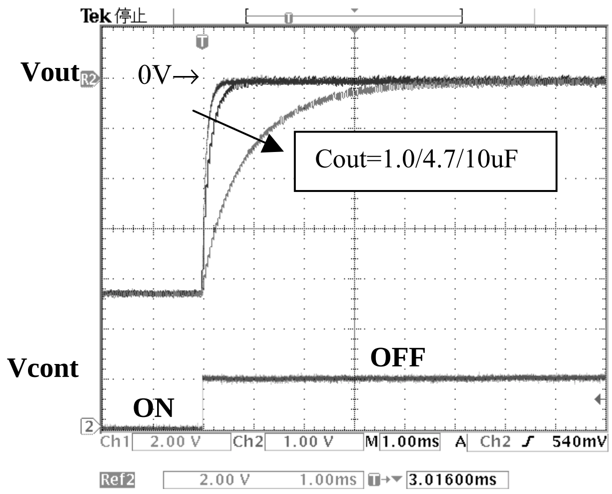
■**TK72125CS**

Vout:2V/div Vcont:1V/div Time:100usec/div



■**TK72185CS**

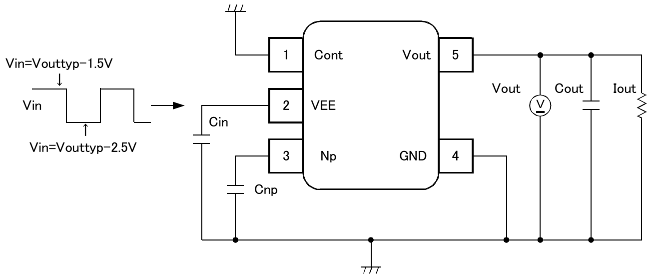
Vout:2V/div Vcont:1V/div Time:1msec/div



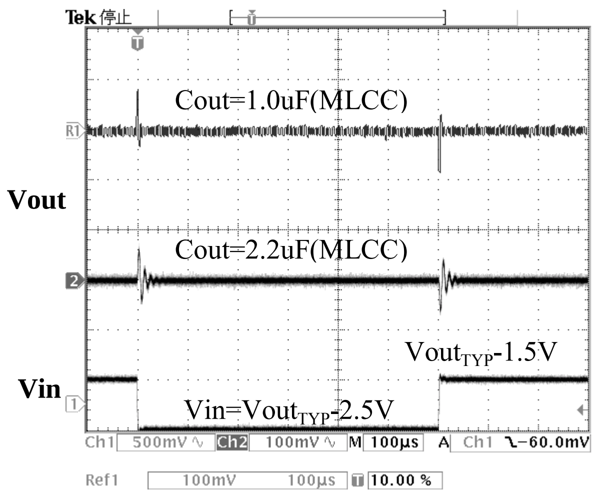
The turn on time will be largely affected by Iout and Cout,but not by Cnp.

10-5 Line Transient

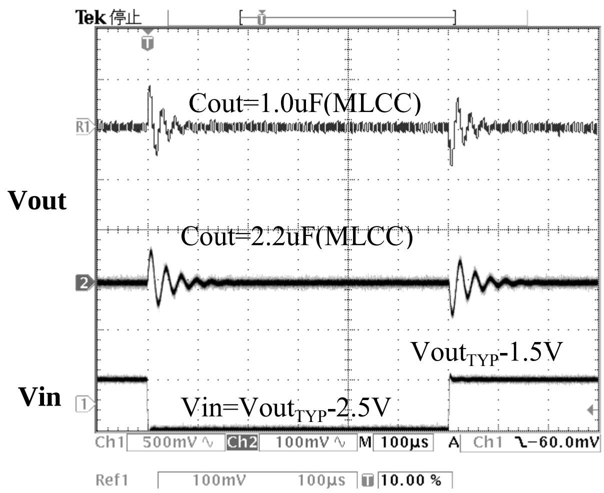
Vin=-Vout$_{TYP}$-1.5→-Vout$_{TYP}$-2.5V,Cin=1.0uF(MLCC),Cnp=0.01uF,Iout=100mA



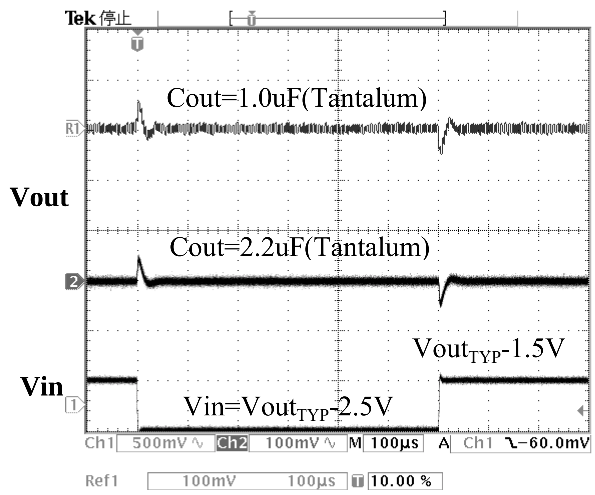
■**TK72125CS**
Vout:100mV/div Vin:1V/div Time:100usec/div



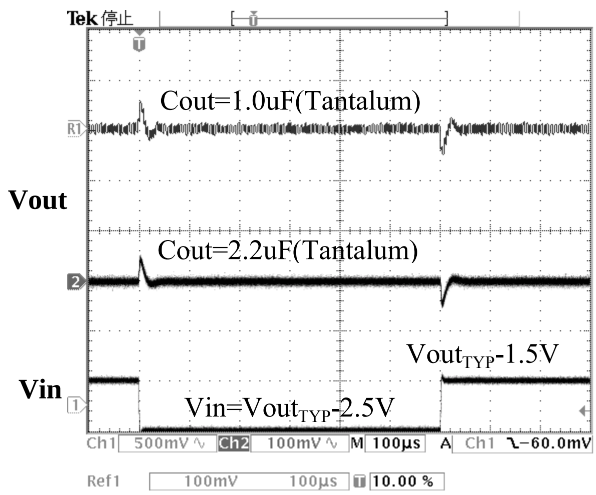
■**TK72185CS**
Vout:100mV/div Vin:1V/div Time:100usec/div



■**TK72125CS**
Vout:100mV/div Vin:1V/div Time:100usec/div



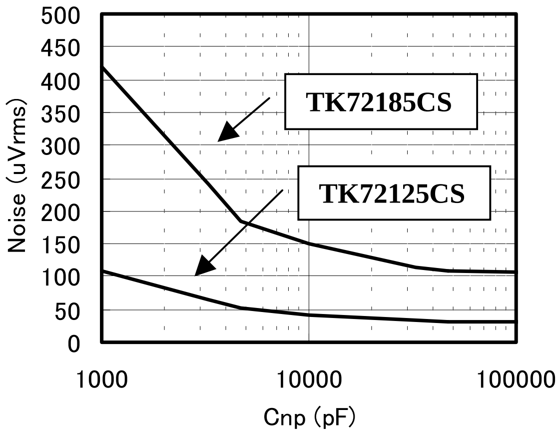
■**TK72185CS**
Vout:100mV/div Vin:1V/div Time:100usec/div



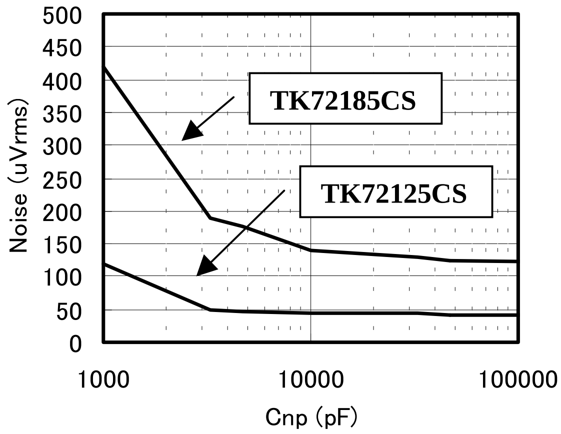
10-6 Noise

Vin= $Vout_{TYP}$-1.5(V) Vcont=0V Cin=1.0uF(MLCC) BPF400 ~ 80kHz Iout=100mA

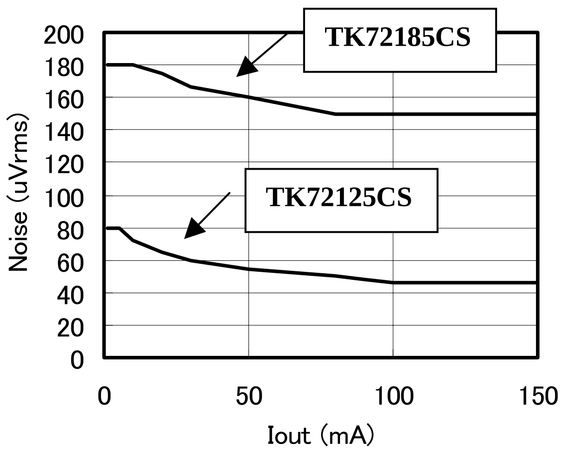
■ Cout=1.0uF(MLCC)



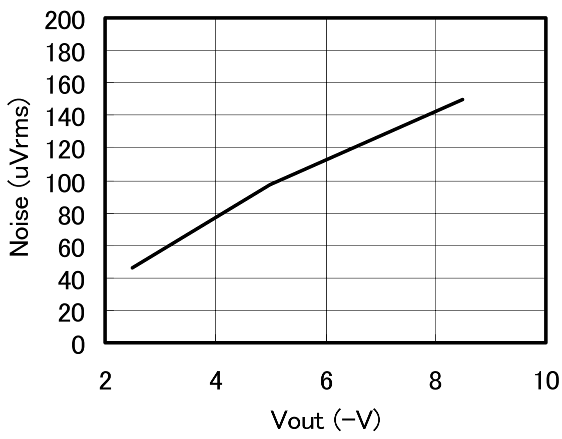
■ Cout=1.0uF(Tantalum)



■ Cout=1.0uF(MLCC) Cnp=103

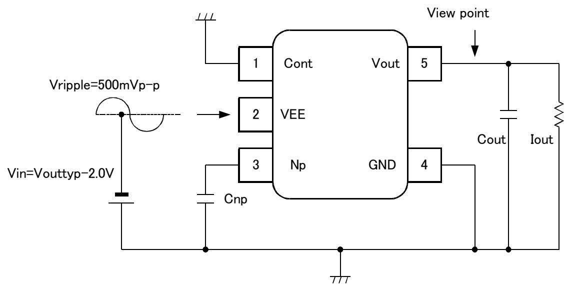


■ Cout=1.0uF(MLCC) Cnp=103 Iout=100mA

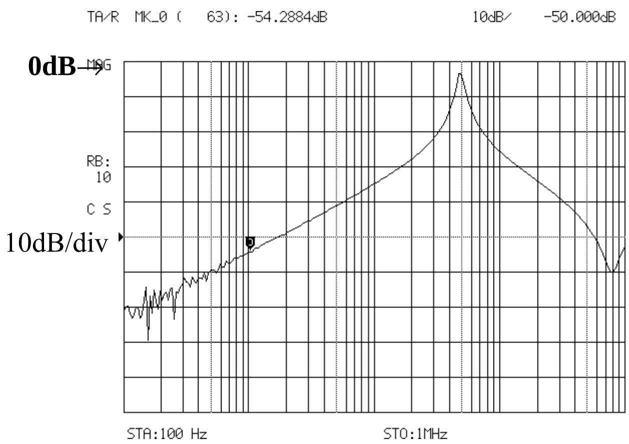


10-7 Ripple Rejection

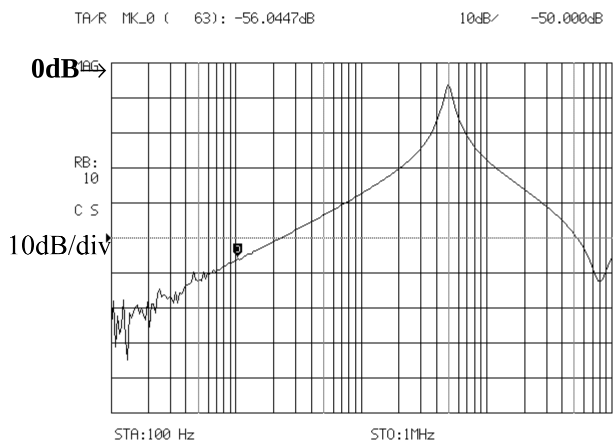
Vin=Vout$_{TYP}$-2.0(V) Vripple=500mVp-p,Cnp=0.01uF,Iout=10mA



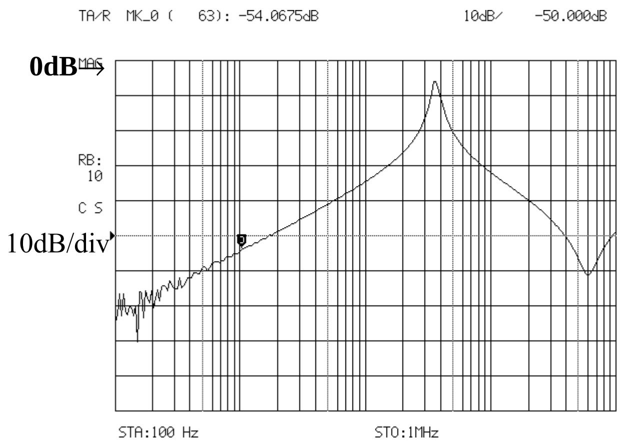
■TK72125CS Cout=1.0uF(MLCC)



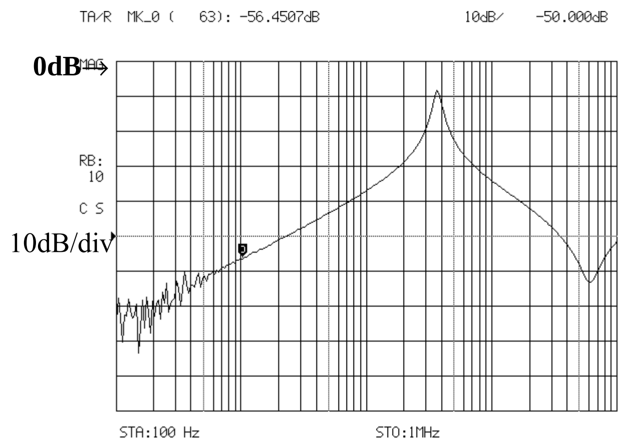
■TK72185CS Cout=1.0uF(MLCC)



■TK72125CS Cout=2.2uF(MLCC)

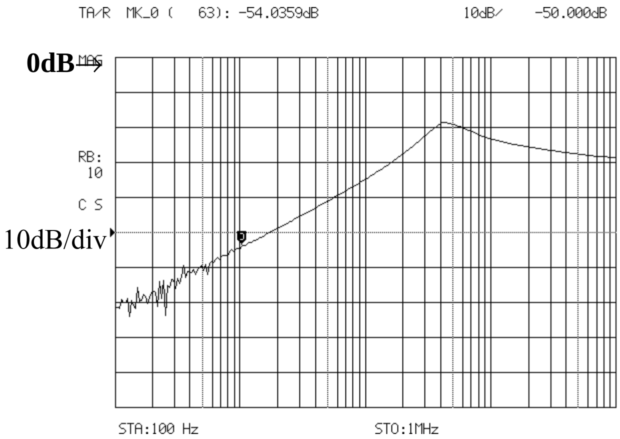


■TK72185CS Cout=2.2uF(MLCC)

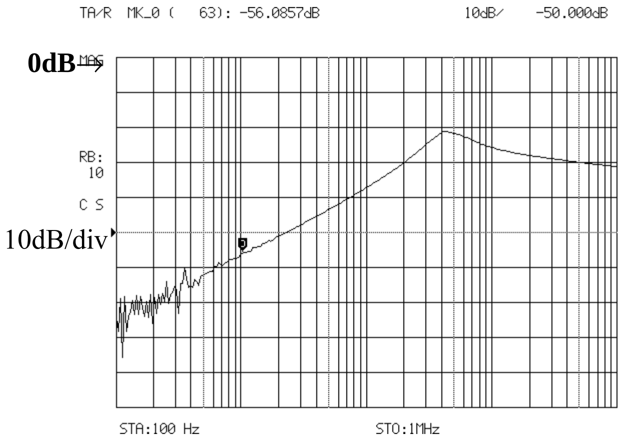


Vin=Vout$_{TYP}$-2.0(V) Vripple=500mVp-p,Cnp=0.01uF,Iout=10mA

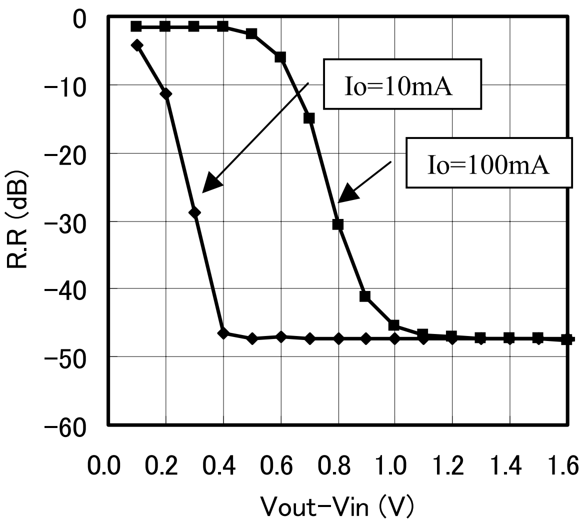
■TK72125CS Cout=1.0uF(Tantalum)



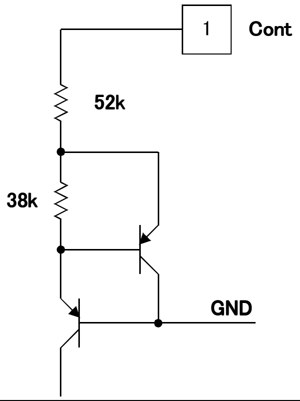
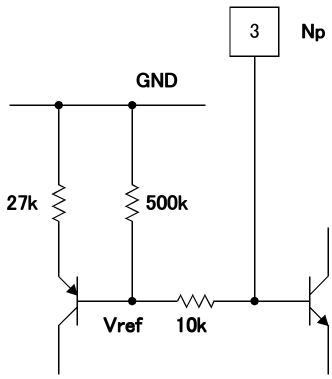
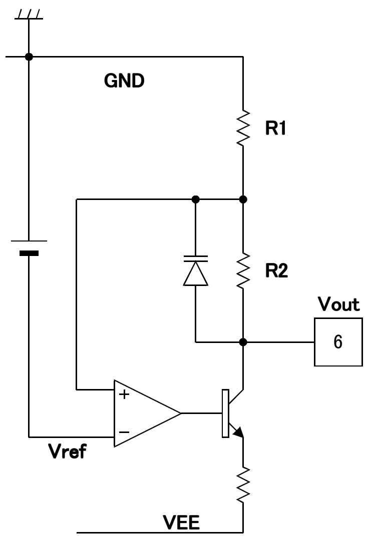
■TK72185CS Cout=1.0uF(Tantalum)



■TK721xxCS f=1kHz,Vripple=100mVp-p



11. PIN DESCRIPTION

Pin No	Pin Description	Internal Equivalent Circuit	Description
1	Cont		ON/OFF control terminal Please do not apply -0.4V or less to this pin. The current might flow from GND.
2	VEE	-	Input terminal
3	Np		Noise pass terminal
4	GND	-	GND terminal
5	Vout		Output terminal $Vout = Vref \times \frac{R1+R2}{R1}$

12. APPLICATIONS INFORMATION

12-1.Definition of term

Relating Characteristic

note Each characteristics will be measured in a short period not to be influenced by joint temperature (Tj).

***Output voltage (Vout)**
The output voltage is specified with Vin= $Vout_{TYP}$+1V and Iout=5mA

***Output current (Iout)**
Output current, which can be used continuously (It is the range where overheating protection of the IC does not operate.)

***Peak output current ($Iout_{PEAK}$)**
The rated output current is specified under the condition where the output voltage drops 90% by increasing the output current, compared to the value specified at Vin=$Vout_{TYP}$-1.5V.

***Dropout voltage (Vdrop)**
It is an I/O voltage difference when the circuit stops the stable operation by decreasing the input voltage.
It is measured when the output voltage drops 100mV from its nominal value by decreasing the input voltage gradually.

***Line Regulation (LinReg)**
It is the fluctuations of the output voltage value when the input voltage is changed.

***Load Regulation (LoaReg)**
It is the fluctuations of output voltage value when the input voltage is assumed to be $Vout_{TYP}$ -1.5V, and the load current is changed.

***Ripple Rejection (R.R)**
Ripple rejection is the ability of the regulator to attenuate the ripple content of the input voltage at the output. It is measured with the condition of Vin=Vout-2.0V. Ripple rejection is the ratio of the ripple content between the output vs. input and is expressed in dB

***Standby current (Istandby)**
It is an input current which flows to the control terminal, when the IC is turned off.

Relating Protection Circuit

***Over Current Protection**
It is a function to protect the IC by limiting the output current when excessive current flows to IC, such as the output is connected to GND, etc.

***Thermal Protection**
It protects the IC not to exceed the permissible power consumption of the package in case of large power loss inside the regulator.
The output is turned off when the chip reaches around 150°C, but it turns on again when the temperature of the chip decreases.

***ESD**
It is tested by connecting charged capacitor to GND pin and Vin pin.

MM	200pF	0Ω	200Vmin
HBM	100pF	1.5kΩ	2000Vmin

12-2. ESR Stability

IC does operates with 1.0uF Cout. If it is 1.0uF or larger, the capacitor of any type can be used in all range without considering ESR. But due to the parts are uneven, please enlarge the capacitance as much as possible. With larger capacity, the output noise decreases more. In addition, the response to the load change, etc. can be improved. The IC won't be damaged by enlarging the capacity.

The input capacitor is necessary in case the battery voltage drops, the power supply impedance increases, or the distance to the power supply is far. 1 input capacitor might be necessary for each 1 IC or for several ICs. It depends on circuit condition. Please confirm the stability by each circuit.

Generally, Multi layer ceramic capacitor (MLCC) has the temperature characteristic and the voltage characteristic. Please select parts in consideration of the voltage and the temperature used.

*The output can be seen as oscillated when the overheating protection or the overcurrent protection start operation, or the input voltage is low. In this case, please lower the power consumption, decrease the load current or make the input voltage higher.

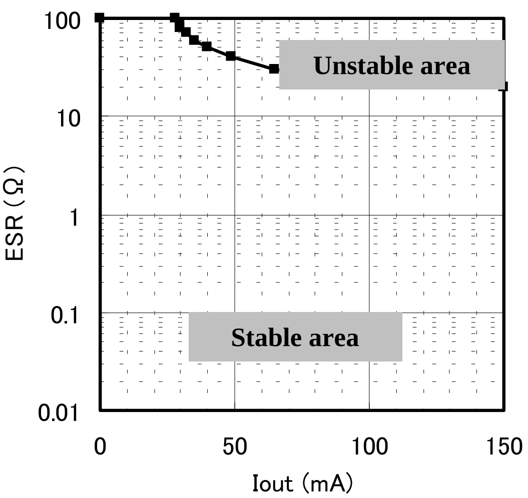
Selection of Cout

Generally, a ceramic capacitor has the temperature characteristic and the voltage characteristic. Please select parts in consideration of the voltage and the temperature used. TOKO recommend B characteristic type.

Stability area graph (Vout=-2.0 ~ -9.5V)

Condition:Vin=$Vout_{TYP}$-1.5V Cin=0.1µF(MLCC)

Cout=1.0uF



12-3.
Operating Region and Power Dissipation

The power dissipation of the device is dependent on the junction temperature. Therefore, the package dissipation is assumed to be an internal limitation. The package itself does not have enough heat radiation characteristic due to the small size. Heat runs away by mounting IC on PCB. This value changes by the material, copper pattern etc. of PCB.

The overheating protection operates when there is a lot of loss inside the regulator (Ambient temperature high, heat radiation bad, etc.). The output current and the output voltage will drop when the protection circuit operates. When joint temperature (Tj) reaches the set temperature, IC stops the operation. However, operation begins at once when joint temperature(Tj) decrease.

The thermal resistance when mounted on PCB

The chip joint temperature during operation is shown by Tj=θja×Pd+Ta. Joint part temperature (Tj) of TK721xxCS is limited around 150°C with the overheating protection circuit. Pd is the value when the overheating protection circuit starts operation.

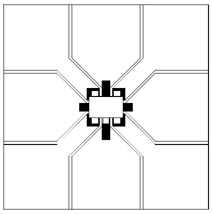
When you assume the ambient temperature to be 25°C,

150=θja×Pd(W)+25

θja×Pd=125

θja=125/Pd (°C /W)

Example of mounting substrate



PCB Material: Two layer glass epoxy substrate (x=30mm,y=30mm,t=1.0mm,Copper pattern thickness 35um)

Please do derating with 5.9mW/°C at Pd=736mW and 25°C or higher. Thermal resistance is (θja=170°C /W)

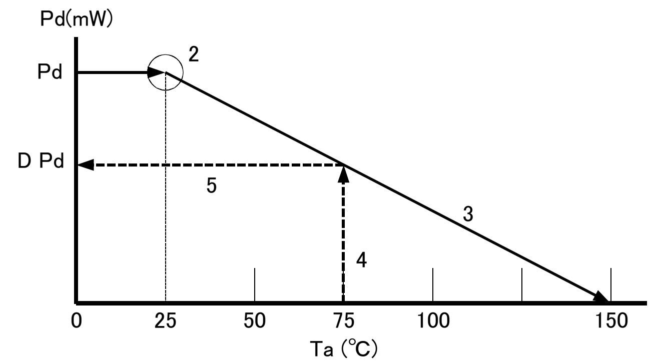
Method of obtaining Pd easily

Connect output terminal to GND(short circuited), and measure the input current by increasing the input voltage gradually up to 10V. The input current will reach the maximum output current, but will decrease soon according to the chip temperature rising, and will finally enter the state of thermal equilibrium (natural air cooling)

The input current and the input voltage of this state will be used to calculate the Pd.

$$Pd(mW) \cong Vin\ (V) \times Iin\ (mA)$$

When the device is mounted, mostly achieve 600mW or more.



Procedure (When mounted on PCB).

1.Find Pd (Vin×Iin when the output is short-circuited).

2. Plot Pd against 25°C.

3. Connect Pd to the point corresponding to the 150°C with a straight line.

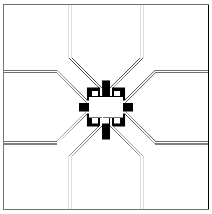
4. Pull a vertical line from the maximum operating temperature in your design (e.g., 75°C).

5. Read the value of Pd against the point at which the vertical line intersects the derating curve(DPd).

6. DPd ÷ (Vinmax−Vout)=Iout (at 75°C)

The maximum output current at the highest operating temperature will be **Iout ≅ DPd ÷ (VinMax−Vout).** Please use the device at low temperature with better radiation. The lower temperature provides better quality.

The operation area



PCB Material : Two layer glass epoxy substrate (x=30mm,y=30mm,t=1.0mm,Copper pattern thickness 35um)

Pd when mounted on the substrate mentioned above (Ta=25°C)
SOT23-5=736mW (derating –5.9mW)

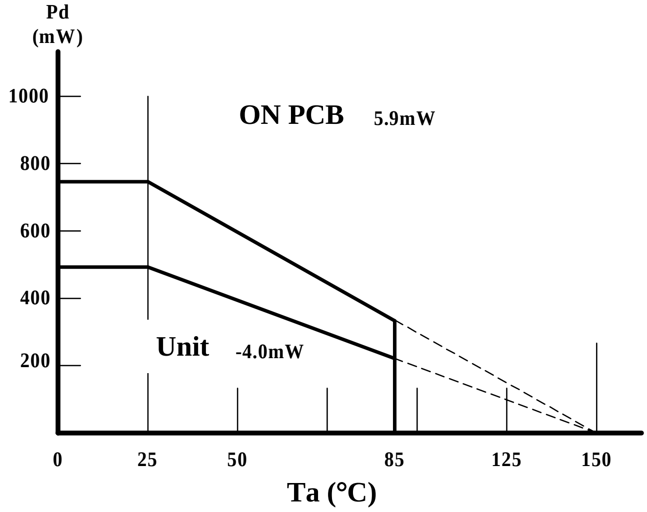
The current which can be used continuously with Ta=25°C min is calculated by the following.

$$Iout(mA) = \frac{736 - 5.9 \times (Ta - 25)}{|Vin| - |Vout|}$$ - SOT23-5

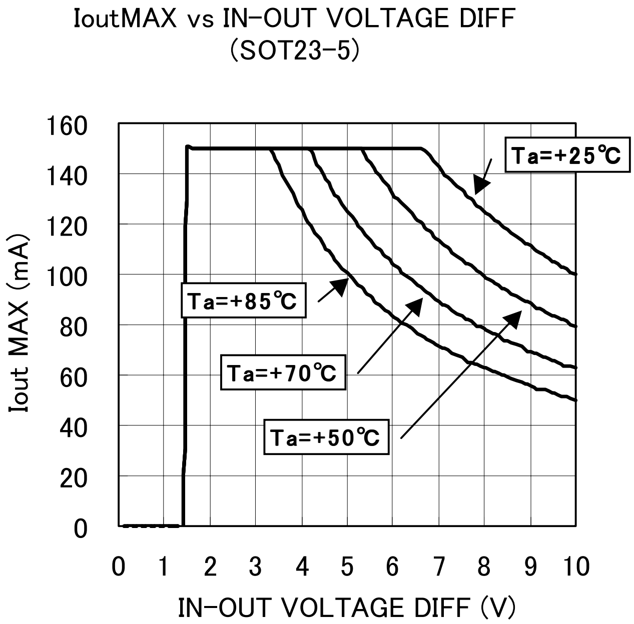
*Iout<150mA

The operation area is the part enclosed in the line including the "0" mentioned in graph1
The overheating sensor may operate, or the output voltage may drop outside those area.
The heat radiation characteristic changes in various conditions, so please check under your condition.

graph1

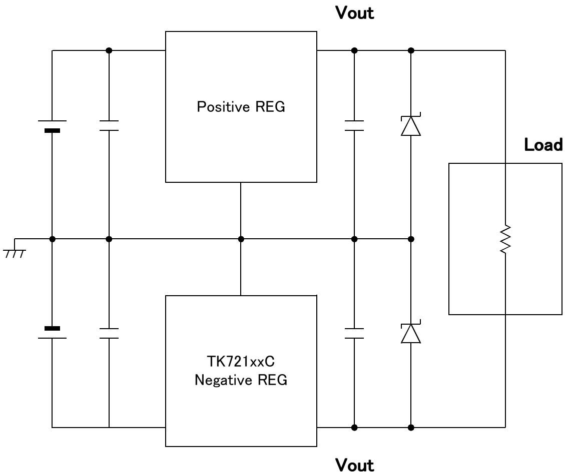


graph2



12-4 Application hint

***When using together with Positive output regulator**



When using positive output regulator together with this device, sometimes the voltage may not be outputted. To solve this problem, please connect Schottkey diode between GND and output, or change the timing of On/Off.

***When not using ON/OFF function**

Please connect the Cont terminal to GND.

***Notes when evaluating with output terminal is connected to GND(short-circuit)**

The output terminal becomes plus potential by the resonance of Cout (C element) connected to output and the short-circuit line (L element). When the output terminal becomes positive, parasitism Tr is caused inside the IC. The latch-up phenomenon occurs and in the worst case, IC may be damaged.($f_0=1 / 2\pi\sqrt{(L C)}$)
This resonance appears remarkably when using a ceramic capacitor with small ESR, etc. This can be solved by connecting 2Ω resistance in series. As a result, the latch-up phenomenon in IC can be prevented.
Generally, tantalum capacitor has enough ESR value and the influence of the resonance decreases.

13. NOTES

■ Please be sure that you carefully discuss your planned purchase with our office if you intend to use the products in this application manual under conditions where particularly extreme standards of reliability are required, or if you intend to use products for applications other than those listed in this application manual.

- Power drive products for automobile, ship or aircraft transport systems; steering and navigation systems, emergency signal communications systems, and any system other than those mentioned above which include electronic sensors, measuring, or display devices, and which could cause major damage to life, limb or property if misused or failure to function.
- Medical devices for measuring blood pressure, pulse, etc., treatment units such as coronary pacemakers and heat treatment units, and devices such as artificial organs and artificial limb systems which augment physiological functions.
- Electrical instruments, equipment or systems used in disaster or crime prevention.

■ Semiconductors, by nature, may fail or malfunction in spite of our devotion to improve product quality and reliability. We urge you to take every possible precaution against physical injuries, fire or other damages which may cause failure of our semiconductor products by taking appropriate measures, including a reasonable safety margin, malfunction preventive practices and fire-proofing when designing your products.

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■ None of the ozone depleting substances(ODS) under the Montreal Protocol are used in our manufacturing process.

14. OFFICES

If you need more information on this product and other TOKO products, please contact us.

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