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-Preliminary-

# AP1159ADSXX

## 14V Input / 100mA Low voltage Output LDO Regulator

## 1. General Description

The AP1159ADSXX is a low dropout linear regulator with ON/OFF control, which can supply 100mA load current. The IC is an integrated circuit with a silicon monolithic bipolar structure. The output voltage, trimmed with high accuracy, is available from 0.9 to 1.2V in 0.1V steps. The output capacitor is available to use a small 0.47μF ceramic capacitor. The over current, thermal and reverse bias protections are integrated, and also the package is small and thin type, SOT23-5. The IC is designed for space saving requirements.

## 2. Features

- Available to use a small 0.47μF ceramic capacitor
- Output Voltage 0.9V, 1.0V, 1.1V, 1.2V
- High Precision output voltage ±50mV
- Output Current 100mA
- High ripple rejection ratio 80dB at 1kHz
- Low Output Noise 30μ$V_{RMS}$
- Wide operating voltage range 2.1V to 14.0V
- Very low quiescent current $I_{QUT}$=110μA at $I_{OUT}$=0mA
- Low Standby Current 0.1μA
- On/Off control (High active)
- Built-in Short circuit protection, thermal shutdown
- Built-in reverse bias over current protection
- Available very low noise application
- Very small surface mount package SOT23-5

## 3. Application

- Automotive accessory equipment
- Any Electronic Equipment
- Battery Powered Systems
- Mobile Communication

# 4. Table of Contents

## 5. Block Diagram

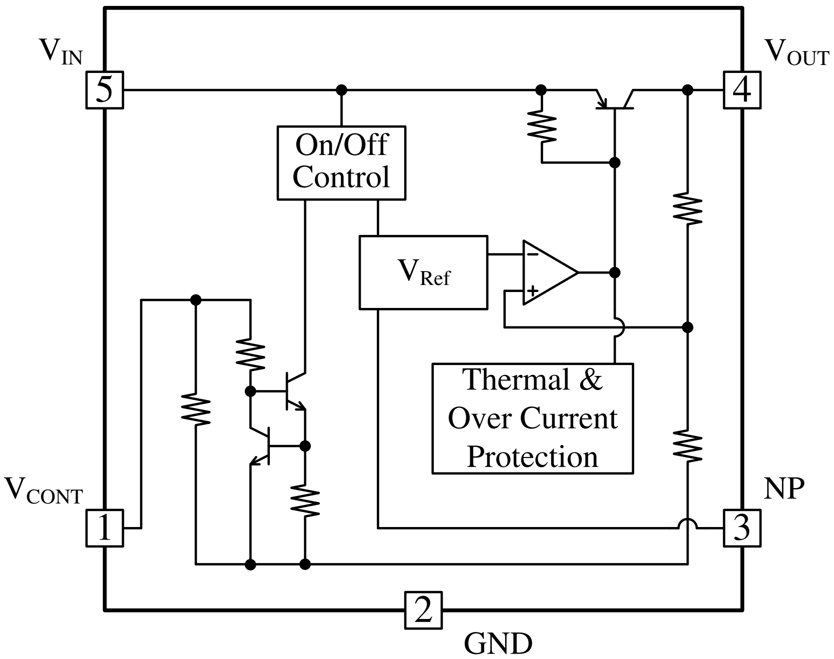



Figure 1. Block Diagram

## 6. Ordering Information

AP1159ADSXX    Ta = -40 to 85°C    SOT23-5

・ Output Voltage Code

For product name, please check the below chart. Please contact your authorized ASAHI KASEI MICRODEVICES representative for voltage availability.

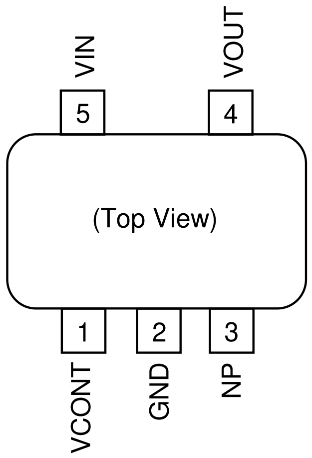
AP1159ADSXX — Output voltage code

Table 1. Standard Voltage Version, Output Voltage & Voltage Code

| XX | VOUT | XX | VOUT | XX | VOUT | XX | VOUT |
|---|---|---|---|---|---|---|---|
| 09 | 0.9 | 10 | 1.0 | 11 | 1.1 | 12 | 1.2 |

# 7. Pin Configurations and Functions

## ■ Pin Configurations




## ■ Pin Functions

| Pin # | Pin Name | Function |
|---|---|---|
| 1 | VCONT | ON/OFF control<br>VCONT > 1.8V : ON<br>VCONT < 0.35V : OFF<br>Internal Pull-down(500kΩ) |
| 2 | GND | GND |
| 3 | NP | Noise pass<br>Connect noise pass capacitor to GND. |
| 4 | VOUT | Output |
| 5 | VIN | Input |

## 8. Absolute Maximum Ratings

| Parameter | Symbol | min | max | Unit | Condition |
|---|---|---|---|---|---|
| Input voltage | $V_{INMAX}$ | -0.4 | 16 | V | |
| Output bias | $V_{REVMAX}$ | -0.4 | 6 | V | |
| NP pin voltage | $V_{NPMAX}$ | -0.4 | 5 | V | |
| Control pin voltage | $V_{CONTMAX}$ | -0.4 | 16 | V | |
| Junction temperature | Tj | - | 150 | °C | |
| Storage temperature | $T_{STG}$ | -55 | 150 | °C | |
| Power dissipation | $P_D$ | - | 400 | mW | (Note 1) |

Note 1. Ambient temperature is over 25°C, power dissipation decreases by 4.0mW/°C. In case of mounting on 2 layer glass epoxy substrate (3cm×3cm, t=1mm, cupper layer t=0.35μm)

WARNING: Operation at or beyond these limits may result in permanent damage to the device. Normal operation is not guaranteed at these extremes.

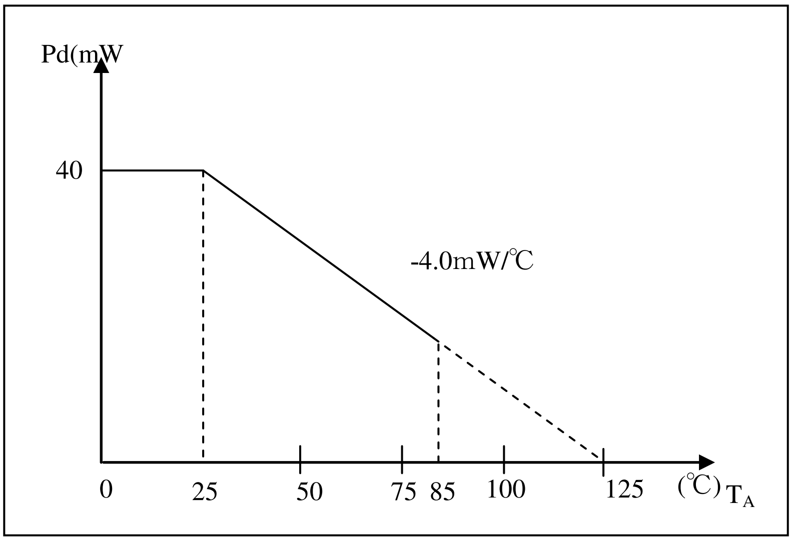



Figure 2. Maximum Power Dissipation

## 9. Recommended Operation Conditions

| Parameter | Symbol | min | typ | max | Unit | Comments |
|---|---|---|---|---|---|---|
| Operational temperature | Ta | -40 | - | 85 | V | |
| Input voltage | $V_{IN}$ | 2.1 | - | 14 | °C | |

# 10. Elecric Characteristics

## ■ Electrical Characteristics of Ta=Tj=25°C

The parameters with min or max values will be guaranteed at Ta=Tj=25°C.

(Ta =Tj= 25°C, $V_{IN}$=2.1V, $V_{CONT}$ = 1.8V, unless otherwise specified)

| Parameter | Symbol | Test Conditions | min | typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output voltage | $V_{OUT}$ | $I_{OUT}$ = 5mA | | (Table 2) | | V |
| Line regulation | $L_{IN}R_{EG}$ | $\Delta V_{IN}$ = 5V | - | 0.0 | 5.0 | mV |
| Load regulation | $L_{OA}R_{EG}$ | $I_{OUT}$= 5mA ~ 50mA | - | 5.0 | 10.0 | mV |
| | | $I_{OUT}$= 5mA ~ 100mA | - | 10.0 | 22.0 | mV |
| Output current | $I_{OUT}$ | | 100 | - | - | mA |
| Quiescent Current | $I_Q$ | $I_{OUT}$ = 0mA | - | 110 | 160 | μA |
| Standby current | $I_{STANDBY}$ | $V_{CONT}$ = 0V | - | 0.0 | 0.1 | μA |
| Ground pin current | $I_{GND}$ | $I_{OUT}$ = 50mA | - | 1.5 | 2.7 | mA |
| **Control pin** | | | | | | |
| Control current | $I_{CONT}$ | $V_{CONT}$ = 1.8V | - | 5.5 | 15.0 | μA |
| Control voltage | $V_{CONT}$ | $V_{OUT}$ ON state | 1.8 | - | - | V |
| | | $V_{OUT}$ OFF state | - | - | 0.35 | V |
| **Reference value** (Note 2) | | | | | | |
| Np pin voltage | $V_{NP}$ | | - | 0.8 | - | V |
| $V_{OUT}$ drift | $V_{OUT}/T_A$ | | - | 60 | - | ppm/°C |
| Output noise voltage | Vnoise | $C_{OUT}$=1.0μF, $C_{NP}$=0.01μF Iout=30mA | - | 30 | - | $\mu V_{RMS}$ |
| Ripple rejection (Note 3) | RR | $V_{IN}$=2.1V, $I_{OUT}$=10mA, f=1kHz $C_{OUT}$=1.0μF, $C_{NP}$=0.001μF | - | 48 | - | dB |
| | | $V_{IN}$=2.3V, $I_{OUT}$=10mA, f=1kHz $C_{OUT}$=1.0μF, $C_{NP}$=0.001μF | - | 80 | - | dB |
| Output rising time | tr | $C_{OUT}$=1.0μF, $C_{NP}$=0.001μF $V_{CONT}$ : pulse input(100Hz) $V_{CONT}$ ON → Vout×95% point | - | 120 | - | μs |

Note 2. Reference value doesn't guarantee.
Note 3. Ripple rejection is varied by output voltage and external components specifications.

Table 2. Standard Voltage Version

| **Parameter** | **Output voltage** | | |
|---|---|---|---|
| | **MIN** | **TYP** | **MAX** |
| | **V** | **V** | **V** |
| AP1159ADS09 | 0.85 | 0.9 | 0.95 |
| AP1159ADS10 | 0.95 | 1.0 | 1.05 |
| AP1159ADS11 | 1.05 | 1.1 | 1.15 |
| AP1159ADS12 | 1.15 | 1.2 | 1.25 |

## ■ Electrical Characteristics of Ta=-40°C~85°C

The parameters with min or max values will be guaranteed at Ta=Tj=-40 ~ 85°C.

(Ta =Tj= -40~85°C, $V_{IN}$=2.1V, $V_{CONT}$ = 1.8V, unless otherwise specified)

| Parameter | Symbol | Test Conditions | Min | typ | max | Unit |
|---|---|---|---|---|---|---|
| Output voltage | $V_{OUT}$ | $I_{OUT}$ = 5mA | (Table 3) | | | V |
| Line regulation | $L_{IN}R_{EG}$ | $\Delta V_{IN}$ = 5V | - | 0 | 8 | mV |
| Load regulation | $L_{OA}R_{EG}$ | $I_{OUT}$= 5mA ~ 50mA | - | 5.0 | 13.0 | mV |
| | | $I_{OUT}$= 5mA ~ 100mA | - | 10.0 | 28.0 | mV |
| Output current | $I_{OUT}$ | | 100 | - | - | mA |
| Quiescent Current | $I_Q$ | $I_{OUT}$ = 0mA | - | 110 | 192 | µA |
| Standby current | $I_{STANDBY}$ | $V_{CONT}$ = 0V | - | 0 | 0.5 | µA |
| Ground pin current | $I_{GND}$ | $I_{OUT}$ = 50mA | - | 1.5 | 3.3 | mA |
| **Control pin** | | | | | | |
| Control current | $I_{CONT}$ | $V_{CONT}$ = 1.8V | - | 5.5 | 15.0 | µA |
| Control voltage | $V_{CONT}$ | $V_{OUT}$ ON state | 1.8 | - | - | V |
| | | $V_{OUT}$ OFF state | - | - | 0.35 | V |
| **Reference value** (Note 4) | | | | | | |
| Np pin voltage | $V_{NP}$ | | - | 0.8 | - | V |
| $V_{OUT}$ drift | $V_{OUT}/T_A$ | | - | 60 | - | ppm/°C |
| Output noise voltage | Vnoise | $C_{OUT}$=1.0µF, $C_{NP}$=0.01µF Iout=30mA | - | 30 | - | $\mu V_{RMS}$ |
| Ripple rejection (Note 5) | RR | $V_{IN}$=2.1V, $I_{OUT}$=10mA, f=1kHz $C_{OUT}$=1.0µF, $C_{NP}$=0.001µF | - | 48 | - | dB |
| | | $V_{IN}$=2.3V, $I_{OUT}$=10mA, f=1kHz $C_{OUT}$=1.0µF, $C_{NP}$=0.001µF | - | 80 | - | dB |
| Output rising time | tr | $C_{OUT}$=1.0µF, $C_{NP}$=0.001µF $V_{CONT}$ : pulse input(100Hz) $V_{CONT}$ ON → Vout×95% point | - | 120 | - | µs |

Note 4. Reference value doesn't guarantee.
Note 5. Ripple rejection is varied by output voltage and external components specifications.

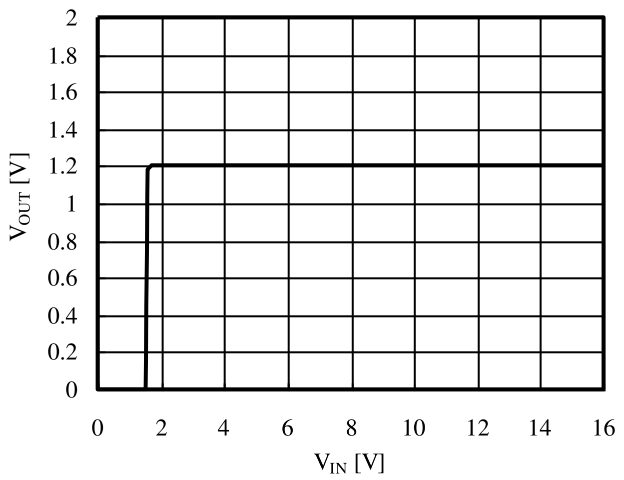
Table 3. Standard Voltage Version

| **Parameter** | **Output voltage** | | |
|---|---|---|---|
| | **MIN** | **TYP** | **MAX** |
| | **V** | **V** | **V** |
| AP1159ADS09 | 0.82 | 0.9 | 0.98 |
| AP1159ADS10 | 0.92 | 1.0 | 1.08 |
| AP1159ADS11 | 1.02 | 1.1 | 1.18 |
| AP1159ADS12 | 1.12 | 1.2 | 1.28 |

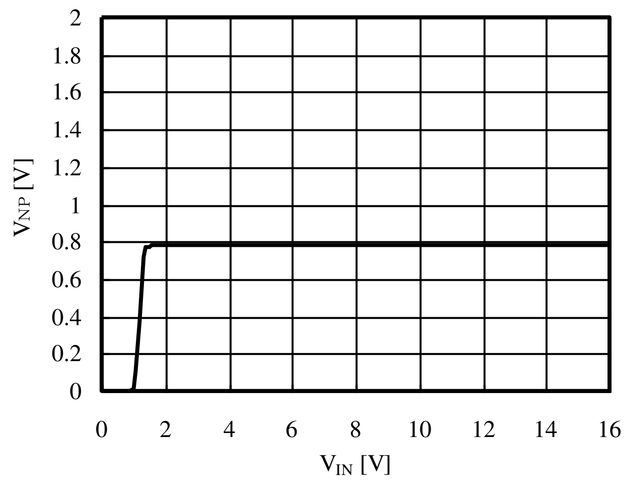
# 11. Functional Descriptions

## 11.1 DC characteristics

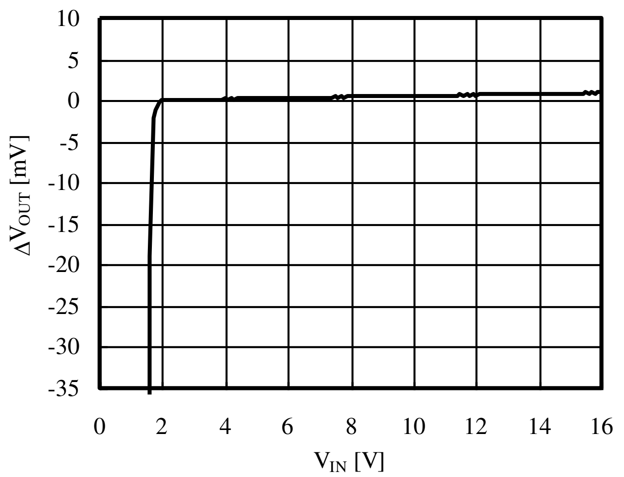
■ $V_{OUT}$ vs $V_{IN}$



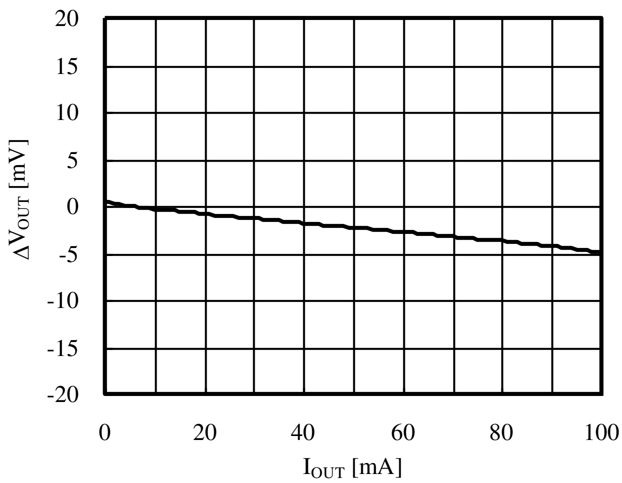

■ $V_{NP}$ vs $V_{IN}$



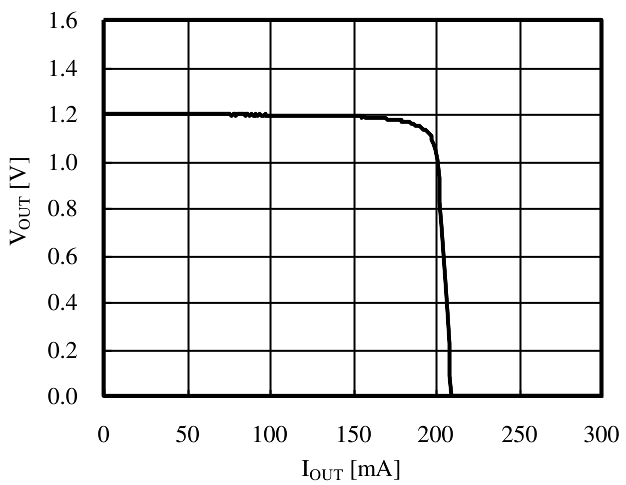

■ Line Regulation



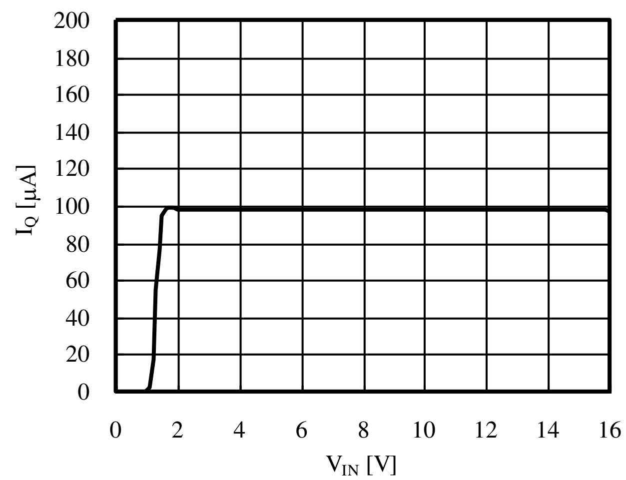

■ Load Regulation



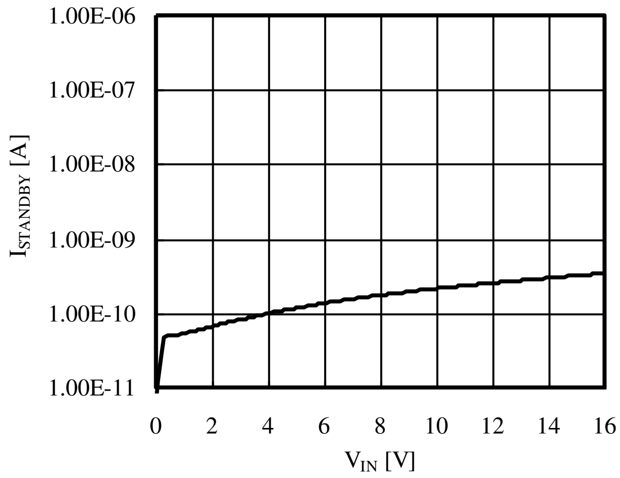

■ Short Circuit Current



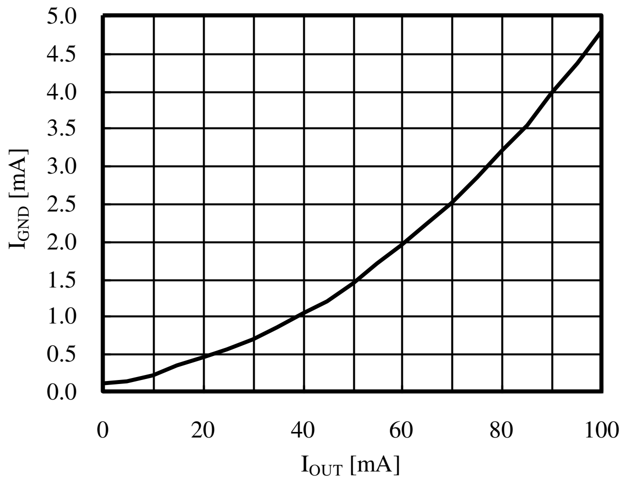

■ Quiescent Current ($I_{OUT}$=0V)



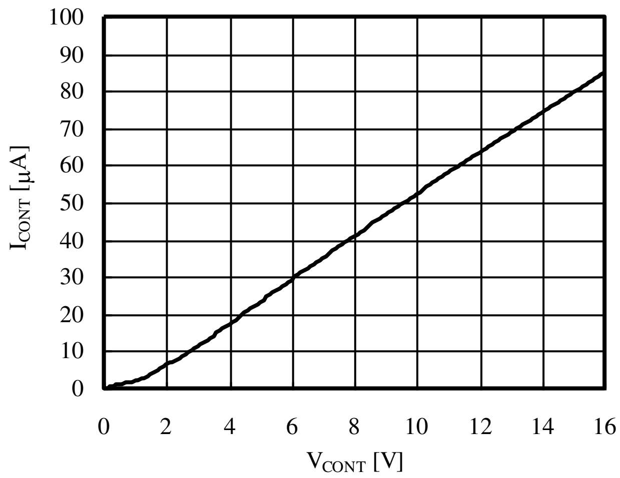
■ Standby Current (VCONT=0V)



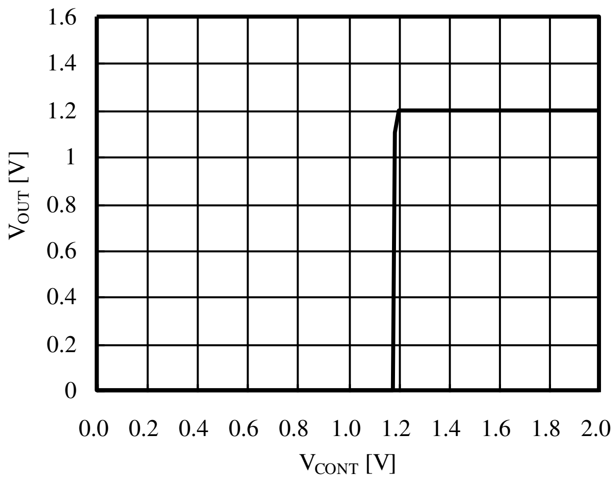

■ GND Pin Current




■ Control Current

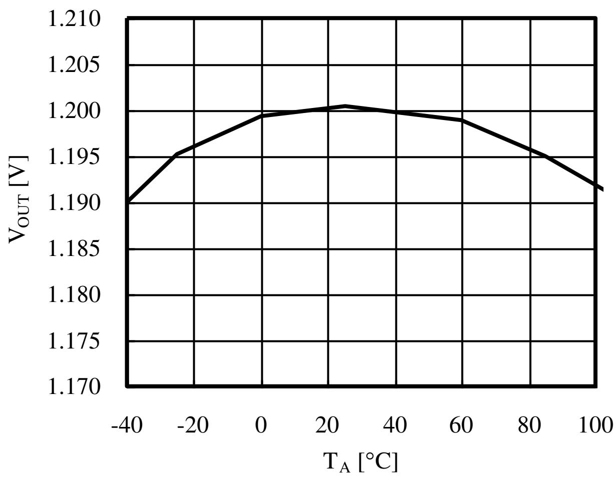



■ VOUT ON/OFF Point

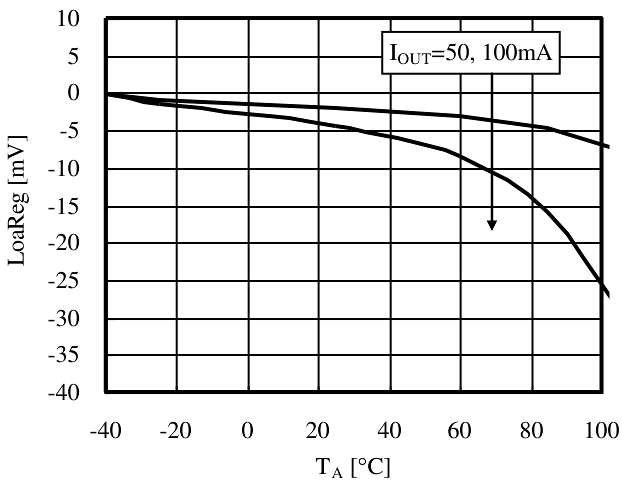


## 11.2 DC temperature characteristics

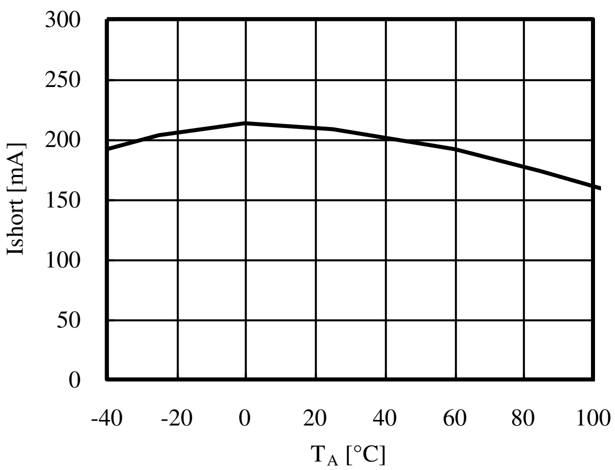
■ $V_{OUT}$



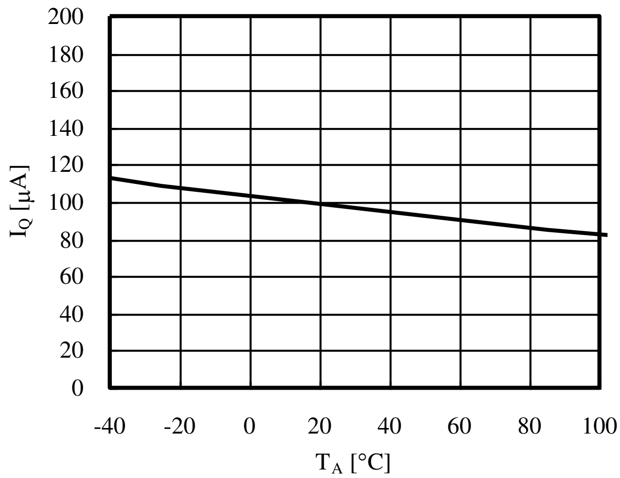

■Load Regulation



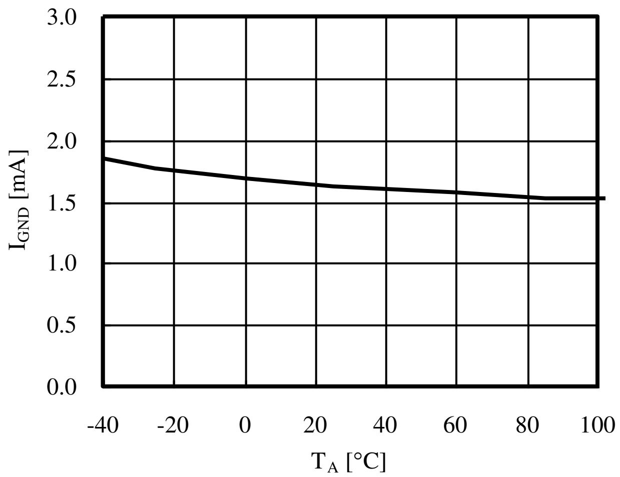

■ Short Circuit Current



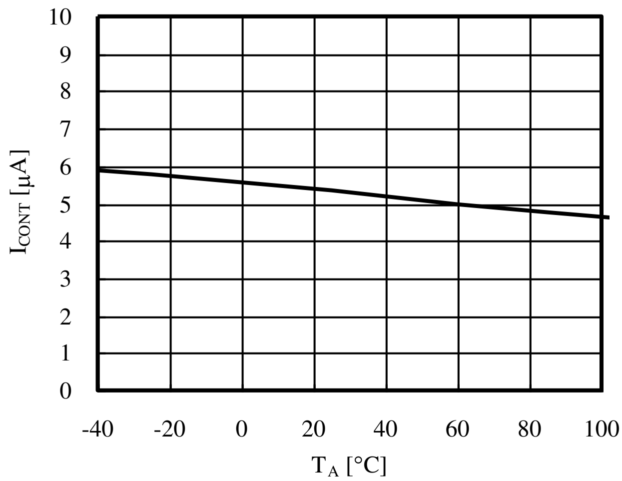

■ Quiescent Current ($I_{OUT}$=0V)



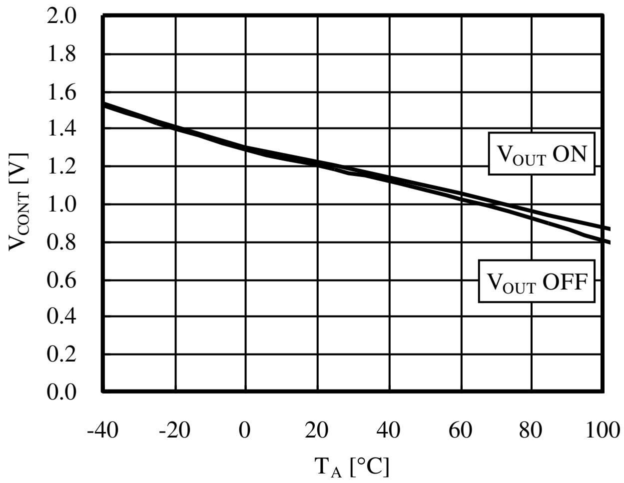

■GND Pin Current




■Control Current

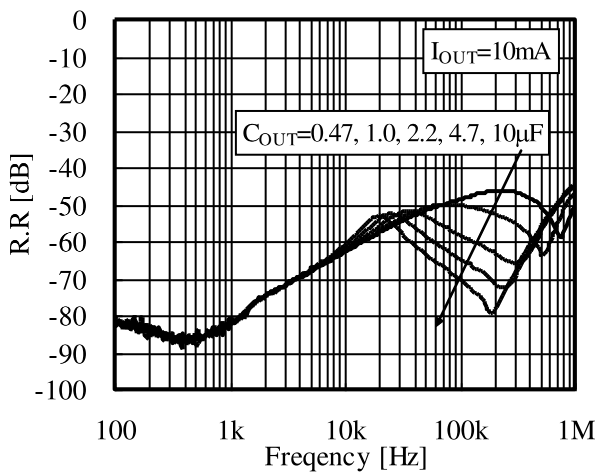


■VOUT ON/OFF Point

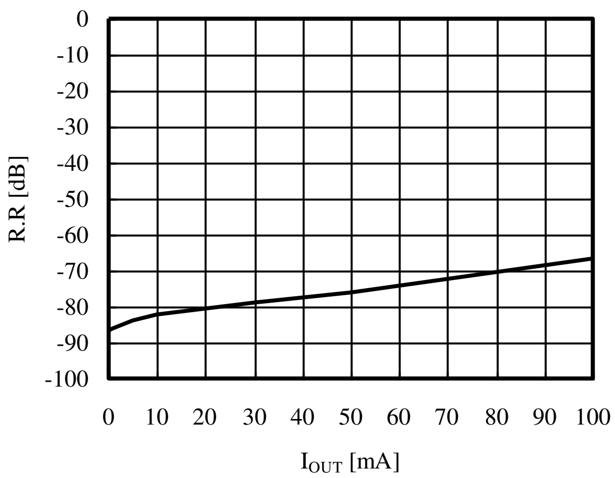



## 11.3 Ripple Rejection

■$C_{OUT}$=0.47, 1.0, 2.2, 4.7, 10 μF

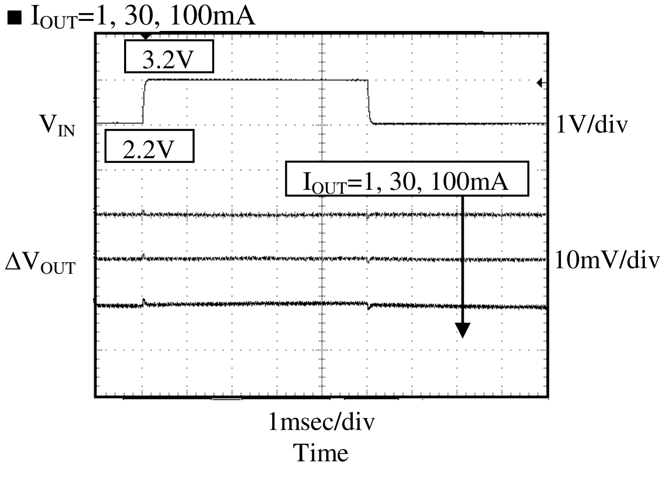



■R.R vs $I_{OUT}$ (Frequency=1kHz)

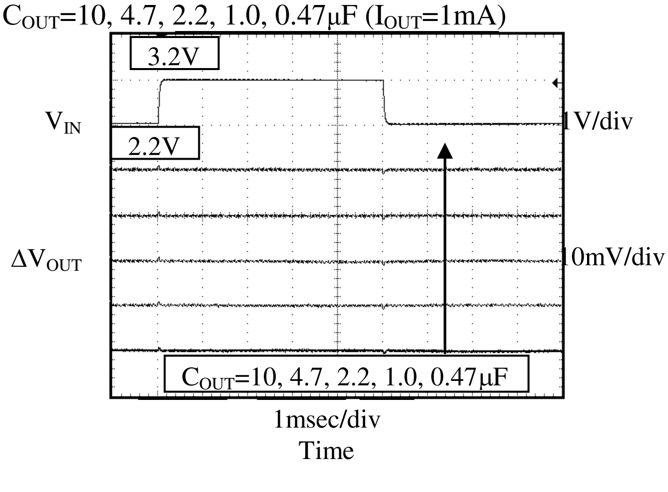



## 11.4 Line Transient

■ $I_{OUT}$=1, 30, 100mA

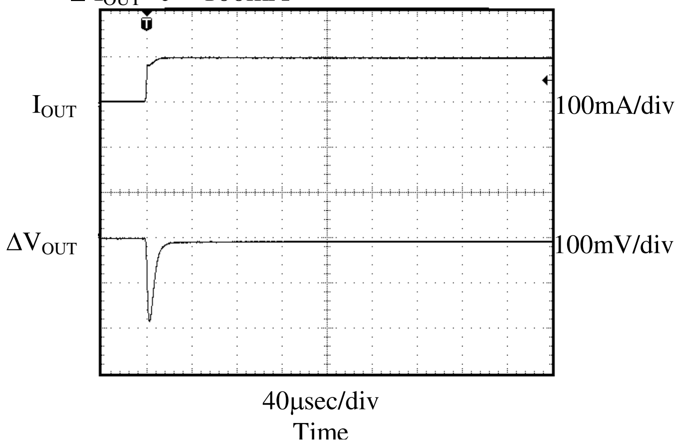



■ $C_{OUT}$=10, 4.7, 2.2, 1.0, 0.47μF ($I_{OUT}$=1mA)

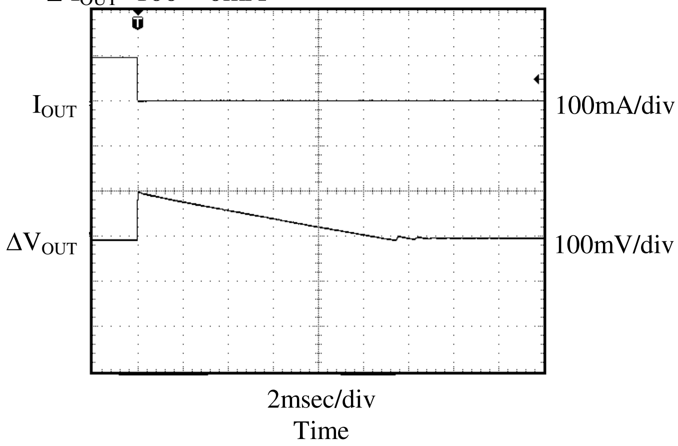


### 11.5 Load Transient

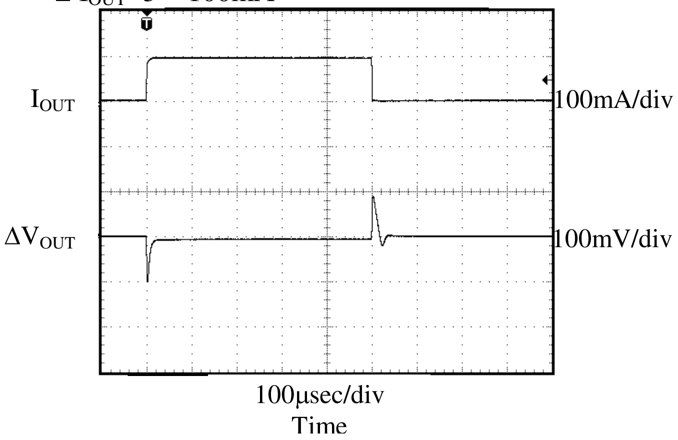
■ $I_{OUT}$=0→100mA



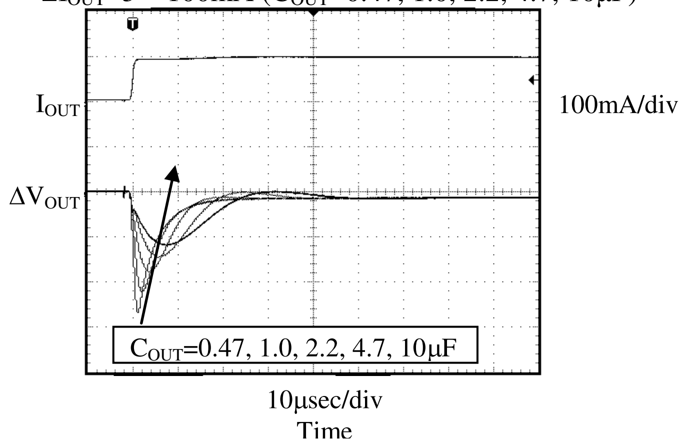

■ $I_{OUT}$=100→0mA




■ $I_{OUT}$=5→100mA

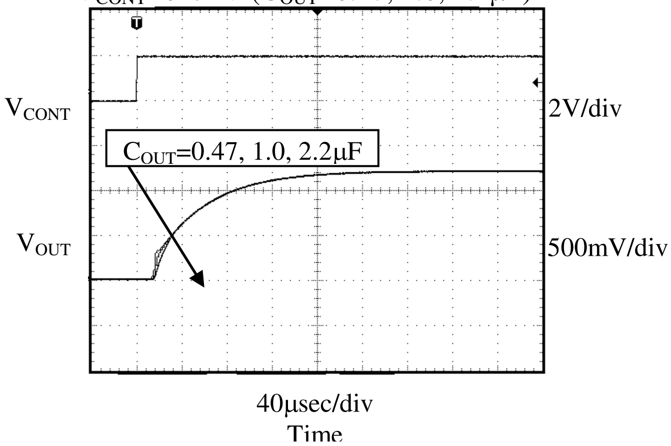



■$I_{OUT}$=5→100mA ($C_{OUT}$=0.47, 1.0, 2.2, 4.7, 10µF)

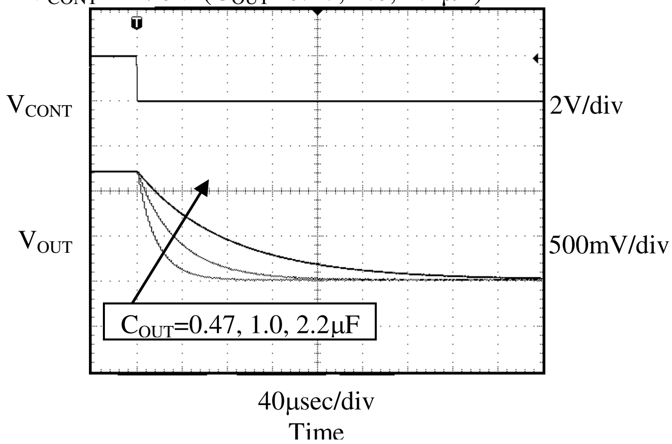


## 11.6 On/Off Transient

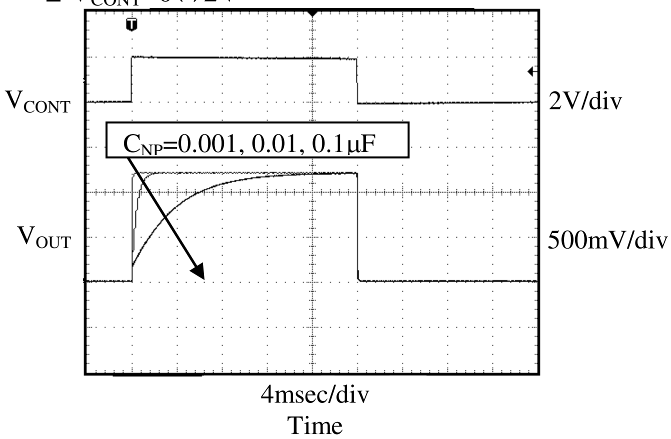
■ $V_{CONT}$=0→2V ($C_{OUT}$=0.47, 1.0, 2.2μF)




■ $V_{CONT}$=2→0V ($C_{OUT}$=0.47, 1.0, 2.2μF)

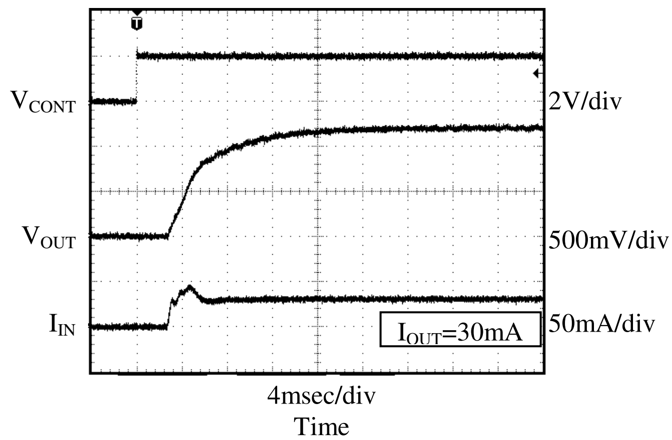



■ $V_{CONT}$=0↔2V

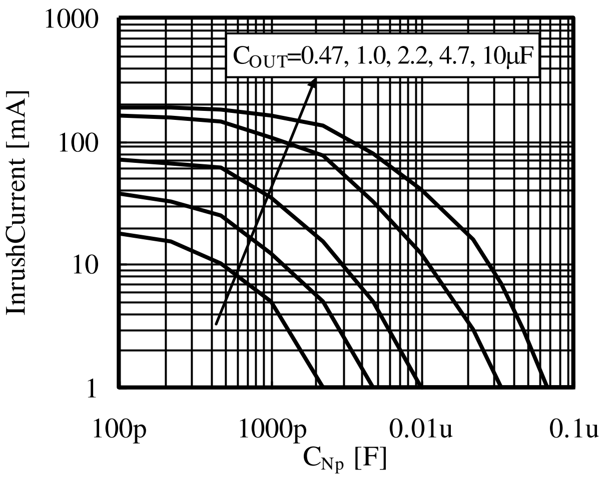



## 11.7 Inrush Current

■ $V_{CONT}$=0→2V ($C_{OUT}$=1.0μF, $C_{NP}$=0.001μF)

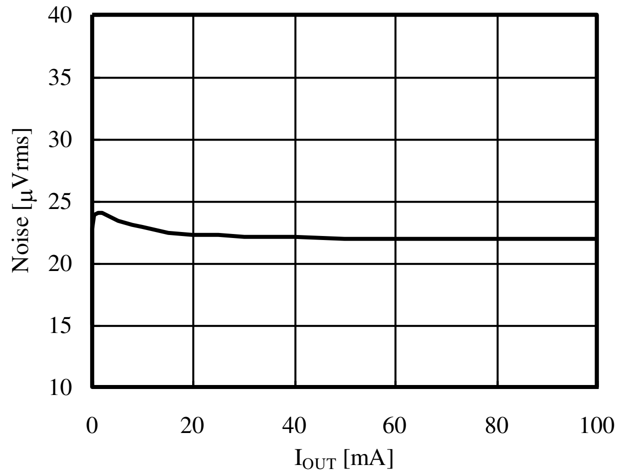



■ InRush Current vs $C_{NP}$

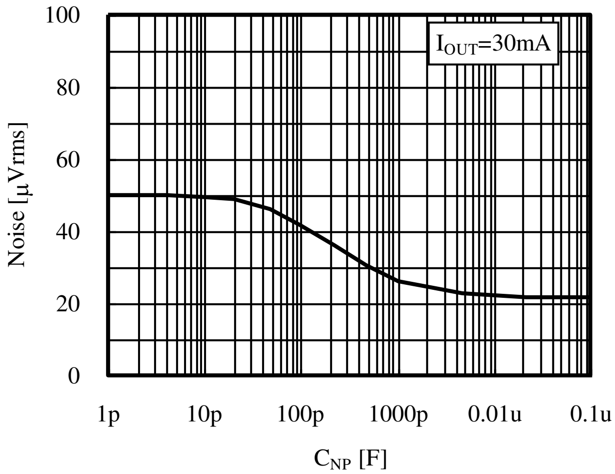


## 11.8 Output Noise

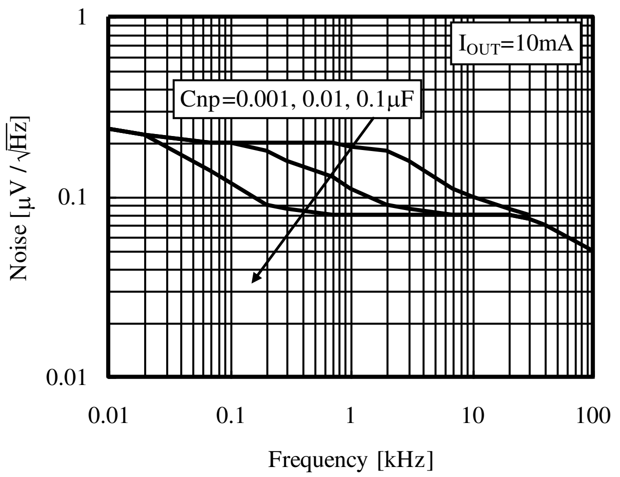
■ Noise vs $I_{OUT}$ (BPF=100Hz～80kHz)




■ Noise vs $C_{NP}$ (BPF=100Hz～80kHz)




■ Noise vs Frequency

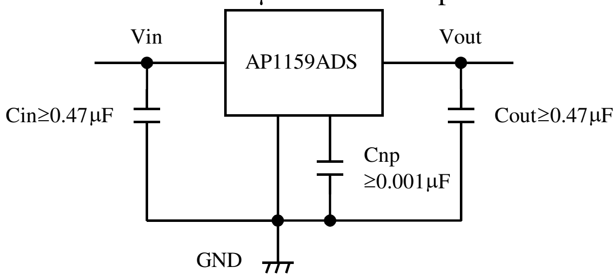


## 11.9 Stability

Linear regulators require input and output capacitors in order to maintain the regulator's loop stability. If 0.47μF or larger capacitor is connected to the output side, the IC provides stable operation at any voltage (0.9V≤$Vout_{TYP}$≤1.2V). (The capacitor must be larger than 0.47μF at all temperature and voltage range) If the capacitor with high Equivalent Series Resistance (ESR) (several ohms) is used, such as tantalum capacitor etc., the regulator may oscillate. Please select parts with low ESR. 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.
A recommended value of the application is as follows.

**Measurement circuit**

Cin=Cout≥0.47μF Ceramic Capacitance




**Output Voltage, Output Current vs. Stable Operation Area**

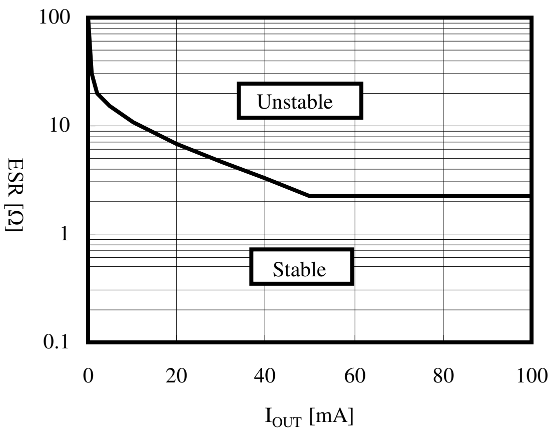



Figure 3. Cout=0.47μF

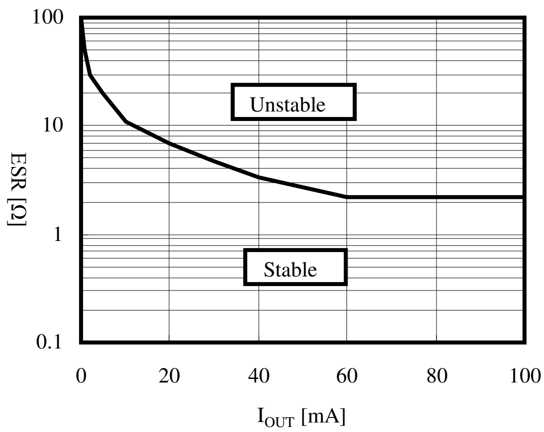



Figure 4. Cout=0.68μF

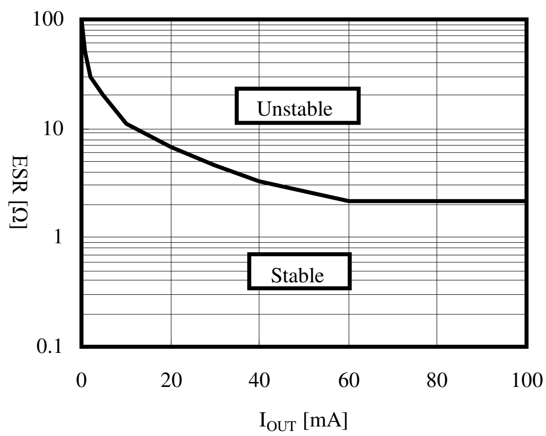



Figure 5. $C_{OUT}$=1.0μF

Generally, a ceramic capacitor has both temperature characteristic and voltage characteristic. Please consider both characteristics when selecting the part. The B curves are the recommend characteristics.

## 11.10 Operating Region and Power Dissipation

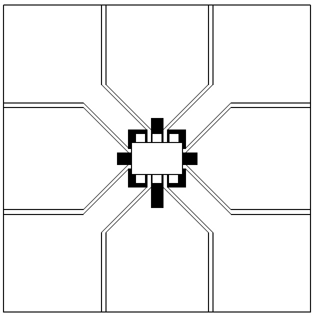


Figure 6. PCB Material: Glass epoxy (t=1.0mm)

Please do derating with 4.0mW/°C at Pd=400mW and 25°C or more. Thermal resistance (θja) is=250°C/W. The package loss is limited at the temperature that the internal temperature sensor works (about 150°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 the small size. The device being mounted on the PCB carries heat away. This value changes by the material and the copper pattern etc. of the PCB. The losses are approximately 400mW. Enduring these losses becomes possible in a lot of applications operating at 25°C.

The overheating protection circuit operates when there are a lot of losses with the regulator (When outside temperature is high or heat radiation is bad). The output current cannot be pulled enough and the output voltage will drop when the protection circuit operates. When the junction temperature reaches 150°C, the IC is shut down. However, operation begins at once when the IC stops operation 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:

$Tj = \theta ja \times Pd + Ta$

Tj of IC is set around 150°C. Pd is the value when the thermal sensor is activated.
If the ambient temperature is 25°C, then:

$150 = \theta ja \times Pd + 25$

$\theta ja = 125/Pd$ (°C /mW)

**Noise bypass capacitor**

The noise and the ripple rejection characteristics depend on the capacitance on the Np terminal.
The ripple rejection characteristic of the low frequency region improves by increasing the capacitance of Cnp. A standard value is Cnp=0.001μF. Increase Cnp in a design with important output noise and ripple rejection requirements. The IC will not be damaged if the capacitor value is increased.
The on/off switching speed changes depending on the Np terminal capacitance. The switching speed slows when the capacitance is large.

## 12. Definition of technical terms

**■Relating Characteristic**

**・Output Voltage (Vout)**

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

**・Maximum Output Current (Iout MAX)**

The rated output current is specified under the condition where the output voltage drops 0.3V the value specified with Iout=5mA. The input voltage is set to $Vout_{TYP}$+1V and the current is pulsed to minimize temperature effect.

**・Dropout Voltage (Vdrop)**

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 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 Vin=$Vout_{TYP}$+1V to Vin=$Vout_{TYP}$+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 Vin=$Vout_{TYP}$+1V. The load regulation is specified output current step conditions of
5mA to 100mA.

**・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 specified with 200$mV_{rms}$, 1kHz super-imposed on the input voltage, where Vin=Vout+1.5V. Ripple rejection is the ratio of the ripple content of the output vs. input and is expressed in dB.

**・Standby Current (Istandby)**

Standby current is the current, which flows into the regulator when the output is turned off by the control function (Vcont=0V).

**■Relating Protection Circuit**

**・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 reduce the loss of the regulator when this protection operate, by reducing the input voltage or make better heat efficiency.
In the case that the power, Vin×Ishort (Short Circuit Current), becomes more than twice of the maximum rating of its power dissipation in a moment, there is a possibility that the IC is destroyed before internal thermal protection works.

**・Reverse Voltage Protection**

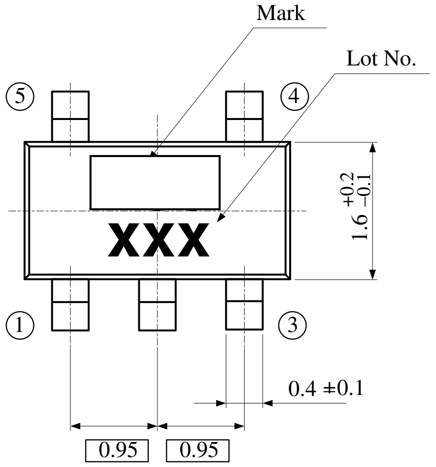
Reverse voltage protection prevents damage due to the output voltage being higher than the input voltage. This fault condition can occur when the output capacitor remains charged and the input is reduced to zero, or when an external voltage higher than the input voltage is applied to the output side

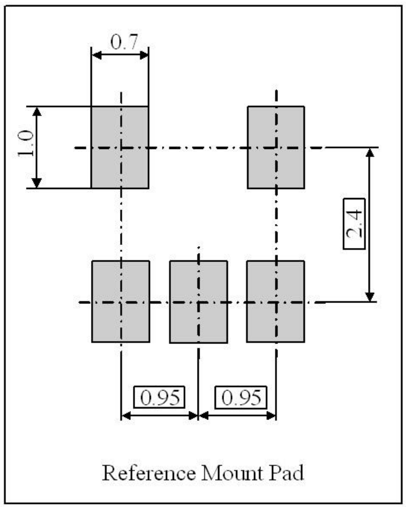
**・ESD**

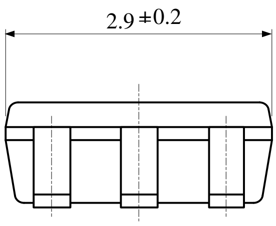
MM: 200pF 0Ω 200V or more HBM: 100pF 1.5kΩ 2000V or more

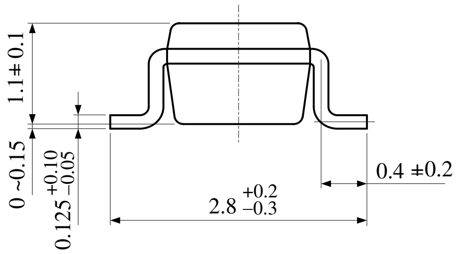
# 13. Package

## ■ Outline Dimensions



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