APPLICATION MANUAL

BiMOS LDO Regulator IC
TK772xxAMH

CONTENTS

BiMOS LDO Regulator
TK772xxAMH

1. DESCRIPTION

The TK772xxAMH is a BiMOS LDO regulator. The package is the small and thin HSON1820A-6. The IC can supply 300mA output current.

A soft start function that gradually ramps up the output voltage is available by connecting a noise pass capacitor. The soft start function adjusts the inrush current to almost zero.

The output voltage is internally fixed from 0.8V to 12V.

2. FEATURES

- ■ Soft start function (can adjust the inrush current to almost zero)
- ■ Capacitor-less
(Without input capacitor, output capacitor, and noise-bypass capacitor)
- ■ Output current 300mA
- ■ Small and thin package HSON1820A-6
(1.8mm × 2.0mm × 0.65mm)
- ■ Wide operation voltage (V_{OP} = 2.5V ~ 14.5V)
- ■ On/Off control (High-On)

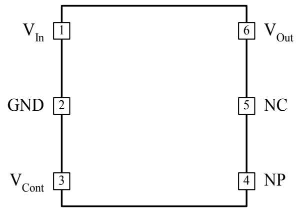
3. APPLICATIONS

- ■ Mobile Communication
- ■ Any Electronic Equipment

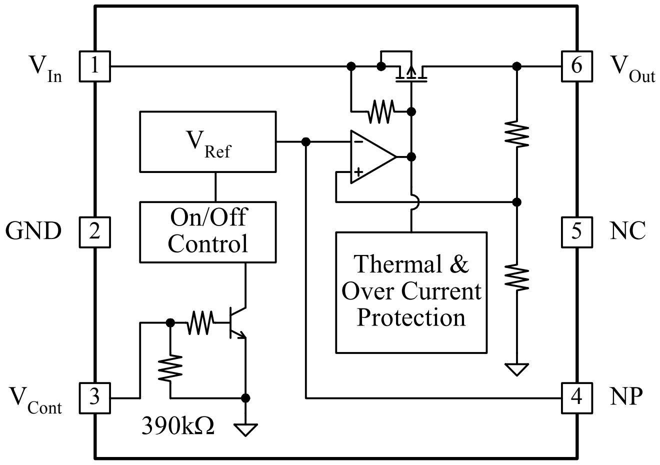
4. PACKAGE OUTLINE

■ HSON1820A-6

(Top View)



5. BLOCK DIAGRAM



6. ORDERING INFORMATION

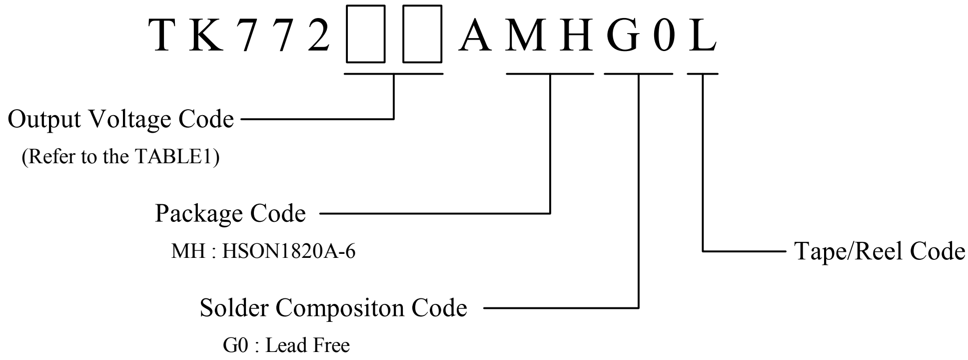


TABLE 1. Voltage Code

Output Voltage	Voltage Code	Output Voltage	Voltage Code	Output Voltage	Voltage Code
1.0V	10	3.0V	30		
1.2V	12	3.2V	32		
1.8V	18	3.3V	33		
2.5V	25	5.0V	50		

7. ABSOLUTE MAXIMUM RATINGS

T_a=25°C

Parameter	Symbol	Rating	Units	Conditions
Absolute Maximum Ratings				
Input Voltage	$V_{In,MAX}$	-0.3 ~ 16.0	V	
Output pin Voltage	$V_{Out,MAX}$	-0.3 ~ V_{In}+0.3	V	
Control pin Voltage	$V_{Cont,MAX}$	-0.3 ~ 16.0	V	
Np pin Voltage	$V_{Np,MAX}$	-0.3 ~ 2.0	V	
Storage Temperature Range	Tstg	-55 ~ 150	°C	
Power Dissipation	P_D	900	mW	Internal Limited T_j=140°C *, when mounted on PCB
Operating Condition				
Operational Temperature Range	T_{OP}	-40 ~ 85	°C	
Operational Voltage Range	V_{OP}	2.5 ~ 14.5	V	
Short Circuit Current	I_{Short}	500	mA	Over Current Protection

* P_D must be decreased at the rate of 7.8mW/°C for operation above 25°C.

*2: The maximum ratings are the absolute limitation values with the possibility of the IC being damaged. If the operation exceeds this standard 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 SQC(Statistical Quality Control) methods. The operation between -40 ~ 85°C is guaranteed by design.

$V_{In}=V_{Out,TYP}+1V(*1)$, $V_{Cont}=1.8V$, $T_a=25°C$

Parameter	**Symbol**	**Value**			**Units**	**Conditions**
		MIN	TYP	MAX		
Quiescent Current	I_Q	-	150	225	µA	$I_{Out}=0mA$
Output Voltage	V_{Out}	Refer to TABLE 2			V	$I_{Out}=5mA$
Line Regulation	LinReg	-	0.8	5	mV	$I_{Out}=5mA$, $\Delta V_{In}=5V$
Load Regulation	LoaReg	Refer to TABLE 2			mV	$I_{Out}=5mA\sim300mA$
Dropout Voltage *2	V_{Drop}	-	500	750	mV	$I_{Out}=300mA$
GND Pin Current	I_{GND}	-	200	300	µA	$I_{Out}=300mA$
Maximum Load Current *3	$I_{Out,MAX}$	350	500	-	mA	$V_{Out}=V_{Out,TYP}\times0.9$
Standby Current	$I_{Standby}$	-	0.01	0.1	µA	$V_{Cont}=0V$
Control Terminal						
Control Current	I_{Cont}	-	4.0	6.0	µA	$V_{Cont}=1.8V$, V_{Out} On
Control Voltage	V_{Cont}	1.8	-	-	V	V_{Out} On state
		-	-	0.3	V	V_{Out} Off state
Np Terminal						
Np pin Voltage	V_{Np}	-	0.39	-	V	$V_{Out} \leq 3.5V$
		-	0.58	-	V	$3.6V \leq V_{Out} \leq 5.1V$
		-	0.78	-	V	$5.2V \leq V_{Out}$

*1: For $V_{Out} \leq 1.5V$, $V_{In}=2.5V$.

*2: For $V_{Out} \leq 2.2V$, no regulations.

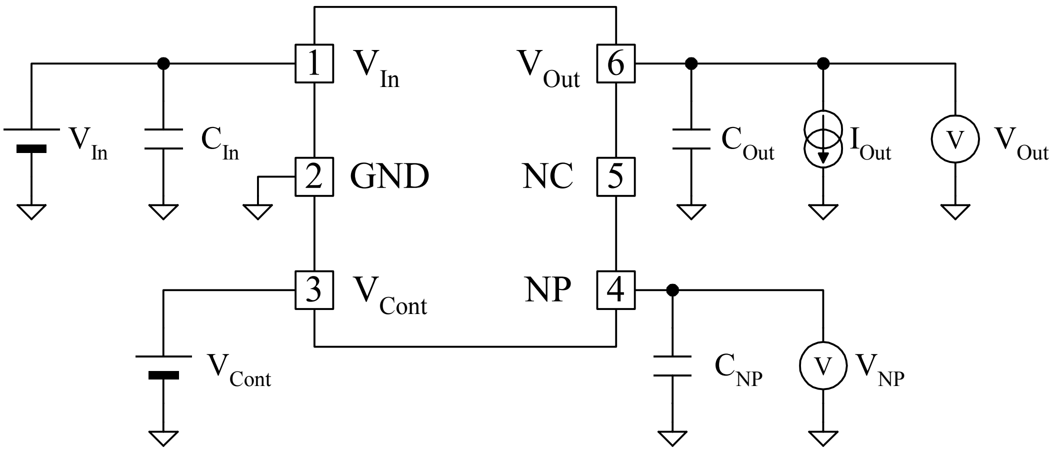
*3: The maximum output current is limited by power dissipation.

The maximum load current is the current where the output voltage decreases to 90% by increasing the output current at $T_j=25°C$, compared to the output voltage specified at $V_{In}=V_{Out,TYP}+1V$

TABLE 2. Preferred Product

Part Number	Output Voltage			Load Regulation	
	MIN	TYP	MAX	TYP	MAX
	V	V	V	mV	mV
TK77210AMH	0.970	1.000	1.030	36	90
TK77212AMH	1.170	1.200	1.230	38	95
TK77218AMH	1.764	1.800	1.836	43	108
TK77225AMH	2.450	2.500	2.550	48	120
TK77230AMH	2.940	3.000	3.060	52	130
TK77232AMH	3.136	3.200	3.264	54	135
TK77233AMH	3.234	3.300	3.366	55	138
TK77250AMH	4.900	5.000	5.100	56	140

9. TEST CIRCUIT



Notice.

The limit value of electrical characteristics is applied when C_{In}=1.0µF(Ceramic), C_{Out}=1.0µF(Ceramic), C_{Np}=200pF(Ceramic).

But C_{In}, C_{Out}, and C_{Np} can be used both the ceramic and the tantalum capacitor.

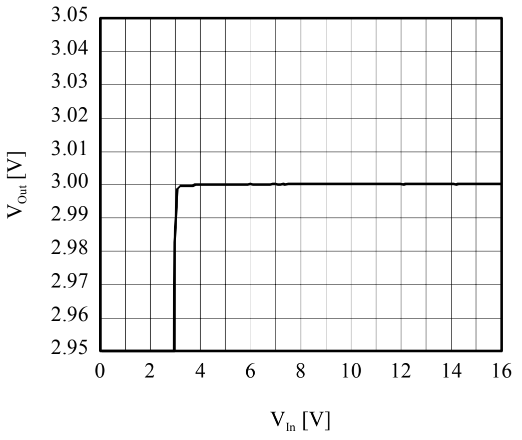
The Np terminal is high impedance. It is not connectable except a C_{Np}.

10. TYPICAL CHARACTERISTICS

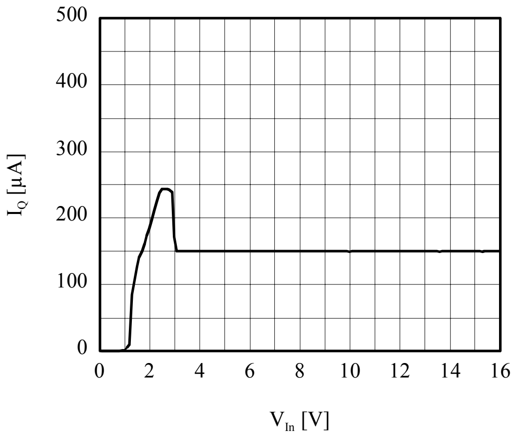
10-1. DC CHARACTERISTICS

(TK77230AMH)

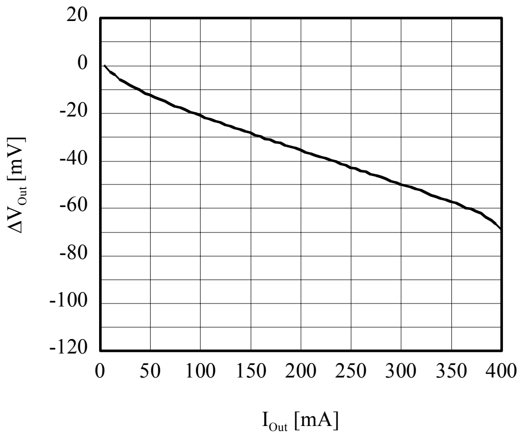
■ Fig. 1 Line Regulation



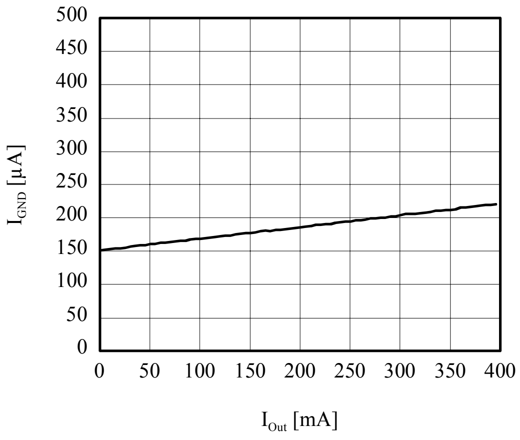
■ Fig. 2 I_Q vs V_{In}



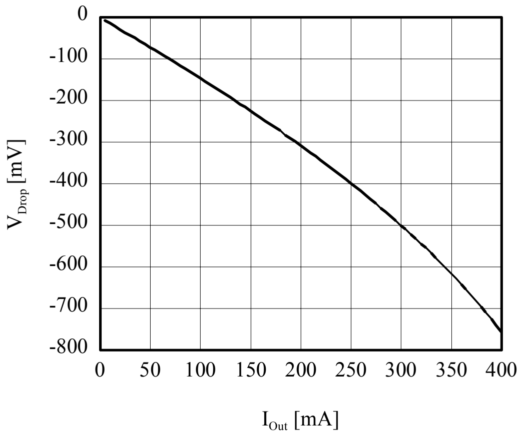
■ Fig. 3 Load Regulation



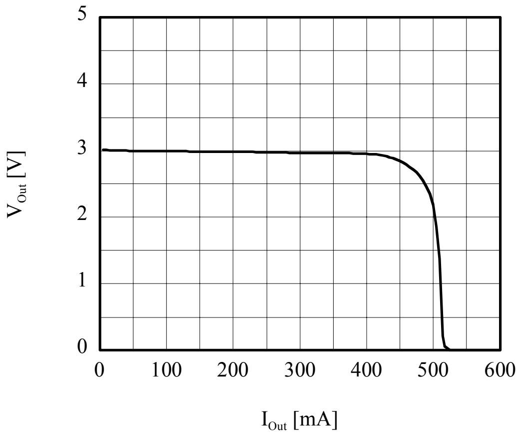
■ Fig. 4 I_{GND} vs I_{Out}



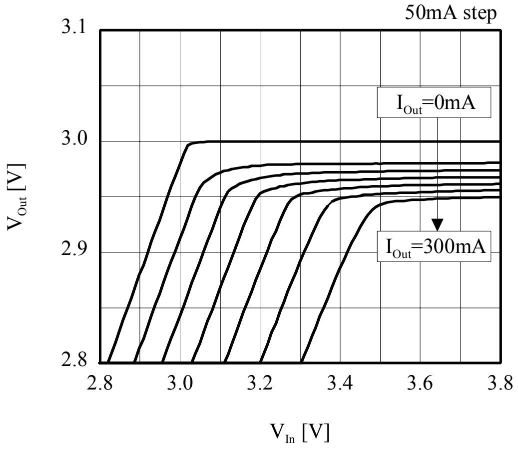
■ Fig. 5 V_{Drop} vs I_{Out}



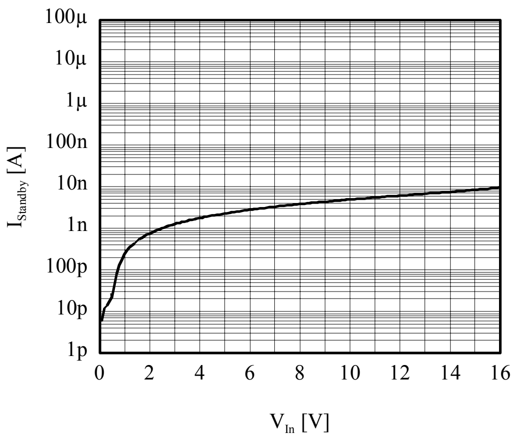
■ Fig. 6 V_{Out} vs I_{Out}



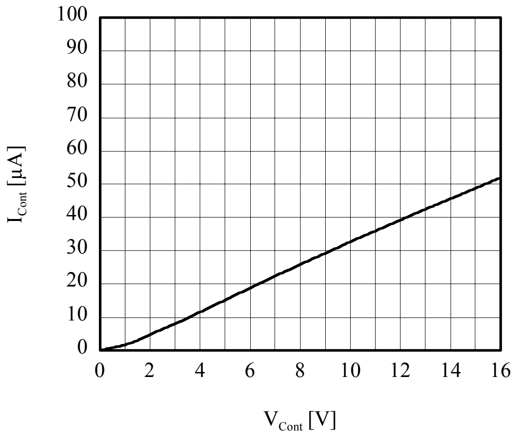
■ Fig. 7 V_{Out} vs V_{In}



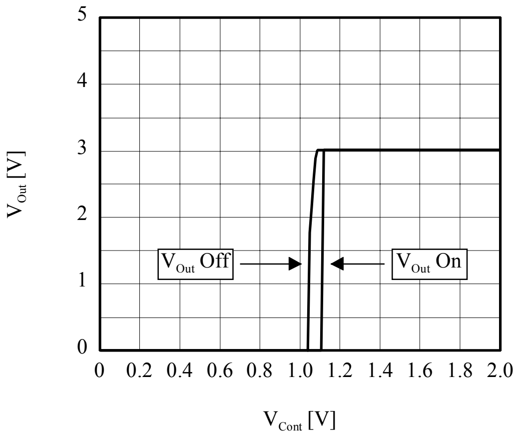
■ Fig. 8 $I_{Standby}$ vs V_{In}



■ Fig. 9 I_{Cont} vs V_{Cont}

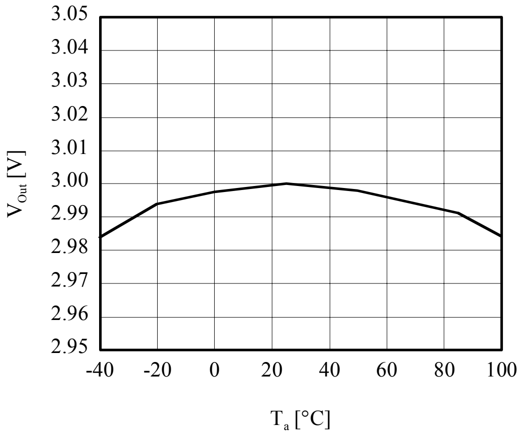


■ Fig. 10 V_{Out} vs V_{Cont}

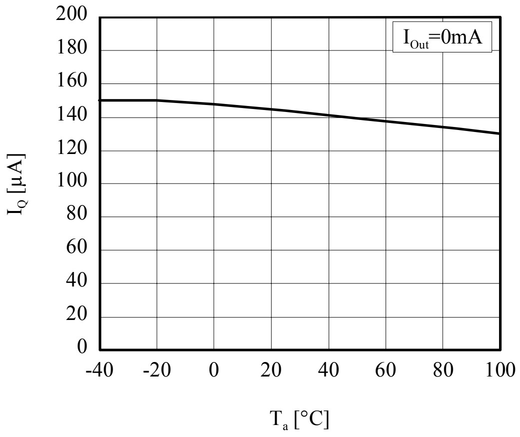


10-2. TEMPERATURE CHARACTERISTICS (TK77230AMH)

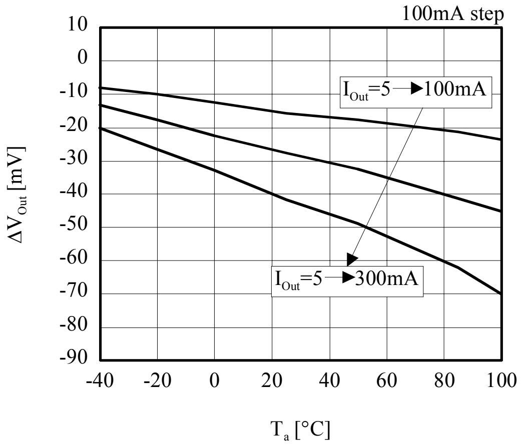
■ Fig. 11 V_{Out} vs T_a



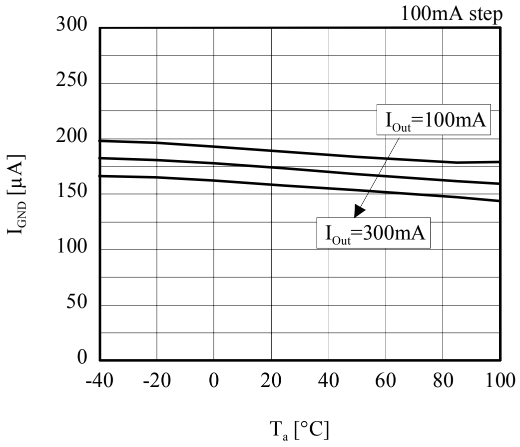
■ Fig. 12 I_Q vs T_a



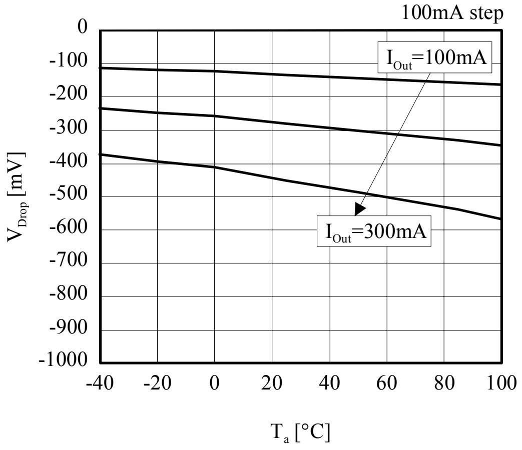
■ Fig. 13 Load Regulation vs T_a



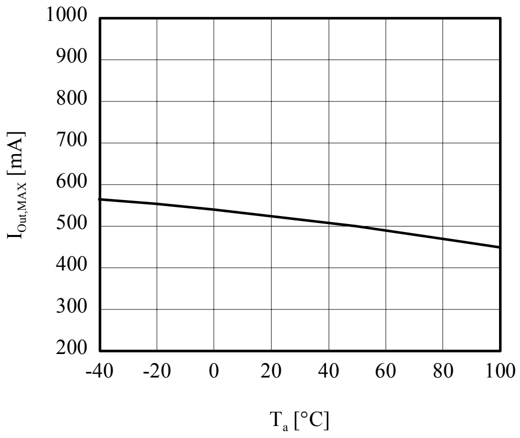
■ Fig. 14 I_{GND} vs T_a



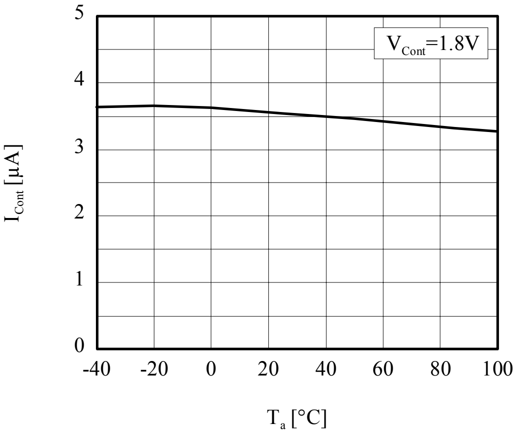
■ Fig. 15 V_{Drop} vs T_a



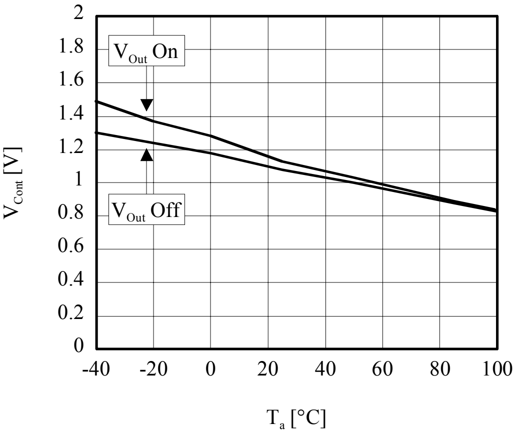
■ Fig. 16 $I_{Out,MAX}$ vs T_a



■ Fig. 17 I_{Cont} vs T_a

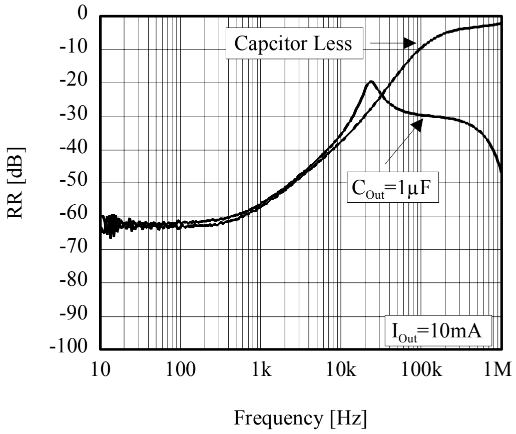


■ Fig. 18 V_{Cont} vs T_a

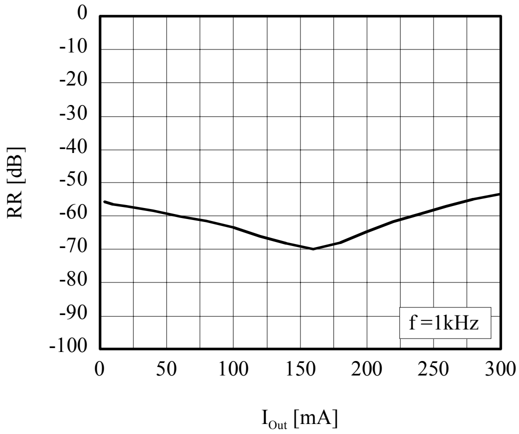


10-3. AC CHARACTERISTICS
(TK77230AMH)

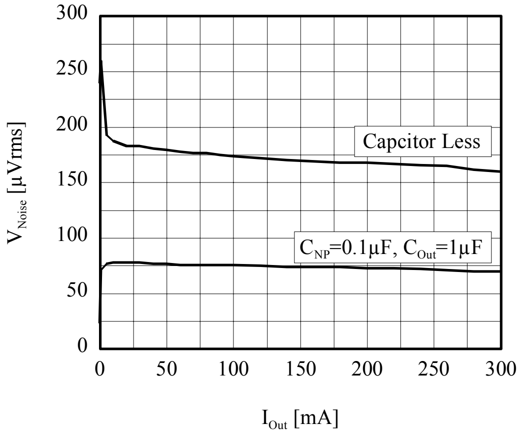
■ Fig. 19 RR vs Frequency



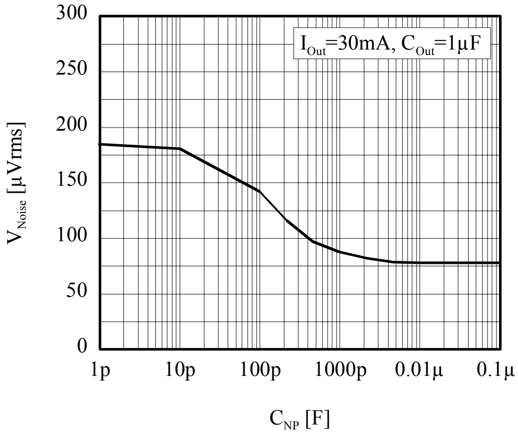
■ Fig. 20 RR vs I_{Out}



■ Fig. 21 V_{Noise} vs I_{Out}

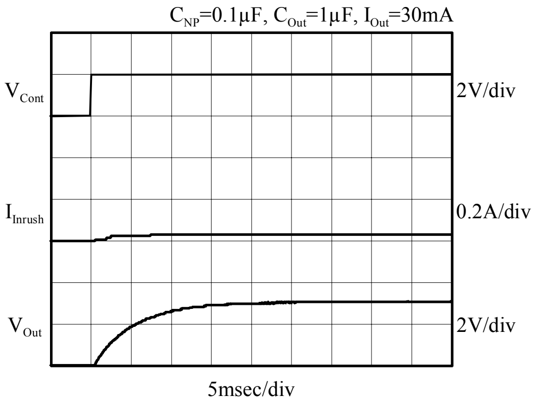


■ Fig. 22 V_{Noise} vs C_{NP}

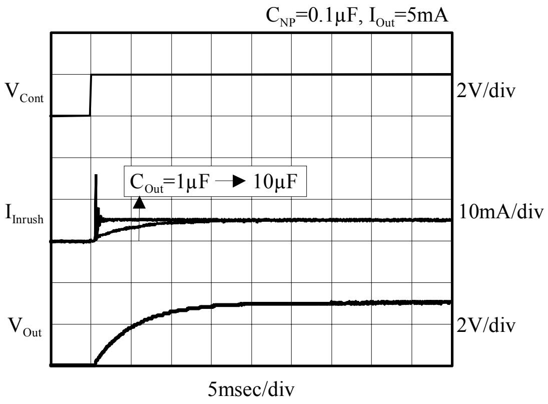


10-4. Transient CHARACTERISTICS (TK77230AMH)

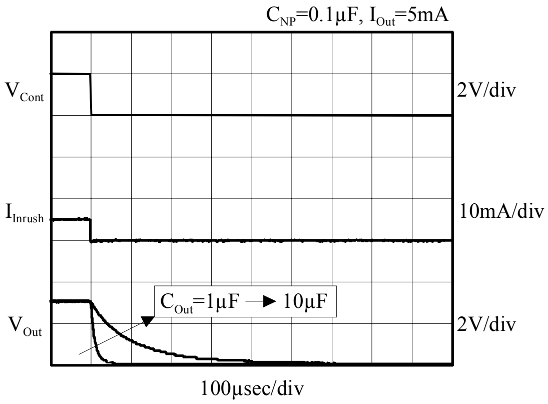
■ Fig. 23 On/Off Transient (V_{Cont}=0→2V)



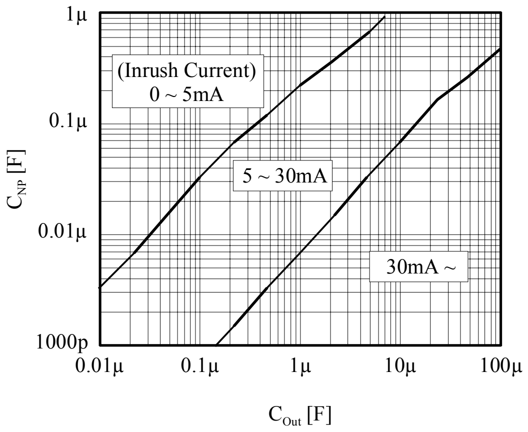
■ Fig. 24 On/Off Transient (V_{Cont}=0→2V)



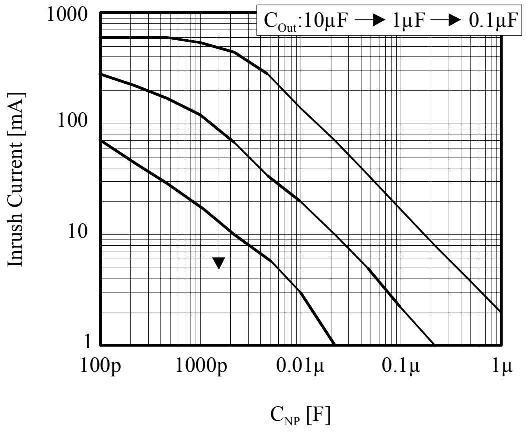
■ Fig. 25 On/Off Transient (V_{Cont}=2→0V)



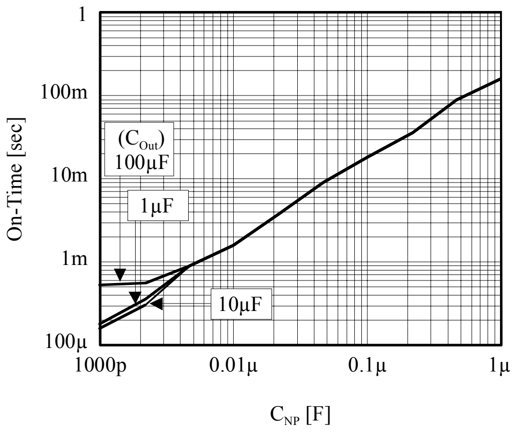
■ Fig. 26 Softstart area



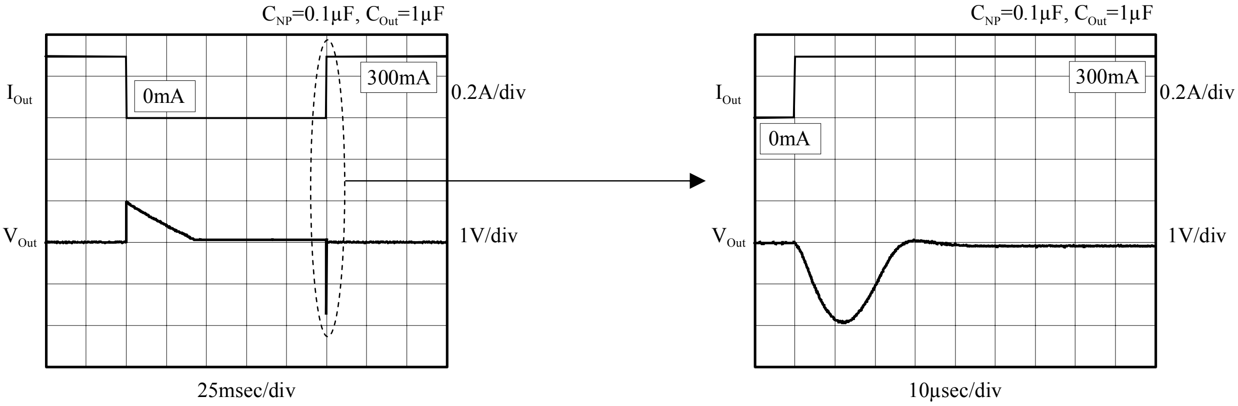
■ Fig. 27 Inrush Current vs C_{NP}



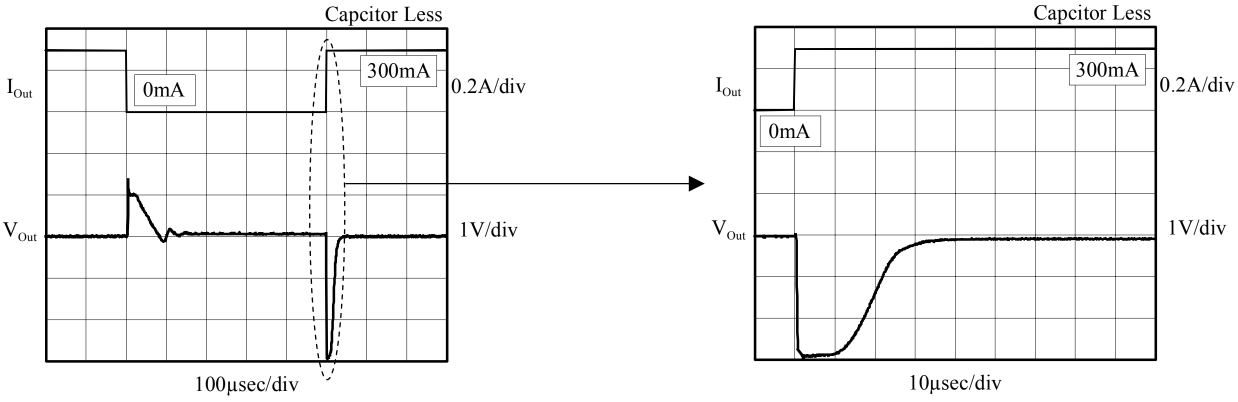
■ Fig. 28 On-Time vs C_{NP}



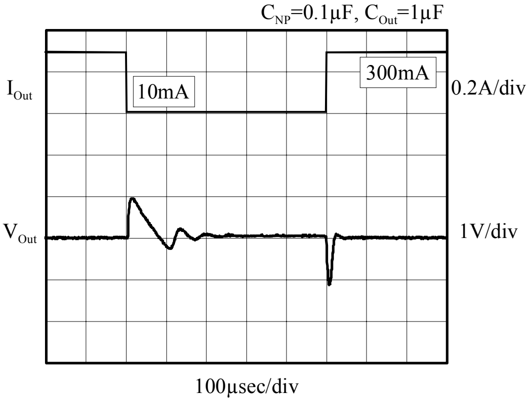
■ Fig. 29 Load Transient (I_{Out}=0↔300mA)



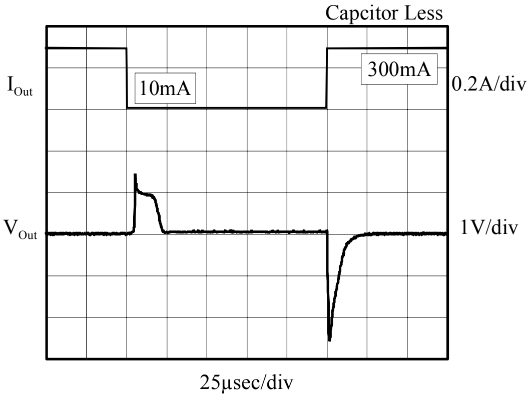
■ Fig. 30 Load Transient (I_{Out}=0↔300mA)



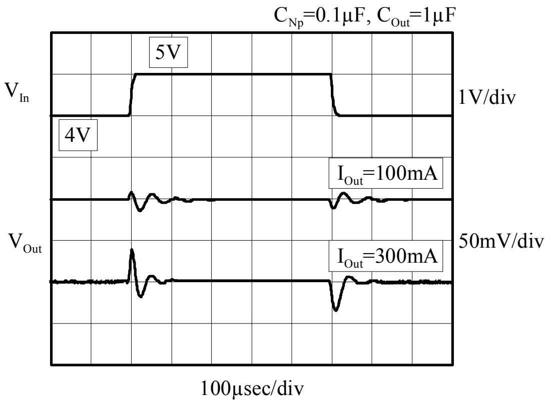
■ Fig. 31 Load Transient (I_{Out}=10↔300mA)



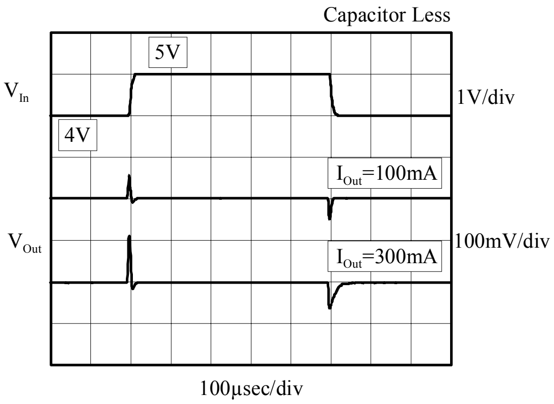
■ Fig. 32 Load Transient (I_{Out}=10↔300mA)



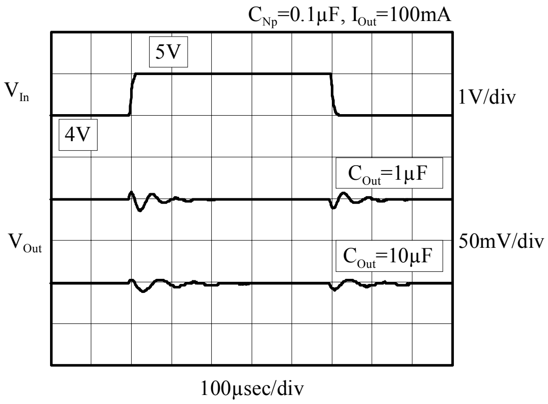
■ Fig. 33 Line Transient (V_{In}=4V↔5V)



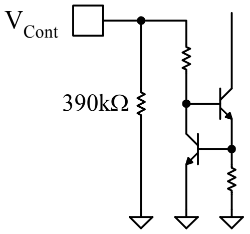
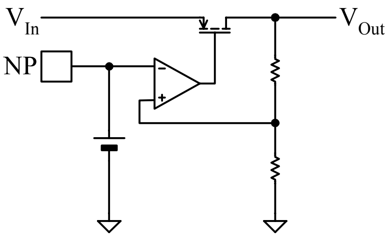
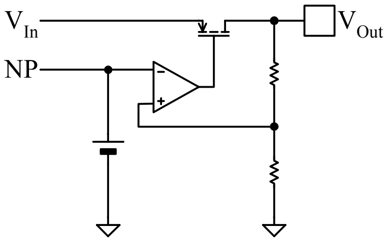
■ Fig. 34 Line Transient (V_{In}=4V↔5V)



■ Fig. 35 Line Transient (V_{In}=4V↔5V)



11. PIN DESCRIPTION

Pin No.	Pin Description	Internal Equivalent Circuit	Description
1	V_{In}		Input Terminal
2	GND		GND Terminal
3	V_{Cont}		Control Terminal $V_{Cont} > 1.8V$: On $V_{Cont} < 0.3V$: Off The pull-down resistor (about 390kΩ) is built-in.
4	NP		Np terminal
5	NC		No Connection
6	V_{Out}		Output Terminal

12. APPLICATIONS INFORMATION

12-1. Soft-Start Function

A big inrush current is generated, with usual regulator, when IC is turned on in order to charge the output capacitor with the maximum capacity of the regulator. This inrush current sometimes reaches double of the recommended current.

In the circuit that multiple LDOs are connected, many unfavorable facts occurs, such as damage the battery with very big current at the start up, DC-DC converter operates abnormally by the momentarily unstableness when LDO is connected to it, etc.

When capacitor (C_{NP}) is connected to the NP pin of the TK772xxAMH, together with the lower noise, voltage rise up becomes gradual, and no sudden charge current occurs (refer to p.11, Fig.23). Suitable C_{NP} value depends on the sum of the output capacitor (refer to p.11, Fig.26).

If small inrush current can be accepted, reduce the C_{NP} value. Increasing the C_{NP} value makes the inrush current small, reducing the C_{NP} value makes it big.

Also, the rise time can be adjusted by the C_{NP} (refer to p.11, Fig.28).

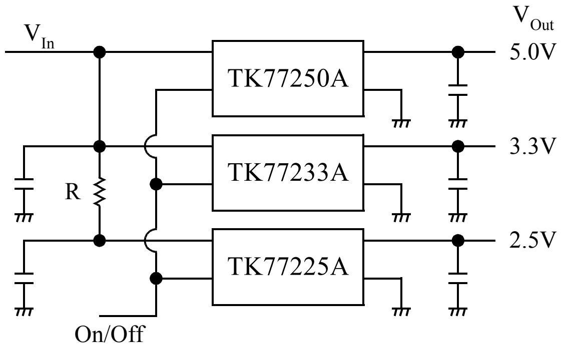
12-2. On/Off Control

It is recommended to turn the regulator Off when the circuit following the regulator is not operating. A design with little electric power loss can be implemented. We recommend the use of the On/Off control of the regulator without using a high side switch to provide an output from the regulator. A highly accurate output voltage with low voltage drop is obtained.

Because the control current is small, it is possible to control it directly by CMOS logic.

Control Terminal Voltage ((V_{Cont})	On/Off State
$V_{Cont} > 1.8V$	On
$V_{Cont} < 0.3V$	Off

Parallel Connected On/Off Control



The above figure is multiple regulators being controlled by a single On/Off control signal. There is concern of overheating, because the power loss of the low voltage side IC (TK77225A) is large. The series resistor (R) is put in the input line of the low output voltage regulator in order to prevent over-dissipation. The voltage dropped across the resistor reduces the large input-to-output voltage across the regulator, reducing the power dissipation in the device. When the thermal sensor works, a decrease of the output voltage, oscillation, etc. may be observed.

12-3. Operating Region and Power Dissipation

The package loss is limited at the temperature that the internal temperature sensor works (about 140°C). Therefore, the package loss is assumed to be an internal limitation. There is no heat radiation characteristic of the package unit assumed because of its small size. Heat is carried away from the device by being mounted on the PCB. This value is directly effected by the material and the copper pattern

The overheating protection circuit operates when the junction temperature reaches 150°C (this happens when the regulator is dissipating excessive power, outside temperature is high, or heat radiation is bad). The output current and the output voltage will drop when the protection circuit operates. However, operation begins again as soon as the output voltage drops and the temperature of the chip decreases.

How to determine the thermal resistance when mounted on PCB

The thermal resistance when mounted is expressed as follows:

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

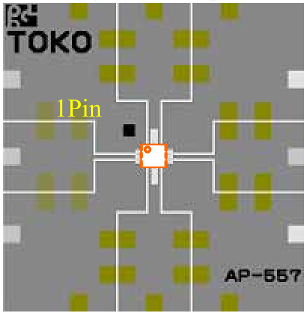
T_j of IC is set around 140°C. P_D is the value when the thermal sensor is activated.

If the ambient temperature is 25°C, then:

$140 = \theta_{ja} \times P_D + 25$

$\theta_{ja} = 115 / P_D$ (°C /mW)

Layout example



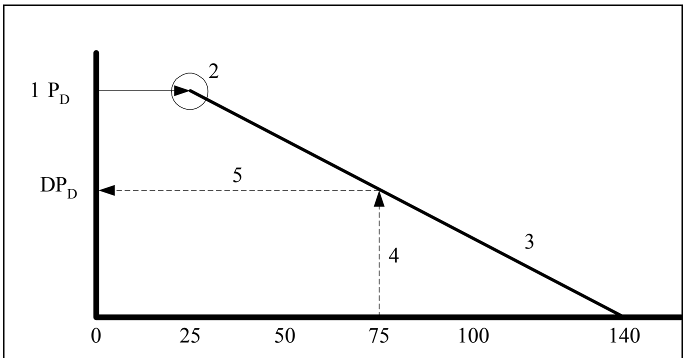
PCB Material: Glass epoxy
(x=30mm, y=30mm, t=1.0mm
Cupper pattern thickness=35µm)

Please do derating with 7.8mW/°C at P_D=900mW , and 25°C or more.

P_D is easily calculated.

A simple way to determine P_D is to calculate $V_{In} \times I_{In}$ when the output side is shorted. Input current gradually falls as output voltage rises after working thermal shutdown. You should use the value when thermal equilibrium is reached.

$$P_D(\text{mW}) \cong V_{In}\ (\text{V}) \times I_{In}\ (\text{mA})$$



Procedure (When mounted on PCB.)

1. Find P_D ($V_{In} \times I_{In}$ when the output side is short-circuited).
2. Plot P_D against 25°C.
3. Connect P_D to the point corresponding to the 140°C with a straight line.
4. In design, take a vertical line from the maximum operating temperature (e.g., 75°C) to the derating curve.
5. Read off the value of P_D against the point at which the vertical line intersects the derating curve. This is taken as the maximum power dissipation DP_D.
6. $DP_D \div (V_{In,MAX} - V_{Out}) = I_{Out}$ at 75°C

The maximum output current at the highest operating temperature will be $I_{Out} \cong DP_D \div (V_{In,MAX} - V_{Out})$.

Please use the device at low temperature with better radiation. The lower temperature provides better quality.

12-4. Definition of term

Characteristics

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

♦ Maximum Output Current ($I_{Out, MAX}$)
The rated output current is specified under the condition where the output voltage drops to 90% of the value specified with I_{Out}=5mA. The input voltage is set to V_{OutTYP}+1V and the current is pulsed to minimize temperature effect.

♦ Dropout Voltage (V_{Drop})
The dropout voltage is the difference between the input voltage and the output voltage at which point the regulator starts to fall out of regulation. Below this value, the output voltage will fall as the input voltage is reduced. It is dependent upon the output voltage, the load current, and the junction temperature.

♦ Line Regulation (LinReg)
Line regulation is the ability of the regulator to maintain a constant output voltage as the input voltage changes. The line regulation is specified as the input voltage is changed from V_{In}=$V_{Out,TYP}$+1V to V_{In}=6V. It is a pulse measurement to minimize temperature effect.

♦ Load Regulation (LoaReg)
Load regulation is the ability of the regulator to maintain a constant output voltage as the load current changes. It is a pulsed measurement to minimize temperature effects with the input voltage set to V_{In}=$V_{Out,TYP}$+1V. The load regulation is specified under an output current step condition of 1mA to 50mA.

♦ 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 specified with 500m$V_{P\text{-}P}$, 1kHz super-imposed on the input voltage, where V_{In}=$V_{Out,TYP}$+1.5V. Ripple rejection is the ratio of the ripple content of 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

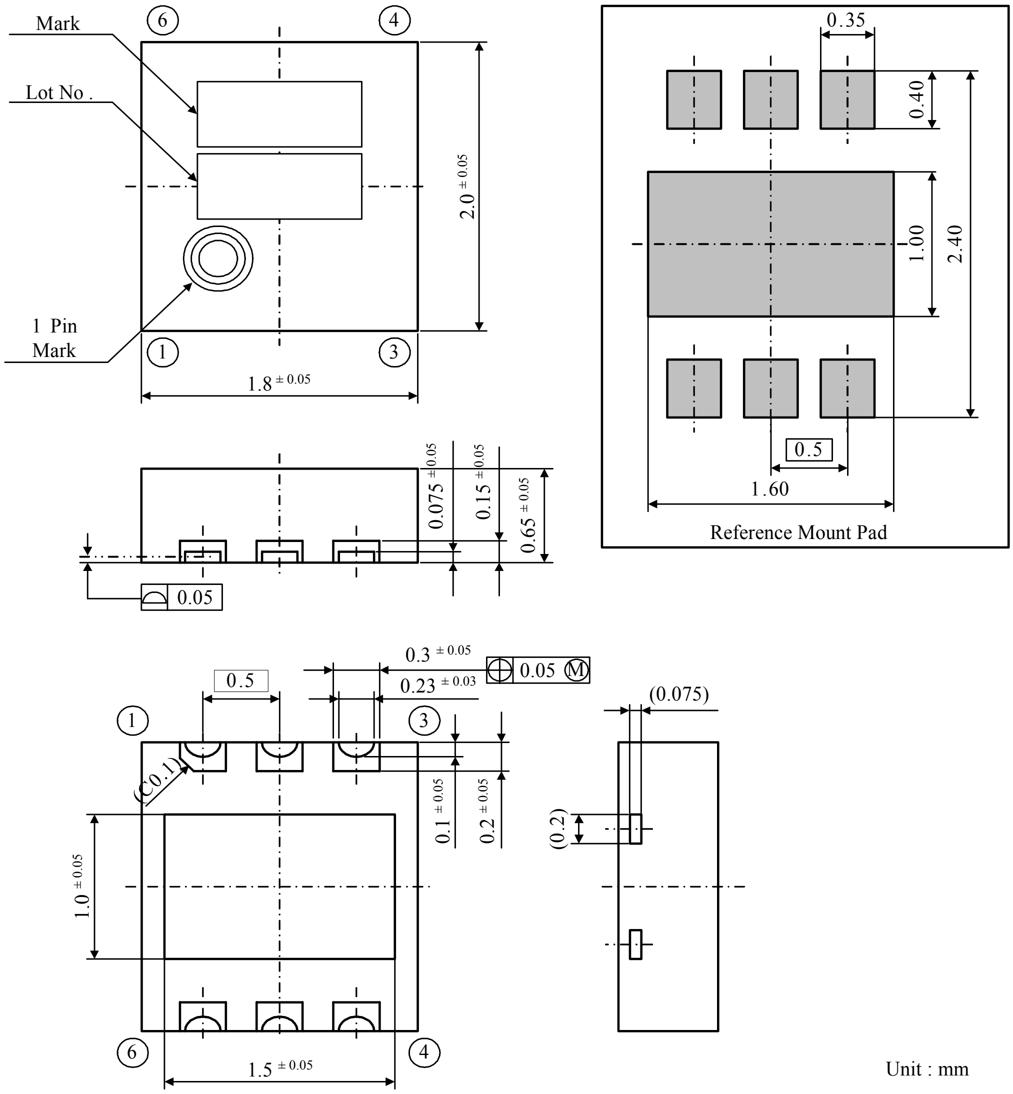
♦ Over Current Sensor
The over current sensor protects the device when there is excessive output current. It also protects the device if the output is accidentally connected to ground.

♦ Thermal Sensor
The thermal sensor protects the device in case the junction temperature exceeds the safe value (T_j=150°C). This temperature rise can be caused by external heat, excessive power dissipation caused by large input to output voltage drops, or excessive output current. The regulator will shut off when the temperature exceeds the safe value. As the junction temperatures decrease, the regulator will begin to operate again. Under sustained fault conditions, the regulator output will oscillate as the device turns off then resets. Damage may occur to the device under extreme fault.
Please prevent the loss of the regulator when this protection operates, by reducing the input voltage or providing better heat efficiency.

♦ ESD
MM : 200pF 0Ω 200V or more
HBM : 100pF 1.5kΩ 2000V or more

13. PACKAGE OUTLINE

■ 6-Lead-Small Outline Non-Leaded Package with Heat Sink : HSON1820A-6



Package Structure and Others

Package Material : Epoxy Resin
Terminal Material : Copper Alloy
Terminal Finish : Ni/Pd/Au

Mark Method : Laser
Country of Origin : Japan
Mass : 0.0072g

Caution in Printed Circuit Board Layout

In addition to the normal pins, this plastic package has exposed metal tabs.
This tab is electrically connected to the GND of internal chip.
Avoid electrical contact with this tab from external print traces, adjacent components other than GND, etc.
This tab is recommended to be solder-mounted so as to enhance heat release.

Marking

Part Number	Marking Code	Part Number	Marking Code	Part Number	Marking Code
TK77210AMH	A10	TK77230AMH	A30		
TK77212AMH	A12	TK77232AMH	A32		
TK77218AMH	A18	TK77233AMH	A33		
TK77225AMH	A25	TK77250AMH	A50		

14. 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.

15. OFFICES

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

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