APPLICATION MANUAL

Adjustable Voltage LDO Regulator IC
TK73400AU3

CONTENTS

1 . DESCRIPTION	2
2 . FEATURES	2
3 . APPLICATIONS	2
4 . PIN CONFIGURATION	2
5 . BLOCK DIAGRAM	2
6 . ORDERING INFORMATION	3
7 . ABSOLUTE MAXIMUM RATINGS	3
8 . ELECTRICAL CHARACTERISTICS	4
9 . APPLICATION EXAMPLES	5
10 . TEST CIRCUIT	6
11 . TYPICAL CHARACHTERISTICS	7
12 . PIN DESCRIPTION	16
13 . APPLICATIONS INFORMATION	17
14. PACKAGE OUTLINE	21
15. NOTES	22
16. OFFICES	22

Adjustable Voltage LDO Regulator IC
TK73400AU3

1. DESCRIPTION

The TK73400AU3 are LDO regulator ICs designed based on a bipolar process technology. These devices are available in the TO252 packages, which feature high heat dissipation. The products supply stable output current of 1A, and offer low dropout voltage and high overall stability. Output voltage can be set between 1.3 and 12.0V using external resistors.

2. FEATURES

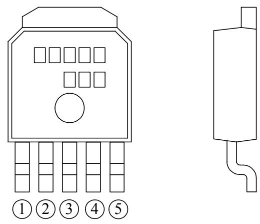
- High heat dissipation packages (TO252-5)
- Low dropout voltage
- High maximum output current
- Over heat and over current protection
- Wide operational temperature range
- High stability
- Low noise application

3. APPLICATIONS

- Power supply for low voltage MPU and the peripherals
- Any Electronic Equipment, etc

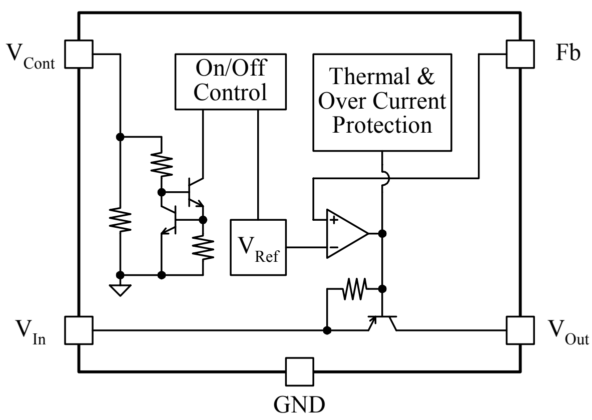
4. PIN CONFIGURATION

- TO252-5



①: V_{Cont} ②: V_{In} ③: GND
④: V_{Out} ⑤: Fb

5. BLOCK DIAGRAM



6. ORDERING INFORMATION

■ TK73400AU3

T K 7 3 4 0 0 A U 3 G 0 L - C

- Voltage Code — 0 0 : Adjustable
- Version
- Package Code — U 3 : TO252-5
- Solder Composion Code — G 0 : Sn 100% (Lead Free)
- Tape/Reel Code
- Operating Temp. Range Code — C : C Rank (Standard)

7. ABSOLUTE MAXIMUM RATINGS

T_a=25°C

Parameter	Symbol	Rating	Units	Condition
Absolute Maximum Ratings				
Input Voltage	$V_{In,Max}$	-0.4 ~ 16.0	V	
Reverse Bias Voltage	$V_{Rev,Max}$	-0.4 ~ 12.0	V	
Fb terminal Voltage	$V_{Fb,Max}$	-0.4 ~ 5.0	V	
Control terminal Voltage	$V_{Cont,Max}$	-0.4 ~ 16.0	V	
Storage Temperature Range	T_{Stg}	-55 ~ +150	°C	
Power Dissipation	P_D	830*2	mW	TK73400AU3 (TO252-5) Unit, Internal Limited (T_j=145°C)
Operating Condition				
Operational Temperature Range	T_{OP}	-40 ~ +85	°C	
Operational Voltage Range	V_{OP}	2.4 ~ 15.0	V	
Output Voltage Range	V_{Out}	1.3 ~ 12.0	V	
Reference				
Short Circuit Current	I_{Short}	1500	mA	V_{Out}=0V

*1: P_D must be decreased at the rate of 6.9mW/°C for operation above 25°C.

The maximum ratings are the absolute limitation values with the possibility of the IC being damaged.
If the operation exceeds any of these standards, quality cannot be guaranteed.

8. ELECTRICAL CHARACTERISTICS

The parameters with min. or max. values will be guaranteed at T_a=T_j=25°C with test when manufacturing or S Q C (Statistical Quality Control) methods. The operation between –40 ~ 85°C is guaranteed by design.

$V_{Out,TYP}$=3.0V (R_1=53kΩ, R_2=36kΩ) V_{In}=4.0V, V_{Cont}=1.8V, T_a=T_j=25°C

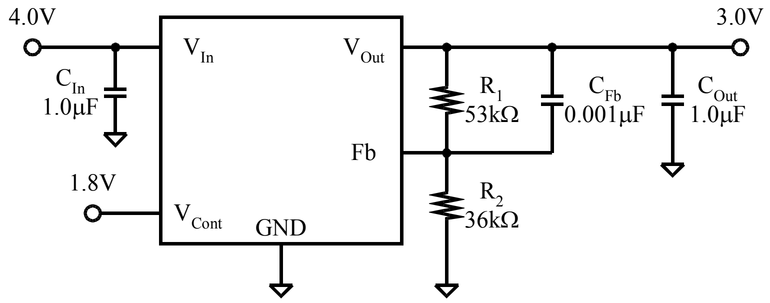
Parameter	Symbol	Value			Units	Conditions
		MIN	TYP	MAX		
Fb voltage	V_{FB}	1.185	1.210	1.245	V	I_{Out}=5mA
Line Regulation	LinReg	-	0	10	mV	ΔV_{In}=5V, I_{Out}=5mA
Load Regulation*1	LoaReg	-	6	20	mV	I_{Out}=5~500mA
		-	20	35		I_{Out}=5~1000mA
Dropout Voltage*2	V_{Drop}	-	150	260	mV	I_{Out}=500mA
		-	300	490		I_{Out}=1000mA
Maximum Output Current*3	$I_{Out,Max}$		1400	-	mA	V_{Out}=$V_{Out,TYP}$×0.9
Quiescent Current	I_Q	-	300	480	μA	I_{Out}=0mA
Standby Current	$I_{Standby}$	-	-	0.1	μA	V_{Cont}=0V
Control Current	I_{Cont}	-	5	10	μA	V_{Cont}=1.8V
Control Voltage	V_{Cont}	1.8	-	-	V	V_{Out} On state
		-	-	0.35	V	V_{Out} Off state

*1: Load Regulation changes with output voltage. The value mentioned above is guaranteed with the condition at $V_{Out,TYP}$=3.0V (R_1=53kΩ, R_2=36kΩ). The standard value is displayed by the absolute value.
*2: For $V_{Out,TYP}$≤2.0V , no regulations.
*3: The maximum output current is limited by power dissipation

Note: Parameters with only typical values are just reference. (Not guaranteed)

9. APPLICATION EXAMPLES

■ $V_{Out,TYP}$=3.0V: Example of selection of external components.



The output voltage value $V_{Out,TYP}$ is determined using the following equation:

$$V_{Out,TYP} = \frac{R_1 + R_2}{R_2} \times V_{Fb}$$

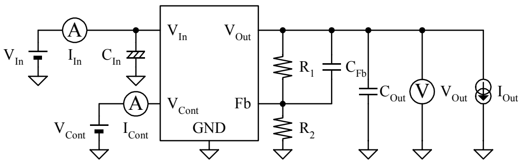
The minimum required current through resistance R_1, R_2 is 30µA, which is determined by $V_{Fb} \div R_2$.

Only a ceramic capacitor should be used for C_{Out}. For C_{In} any type of capacitor may be selected. For C_{Out} and C_{In}, use capacitors rated at 1µF or higher. For details, refer to page 17.

The Fb terminal has high impedance and is therefore susceptible to external noise, etc. Connecting capacitor C_{Fb} between the V_{Out} terminal and the Fb terminal minimizes the effects of external noise and also reduces output noise.

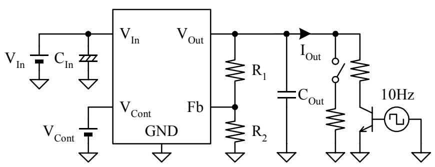
10. TEST CIRCUIT

■ Test circuit for DC characteristics



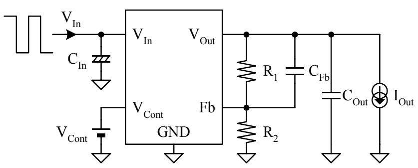
$V_{Out,TYP}$=3.0V(R_1=53kΩ, R_2=36kΩ)
V_{In}=4.0V, V_{Cont}=1.8V, I_{Out}=5mA
C_{In}=1.0µF(Tantalum), C_{Fb}=0.001µF(Ceramic),
C_{Out}=1.0µF(Ceramic), T_a=25°C

■ Test circuit for Load Transient



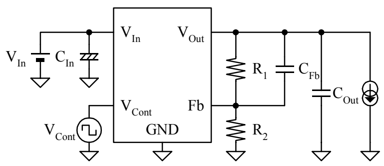
$V_{Out,TYP}$=3.0V(R_1=53kΩ, R_2=36kΩ)
V_{In}=4.0V, V_{Cont}=1.8V
C_{In}=1.0µF(Tantalum), T_a=25°C

■ Test circuit for Line Transient



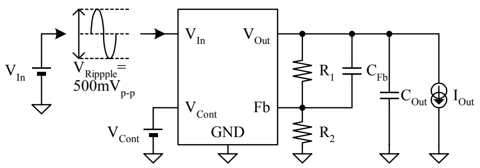
$V_{Out,TYP}$=3.0V(R_1=53kΩ, R_2=36kΩ)
V_{In}=4.0V↔5.0V(100Hz), V_{Cont}=1.8V, I_{Out}=100mA
C_{In}=1.0µF(Tantalum), C_{Fb}=none, T_a=25°C

■ Test circuit for On/Off Transient



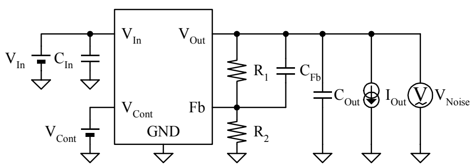
$V_{Out,TYP}$=3.0V(R_1=53kΩ, R_2=36kΩ)
V_{In}=4.0V, V_{Cont}=0.0V↔2.0V(10Hz), I_{Out}=100mA
C_{In}=1.0µF(Tantalum), C_{Fb}=none, T_a=25°C

■ Test circuit for Ripple Rejection



$V_{Out,TYP}$=3.0V(R_1=53kΩ, R_2=36kΩ)
V_{In}=4.5V, V_{Cont}=2.0V, V_{Ripple}=500mV$_{p-p}$, I_{Out}=100mA
C_{In}=none, C_{Fb}=none, T_a=25°C

■ Test circuit for Output Noise

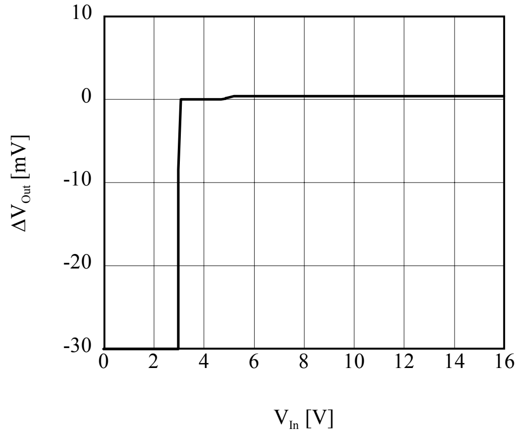


R_2=36kΩ
V_{In}=$V_{Out,TYP}$+1.0V, V_{Cont}=2.0V, I_{Out}=100mA
BPF=400Hz~80kHz
C_{In}=C_{Out}=1.0µF(Ceramic), C_{Fb}=none, T_a=25°C

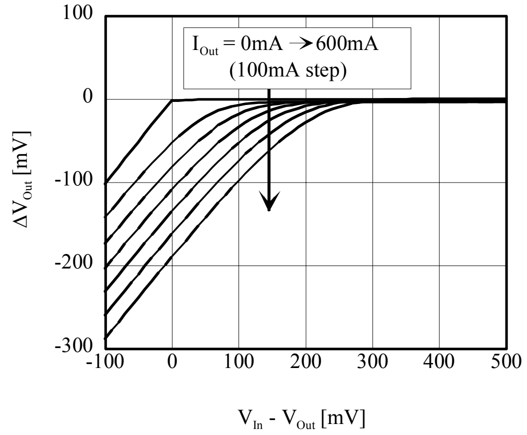
11. TYPICAL CHARACHTERISTICS

11-1. DC CHARACTERISTICS

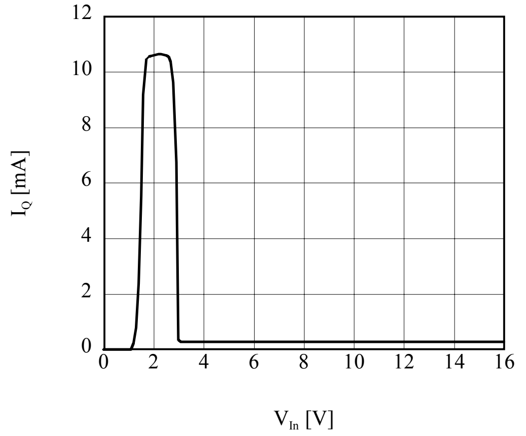
■ ΔV_{Out} vs V_{In} (TK73400AU3)



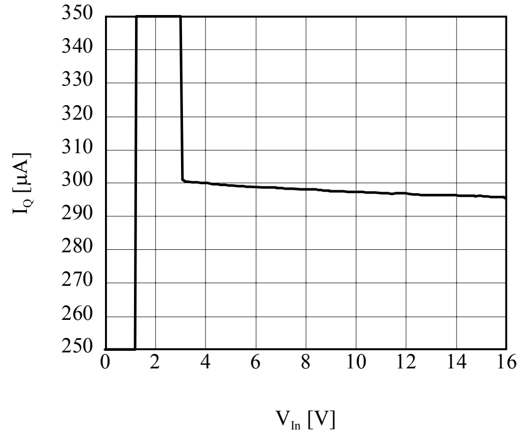
■ ΔV_{Out} vs V_{In} (TK73400AU3)



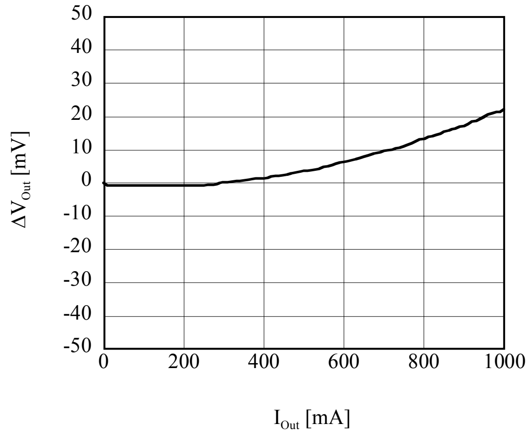
■ I_Q vs V_{In} (TK73400AU3)



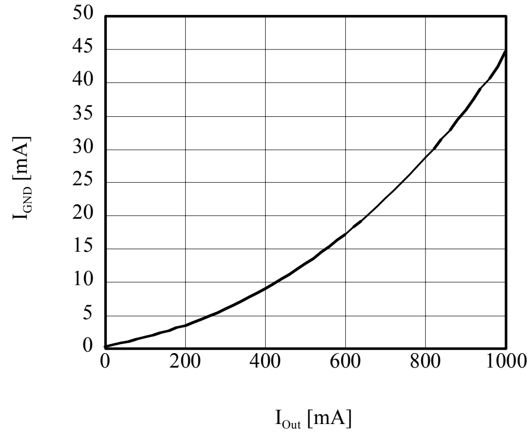
■ I_Q vs V_{In} (TK73400AU3)



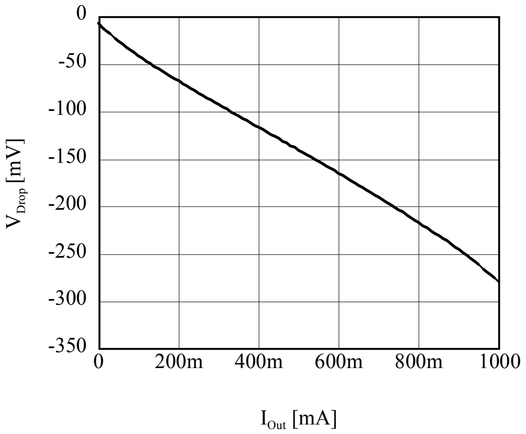
■ ΔV_{Out} vs I_{Out} (TK73400AU3)



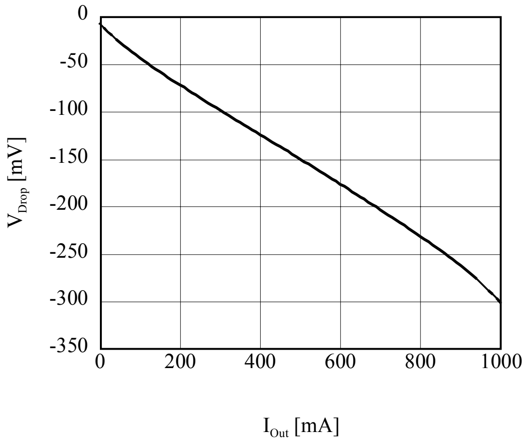
■ I_{GND} vs I_{Out} (TK73400AU3)



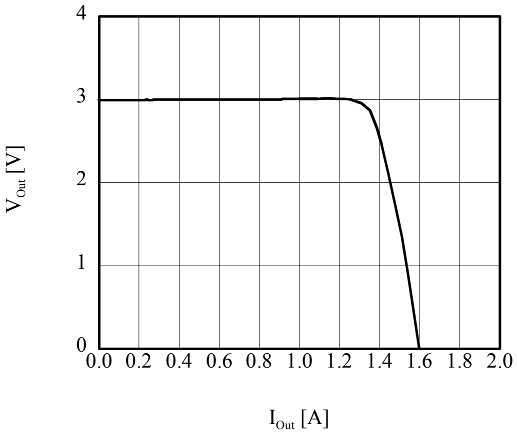
■ V_{Drop} vs I_{Out} (TK73400AU3)



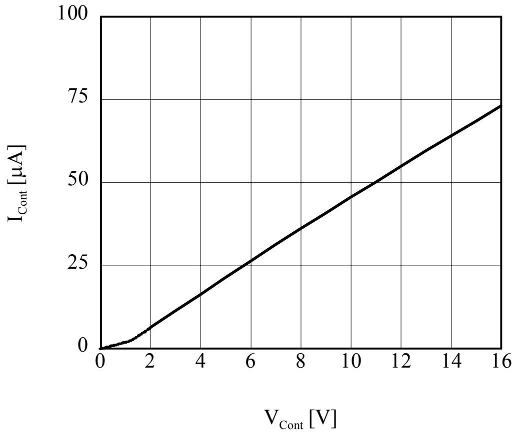
■ V_{Drop} vs I_{Out} (TK73400AU3)



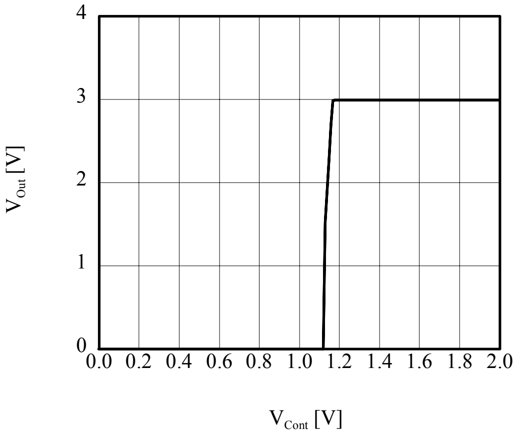
■ V_{Out} vs I_{Out} (TK73400AU3)



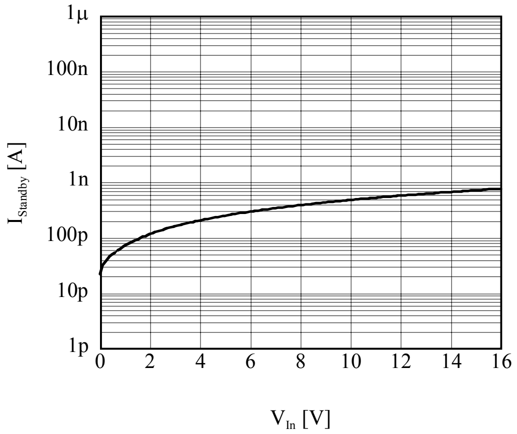
■ I_{Cont} vs V_{Cont} (TK73400AU3)



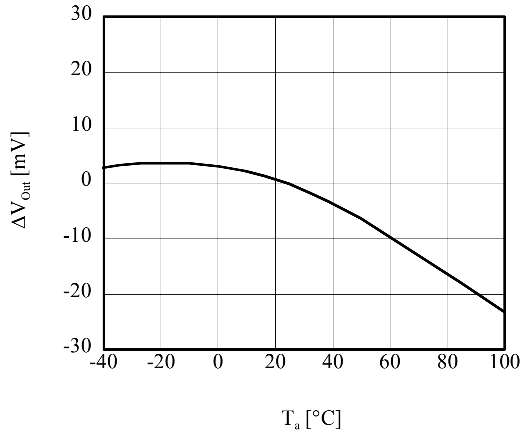
■ V_{Out} vs V_{Cont} (TK73400AU3)



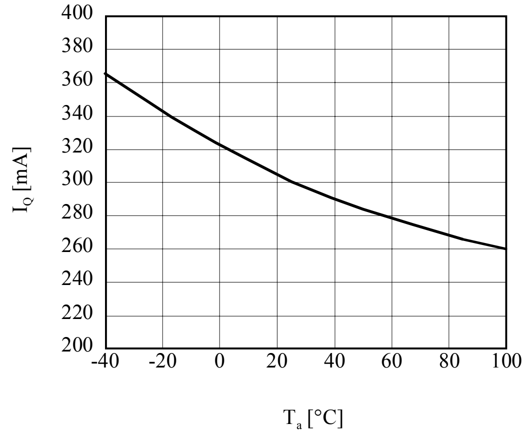
■ $I_{Standby}$ vs V_{In} (TK73400AU3)



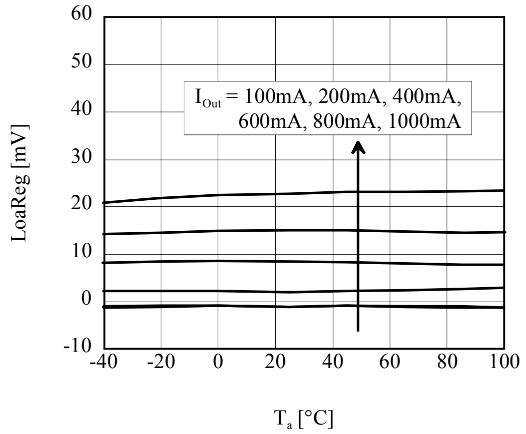
■ ΔV_{Out} vs T_a (TK73400AU3)



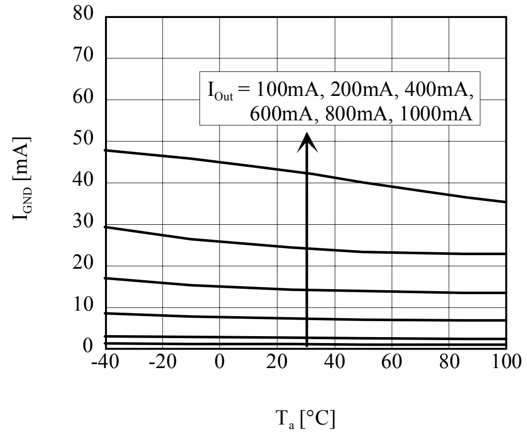
■ I_Q vs T_a (TK73400AU3)



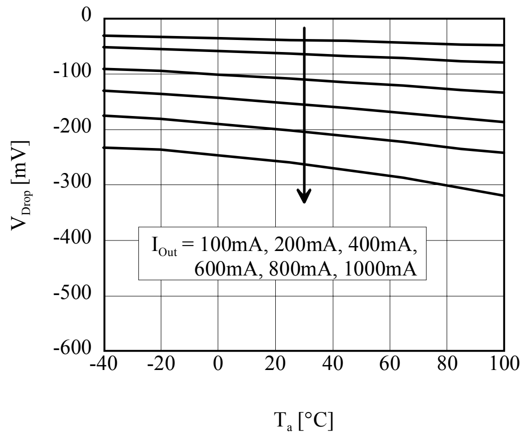
■ LoaReg vs T_a (TK73400AU3)



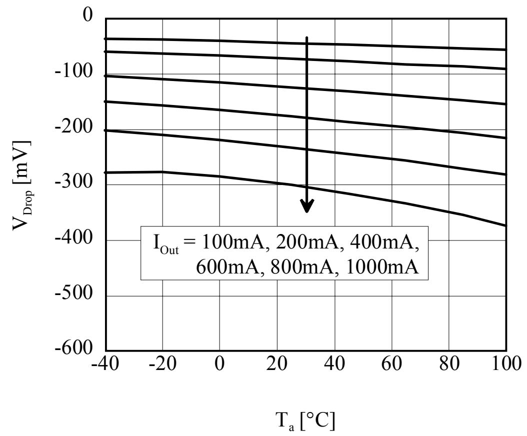
■ I_{GND} vs T_a (TK73400AU3)



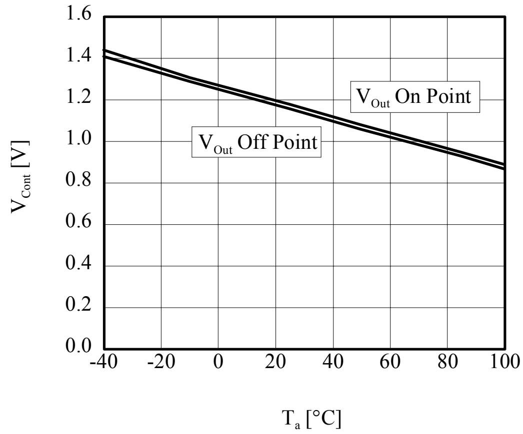
■ V_{Drop} vs T_a (TK73400AU3)



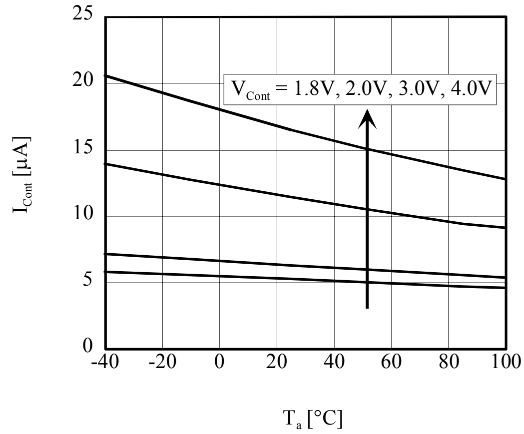
■ V_{Drop} vs T_a (TK73400AU3)



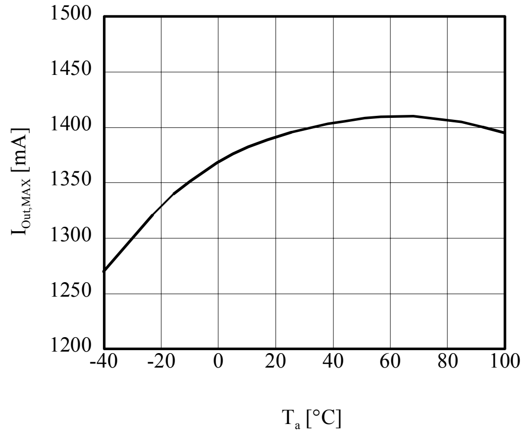
■ V_{Out} On/Off Point vs T_a (TK73400AU3)



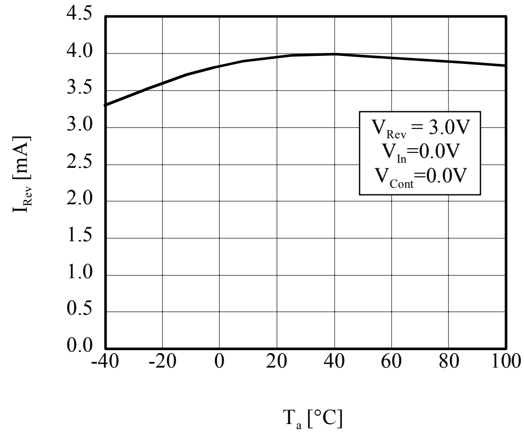
■ I_{Cont} vs T_a (TK73400AU3)



■ $I_{Out,MAX}$ vs T_a (TK73400AU3)

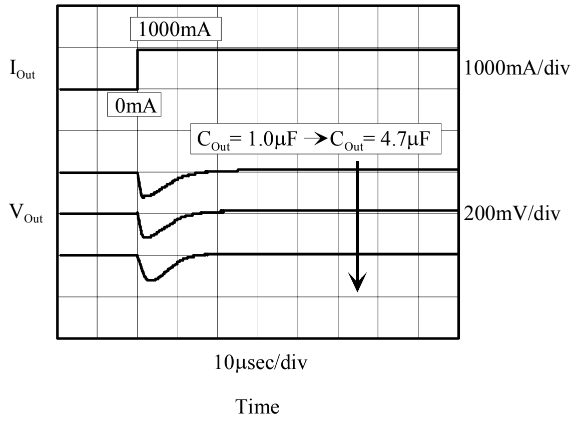


■ Reverse Bias Current(I_{Rev}) vs T_a (TK73400AU3)

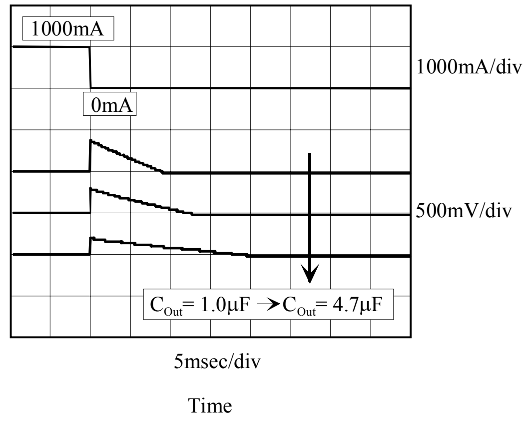


11-2. Load Transient

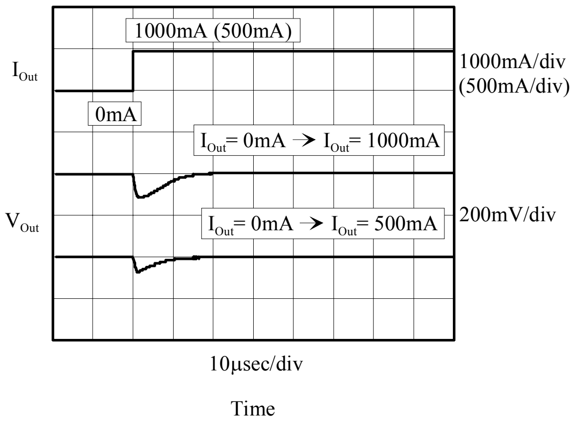
■ I_{Out}=0mA→1000mA, C_{Out}=1.0µF, 2.2µF, 4.7µF



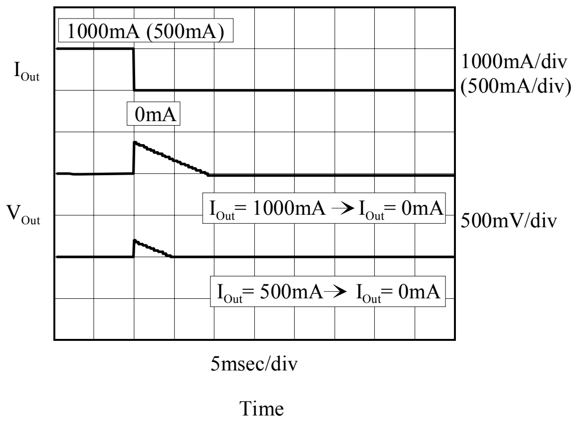
■ I_{Out}=1000mA→0mA, C_{Out}=1.0µF, 2.2µF, 4.7µF



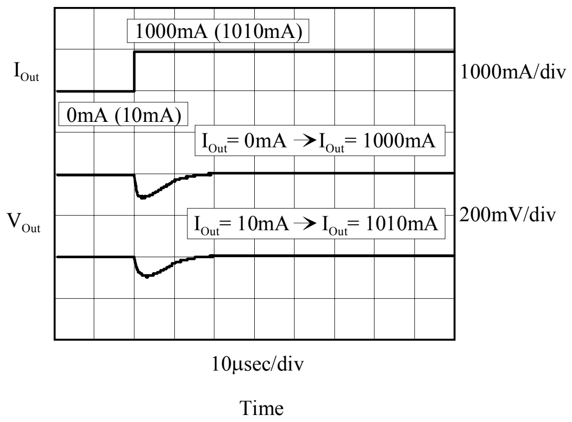
■ I_{Out}=0mA→500mA, 0mA→1000mA



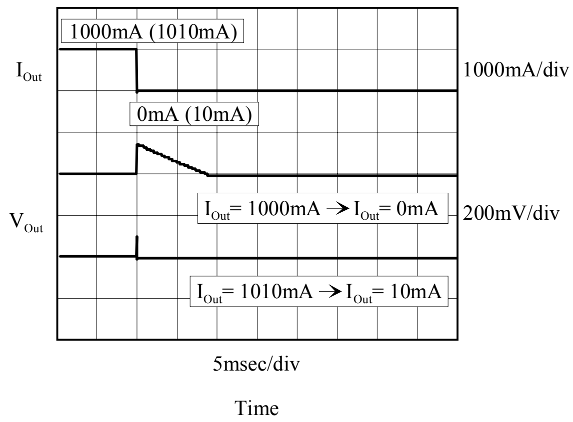
■ I_{Out}=500mA→0mA, 1000mA→0mA



■ I_{Out}=0mA→1000mA, 10mA→1010mA

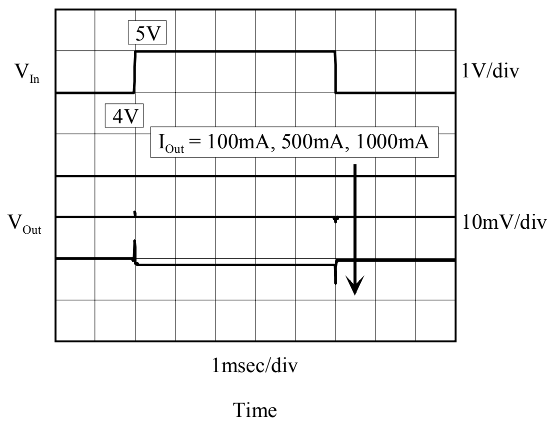


■ I_{Out}=1000mA→0mA, 1010mA→10mA

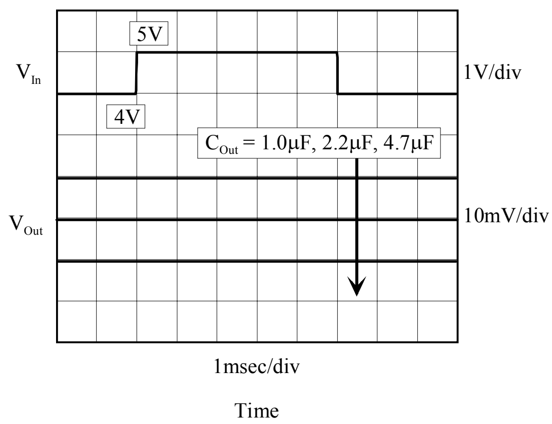


11-3. Line Transient

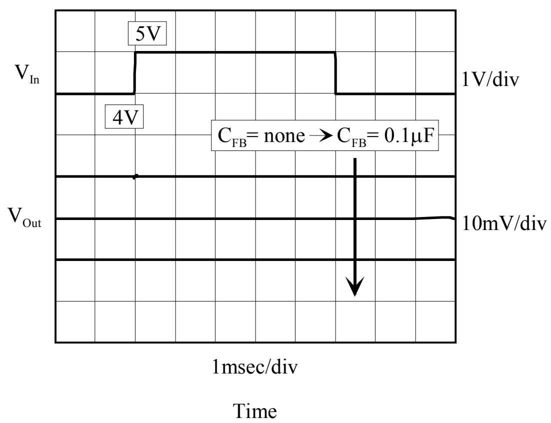
■ I_{Out}=100mA, 500mA, 1000mA



■ C_{Out}=1.0µF, 2.2µF, 4.7µF

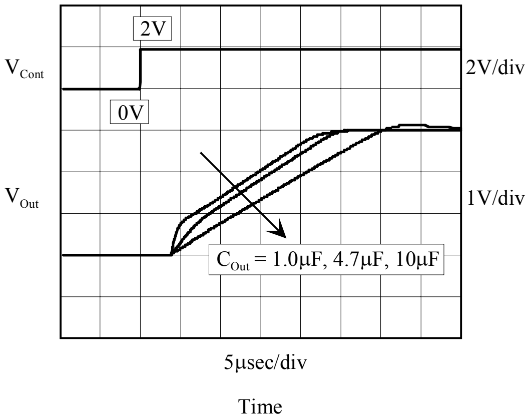


■ C_{Fb}=none, 1000pF, 0.1µF

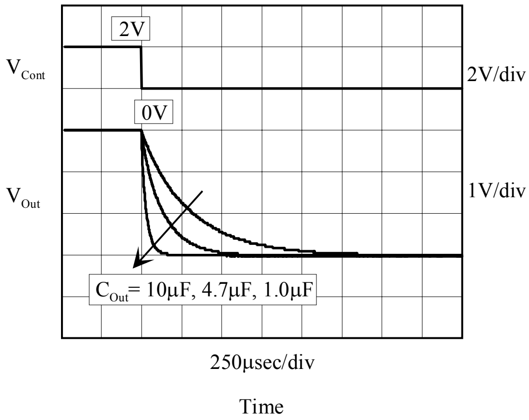


11-4. On/Off Transient

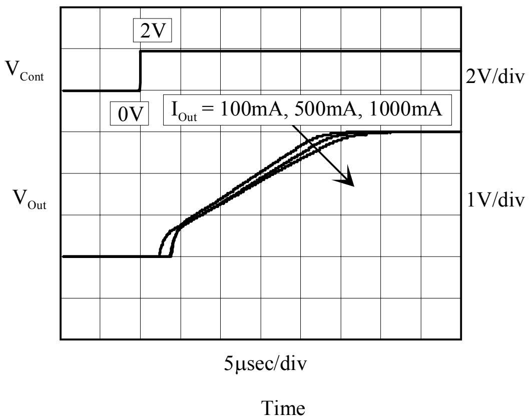
■ V_{Cont}=0.0V→2.0V, C_{Out}=1.0μF, 4.7μF, 10μF



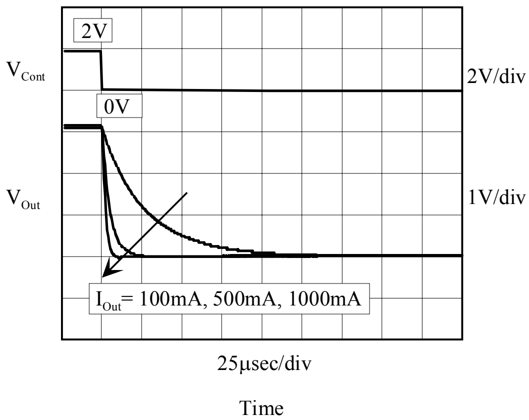
■ V_{Cont}=2.0V→0.0V, C_{Out}=1.0μF, 4.7μF, 10μF



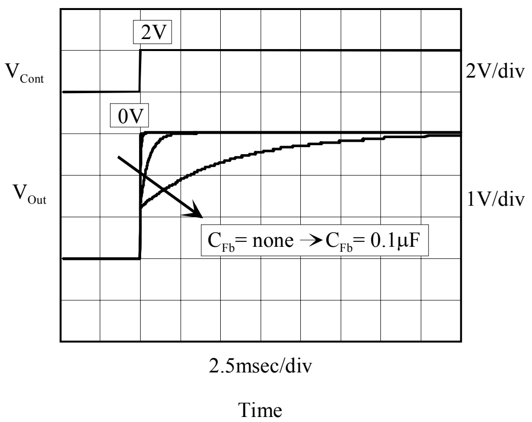
■ V_{Cont}=0.0V→2.0V, I_{Out}=100mA, 500mA, 1000mA



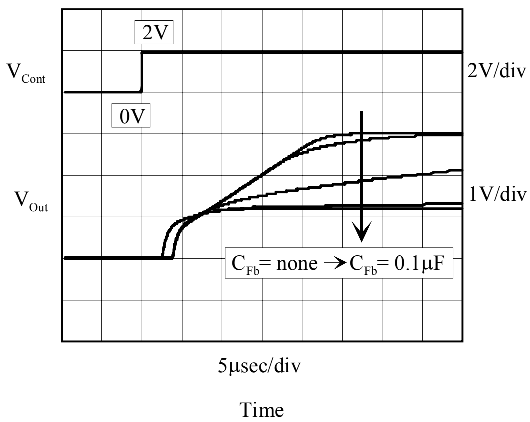
■ V_{Cont}=2.0V→0.0V, I_{Out}=100mA, 500mA, 1000mA



■ V_{Cont}=0.0V→2.0V, C_{Fb}=none~0.1μF*



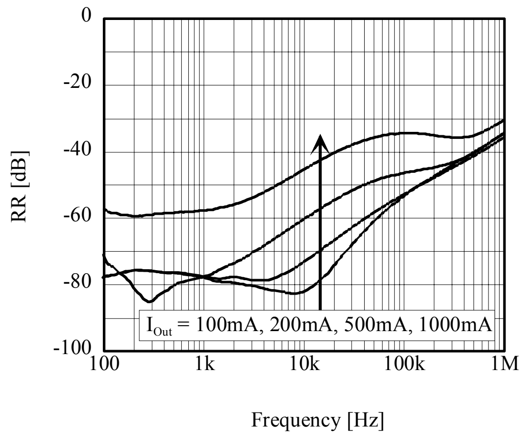
■ V_{Cont}=0.0V→2.0V, C_{Fb}=none~0.1μF*



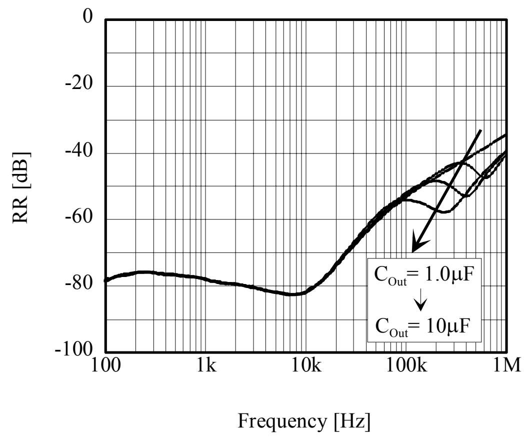
* C_{Fb}=none, 100pF, 1000pF, 0.001μF, 0.01μF, 0.1μF

11-5. Ripple Rejection

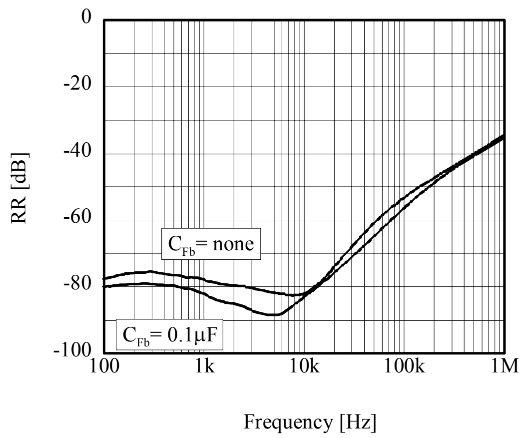
■ I_{Out}=100mA, 200mA, 500mA, 1000mA



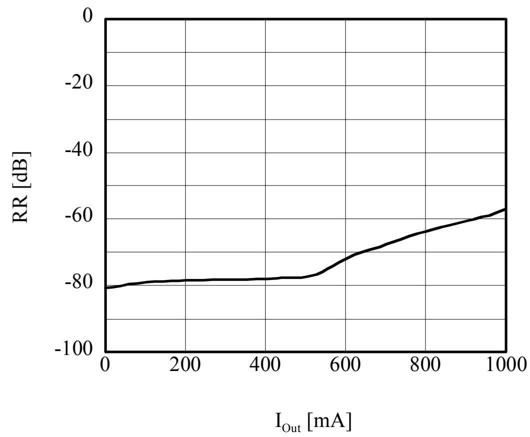
■ C_{Out}=1.0µF, 2.2µF, 4.7µF, 10µF



■ C_{Fb}=none, 0.1µF

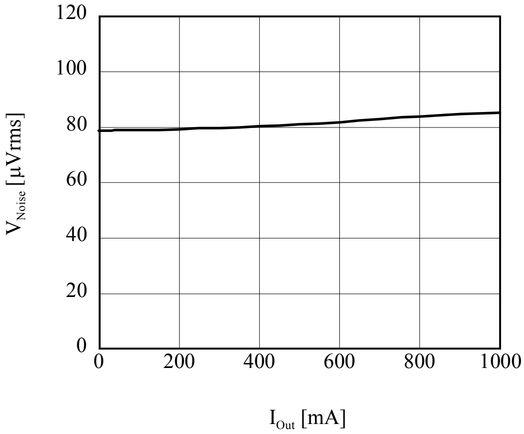


■ I_{Out}=1mA~1000mA, f=1kHz

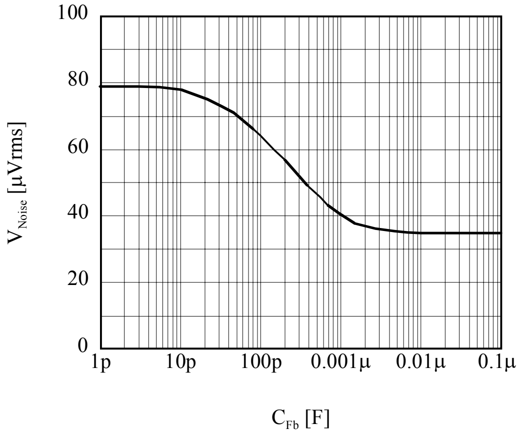


11-6. Output Noise

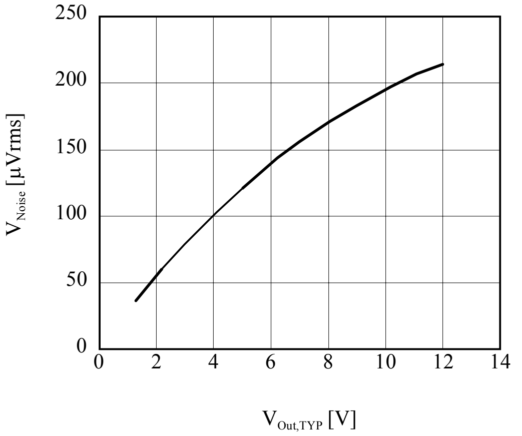
■ $V_{Out,TYP}$=3.0V, I_{Out}=0.1mA~1000mA



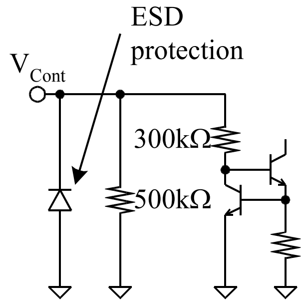
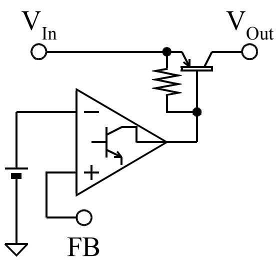
■ $V_{Out,TYP}$=3.0V, C_{Fb}=1pF~0.1µF



■ $V_{Out,TYP}$=1.3V ~ 12V



12. PIN DESCRIPTION

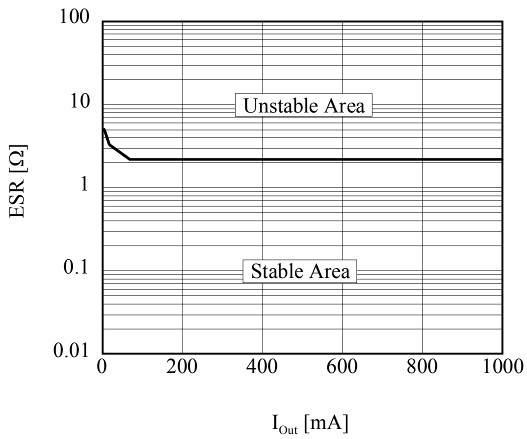
Pin Number	Symbol	Internal Equivalent Circuit	Description
1	V_{Cont}		**On/Off control Terminal** The On/Off voltages are as follows: $V_{Cont} \geq 1.8V$: V_{Out} On state $V_{Cont} \leq 0.35V$: V_{Out} Off state Pull-down resistance (500kΩ) is built-in.
2	V_{In}	-	**Input Terminal** Connect a capacitor of 1µF or higher between V_{In} terminal and GND.
3	GND	-	**GND Terminal**
4	V_{Out}		**Output Terminal** Connect resistance R_1 between V_{Out} terminal and Fb terminal, and resistance R_2 between Fb terminal and GND. Output voltage $V_{Out,TYP}$ is determined by the following equation: $V_{Out,TYP} = V_{Fb} \times \frac{R_1 + R_2}{R_2}$ Connect a ceramic capacitor with a capacitance higher than the following values between V_{Out} terminal and GND. $V_{Out,TYP} \geq 2.4V$: 1µF $V_{Out,TYP} < 2.4V$: 2.2µF
5	Fb		**Feedback Terminal** Connecting a capacitor between V_{Out} terminal and Fb terminal reduces output noise. This terminal features very high impedance; please note that it is susceptible to external noise, etc.

13. APPLICATIONS INFORMATION

13-1.Stability

The standard capacitor recommended for use on the output side is a ceramic capacitor equal to or greater than 1.0µF. For operations at 2.4V or less, use at least a 2.2µF capacitor.

■Stable operation area when $V_{Out,TYP}$=3.0V



The above graph indicates that operation is stable in the entire current range with a resistance of 1Ω or less (equivalent series resistance or 'ESR') connected in series to the output capacitor.

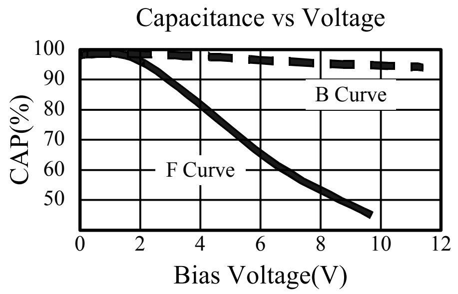
Generally, the ESR of a ceramic capacitor is very low (several tens of mΩ), and no problems should arise in actual use.

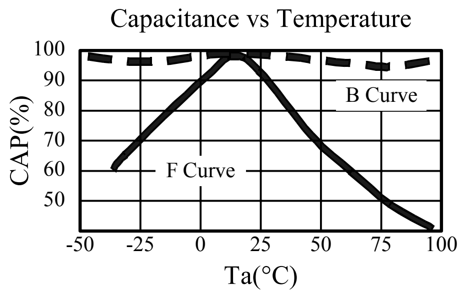
If an application requires use of a large ESR capacitor, connecting a ceramic capacitor with low ESR in parallel will enable operations at this level.

When parallel output capacitors are used, be sure to position the ceramic capacitor as close to the IC as possible. The other capacitor connected in parallel may be located away from the IC. The IC will not be damaged by the increased capacitance.

Input capacitors are necessary when the power supply impedance increases due to battery depletion or when the line to the power supply is particularly long. There is no general rule that can be used to determine the required number of capacitors used for such purposes. In some cases, only one capacitor is necessary for several regulator ICs. In some cases, one capacitor is required for each IC. To determine the required number of capacitors in a specific application, be sure to verify operation with all parts in the installed configuration.

■General characteristics of ceramic capacitors





Ceramic capacitors normally have specific temperature and voltage characteristics. Be sure to take the operating voltage and temperature into consideration when selecting parts for use. We recommend parts featuring B characteristics.

For evaluation

Kyocera : CM05B104K10AB , CM05B224K10AB , CM105B104K16A , CM105B224K16A , CM21B225K10A

Murata : GRM36B104K10 , GRM42B104K10 , GRM39B104K25 , GRM39B224K10 , GRM39B105K6.3

13-2. Operating Region and Power Dissipation

Power dissipation capability is limited by the junction temperature that triggers the built-in overheat protection circuit. Therefore, power dissipation capability is regarded as an internal limitation. The package itself does not offer high heat dissipation because of its small size. The package is, however, designed to release heat effectively when mounted on the PCB. Therefore, the heat-dissipation value will vary depending on the material, copper pattern, etc. of the PCB on which the package is mounted.

When the regulator loss is large (high ambient temperature, poor heat radiation), the overheat protection circuit is activated. When this occurs, output current cannot be obtained, and an output voltage drop is observed. When the junction temperature reaches the set value, the IC stops operating. However, after the IC has stopped operation and the junction temperature lowers sufficiently, the IC restarts operation immediately.

How to determine the thermal resistance when installation on PCB

The chip junction temperature during operation is expressed by

$$T_j = \theta_{ja} \times P_D + 25$$

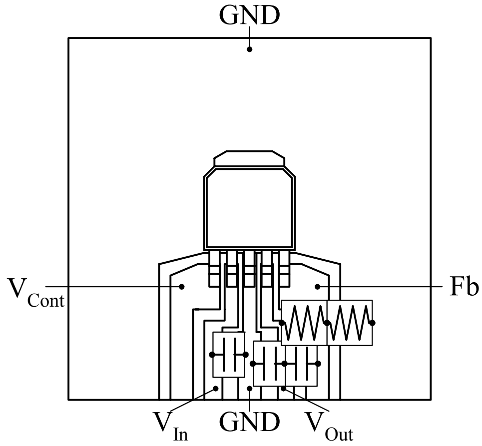
The junction temperature of the TK73400AU3 is limited to approximately 145°C by the overheat protection circuit. P_D is the value observed when the overheat protection circuit is activated. The following example is based on an ambient temperature of 25°C.

$$145 = \theta_{ja} \times P_D + 25$$

$$\theta_{ja} \times P_D = 120$$

$$\theta_{ja} = \frac{120}{P_D} \quad (°C/W)$$

■Example of TK73400AU3 installation on circuit board
Glass epoxy substrate with double-layer wiring
(copper pattern thickness: 35µm)



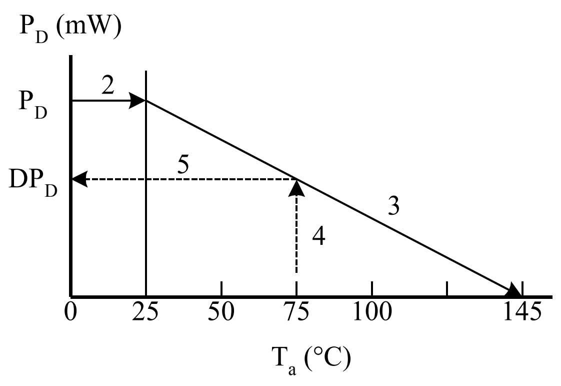
In the above installation example, P_D is 2200mW. If the temperature exceeds 25°C, be sure to derate at -19.7mW/°C.

P_D is easily calculated.

With the output terminal shorted-circuited to GND, gradually increase the input voltage and measure the input current.

Slowly increase the input voltage to about 10V. The initial input current value becomes the maximum instantaneous output current value, but gradually lowers as the chip temperature rises, and ultimately reaches a state of thermal equilibrium (through natural air cooling). P_D is calculated using the input value for input current and the input voltage value in the equilibrium state.

$$P_D \cong V_{In} \times I_{In}$$



Procedure (conducted at the time of installation on PCB)

1: Obtain P_D ($V_{In} \times I_{In}$ when output is short-circuited).
2: Plot P_D on the 25°C line.
3: Draw a straight line between P_D and the 145°C line.
4: Extend a straight-line perpendicular from the point of the designed maximum operating temperature (for example, 75°C).
5: Extend a line to the left from the intersection of the derating curve and the line drawn in 4, and read the P_D value (this value is DP_D).
6: $DP_D \div (V_{In,MAX} \times V_{Out}) = I_{Out}$ at 75°C

The maximum operating current at the maximum temperature is as follows:

$$I_{Out} \cong \{DP_D \div (V_{In,MAX} - V_{Out})\}$$

Try to achieve maximum heat dissipation in your design in order to minimize the part's temperature during operation. Generally speaking, lower part temperatures result in higher reliability in operation.

13-3.Difinition of term

Characteristics

■ Output Voltage (V_{Out})
The output voltage is specified with $V_{In}=V_{Out,TYP}+1V$ and $I_{Out}=5mA$.

■ Output Current (I_{Out})
Output current, which can be used continuously (It is the range where overheating protection of the IC does not operate).

■ Maximum output current ($I_{Out,Max}$)
The rated output current is specified under the condition where the output voltage drops 0.9V times the value specified with $I_{Out}=5mA$ by increasing the output current. The input voltage is set to $V_{OutTYP}+1V$ and the current is pulsed to minimize temperature effect.

■ Dropout Voltage (V_{Drop})
It is the difference between the input voltage and the output voltage 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 the output voltage value when the input voltage is assumed to be $V_{Out,TYP}+1V$, and the output current is changed.

■ Ripple Rejection (RR)
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 $V_{In}=V_{Out,TYP}+1.5V$. Ripple rejection is the ratio of the ripple content between the output vs. input and is expressed in dB

■ Standby Current ($I_{Standby}$)
Standby current is the current which flows into the regulator when the output is turned off by the control function ($V_{Cont}=0V$).

Protections

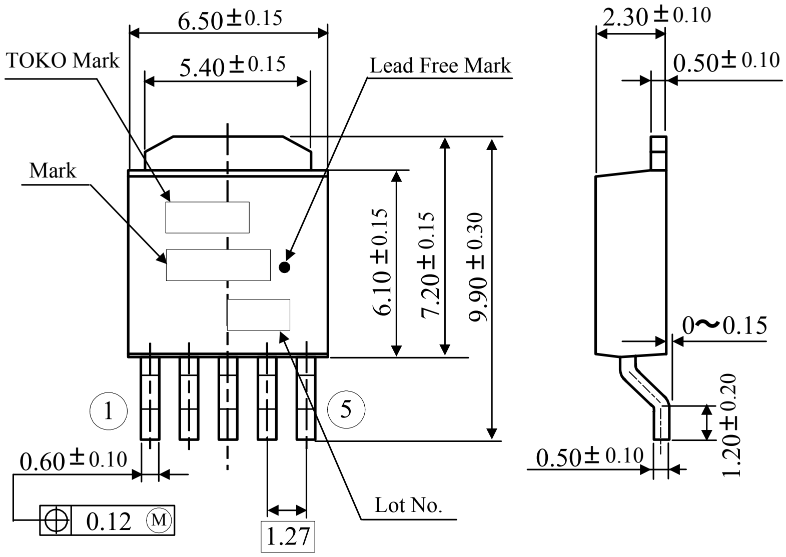
■ Over Current Protection
It is an function to protect the IC by limiting the output current when excessive current flows to IC, such as the output is connected to GND, ets.

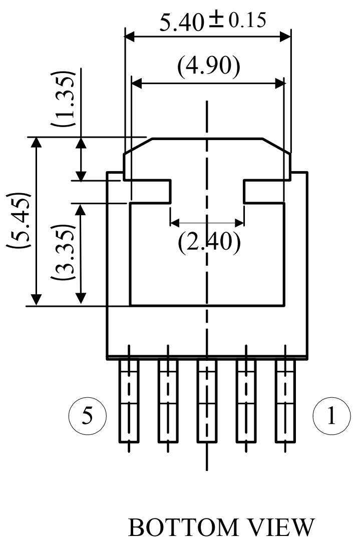
■ Thermal Protection
It protects the IC not to exceed the permissible power consumption of the package in case of large power loss inside the regulator. The output is turned off when the chip reaches around 145°C, but it turns on again when the temperature of the chip decreases.

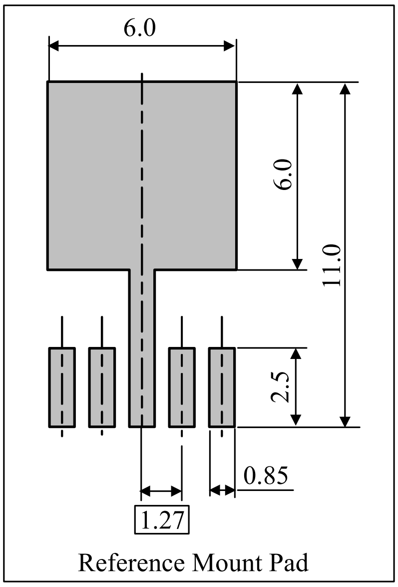
■ ESD
MM: 200pF 0Ω 200V or over
HBM: 100pF 1.5kΩ 2000V or over

14. PACKAGE OUTLINE

■ TO252-5







Unit : mm

15. 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.

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

16. OFFICES

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