-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 $30\mu V_{RMS}$
- 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

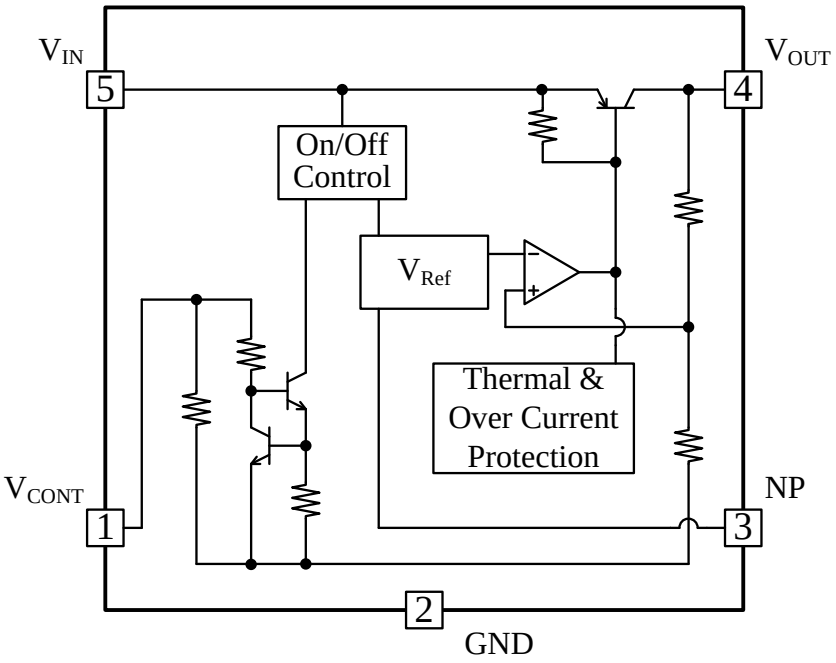


Figure 1. Block Diagram

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.

AP1159ADS<u>XX</u>

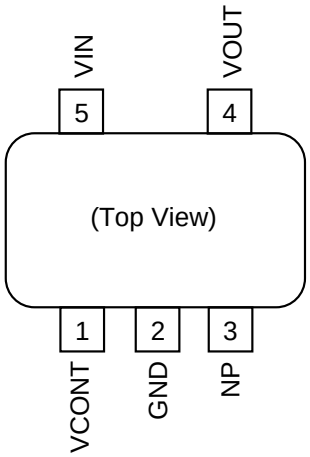
Output voltage code

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 VCONT > 1.8V : ON VCONT < 0.35V : OFF Internal Pull-down(500kΩ)
2	GND	GND
3	NP	Noise pass 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.

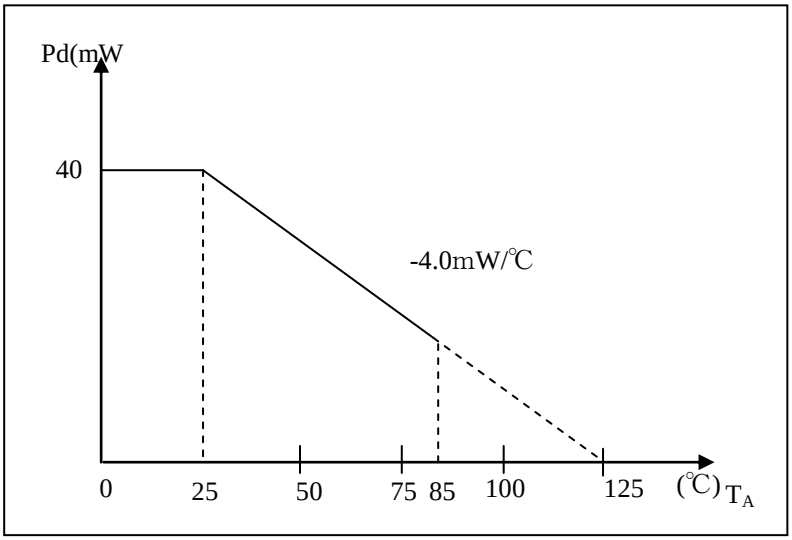


Figure 2. Maximum Power Dissipation

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	$L_{IN}R_{EG}$	ΔV_{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	-	μV_{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	$L_{IN}R_{EG}$	ΔV_{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	-	μV_{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.

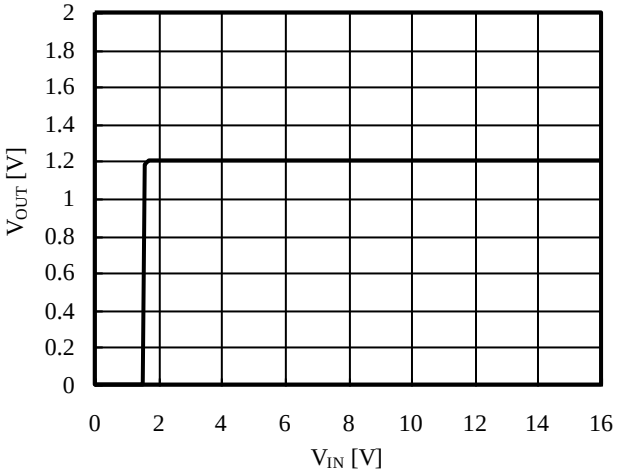
Table 3. Standard Voltage Version

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

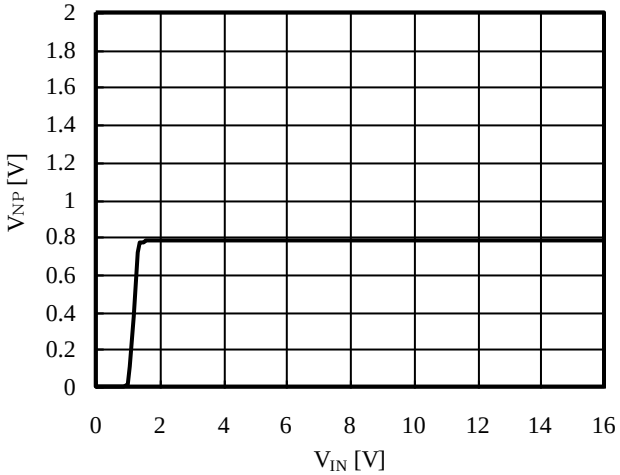
11. Functional Descriptions

11.1 DC characteristics

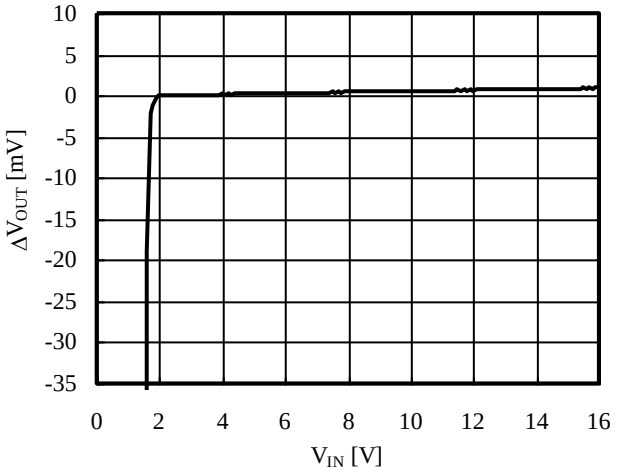
■ V_{OUT} vs V_{IN}



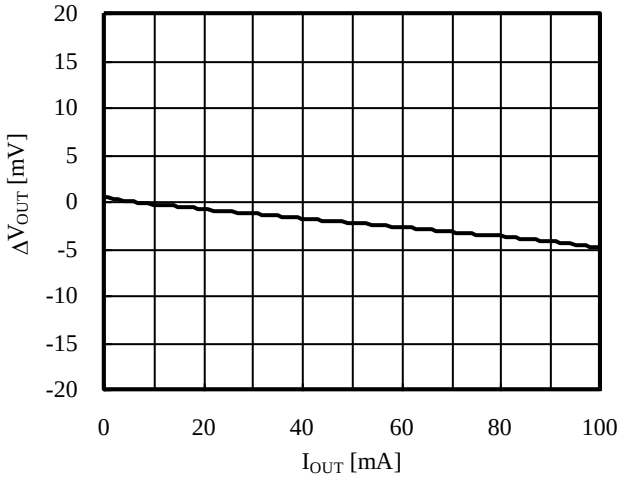
■ V_{NP} vs V_{IN}



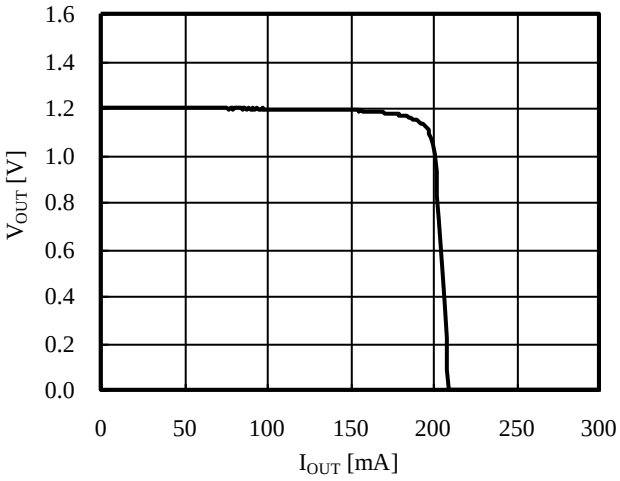
■ Line Regulation



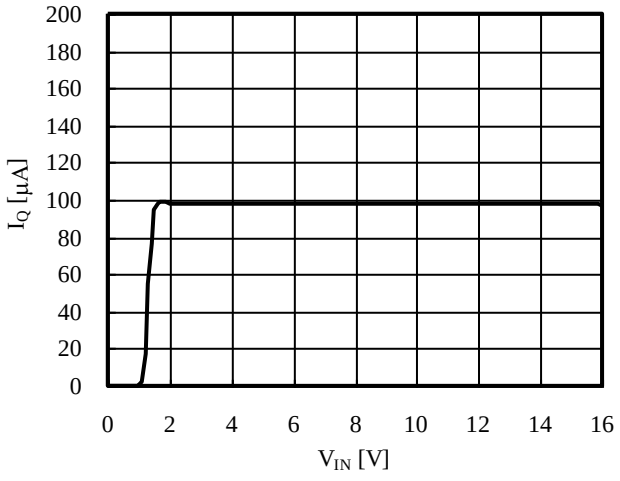
■ Load Regulation



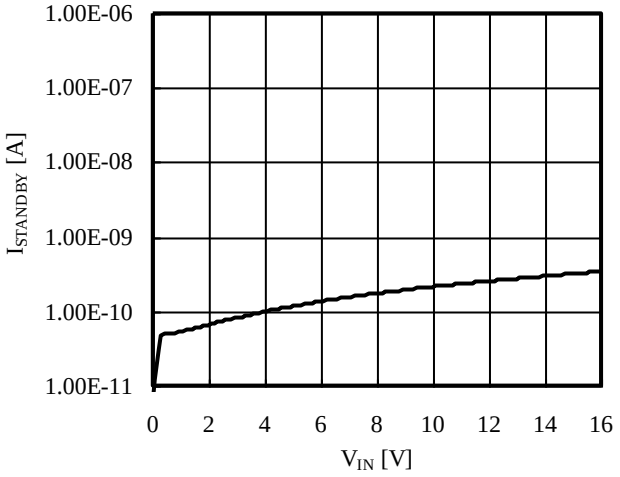
■ Short Circuit Current



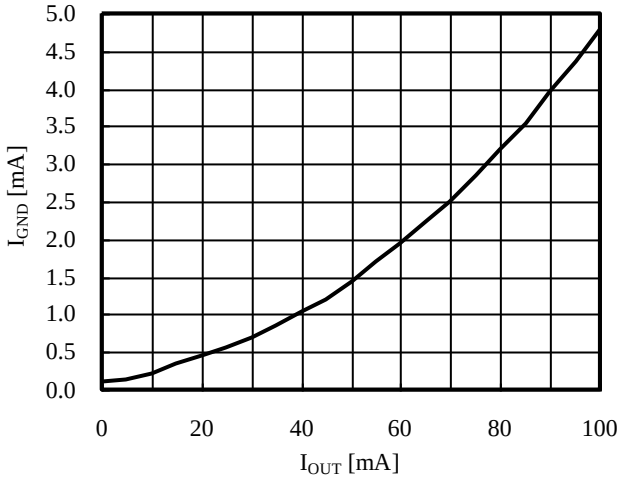
■ Quiescent Current (I_{OUT}=0V)



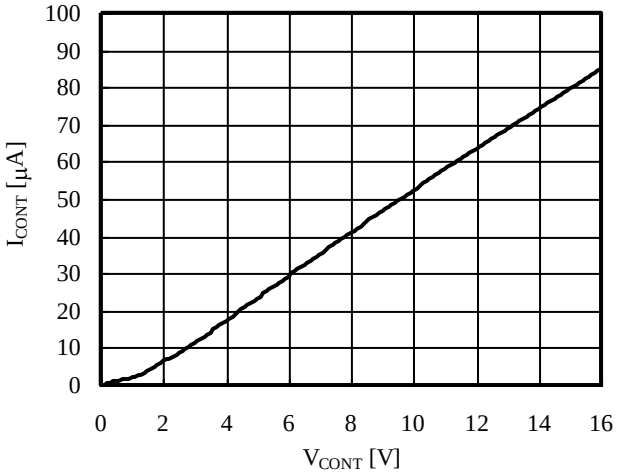
■ Standby Current (VCONT=0V)



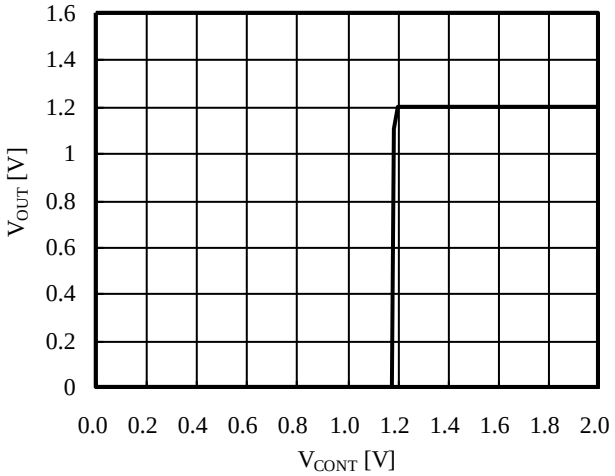
■ GND Pin Current



■ Control Current

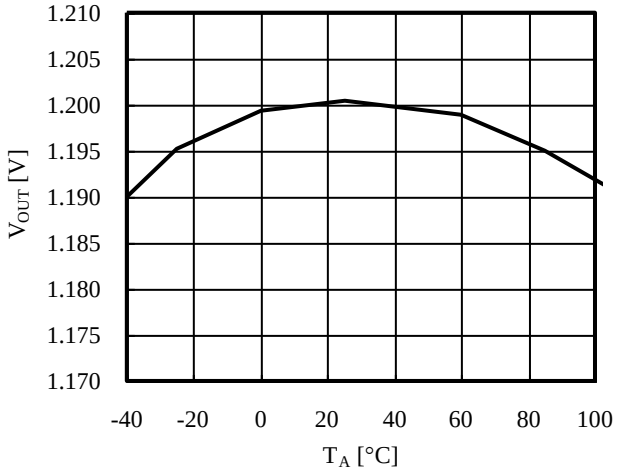


■ VOUT ON/OFF Point

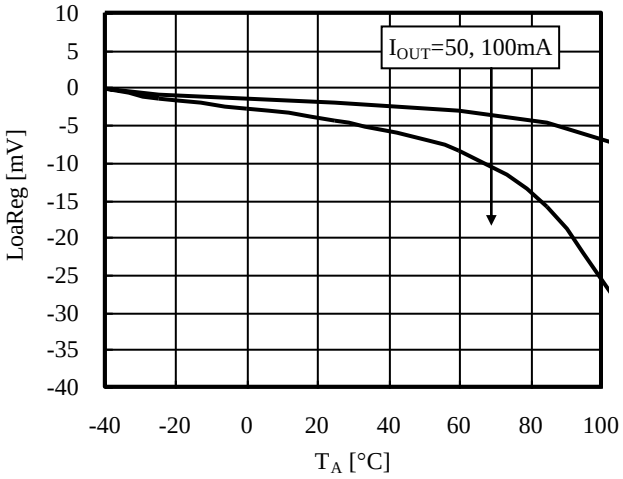


11.2 DC temperature characteristics

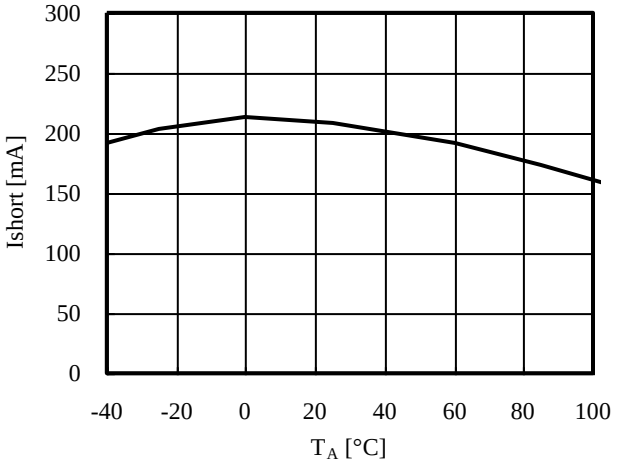
■ V_{OUT}



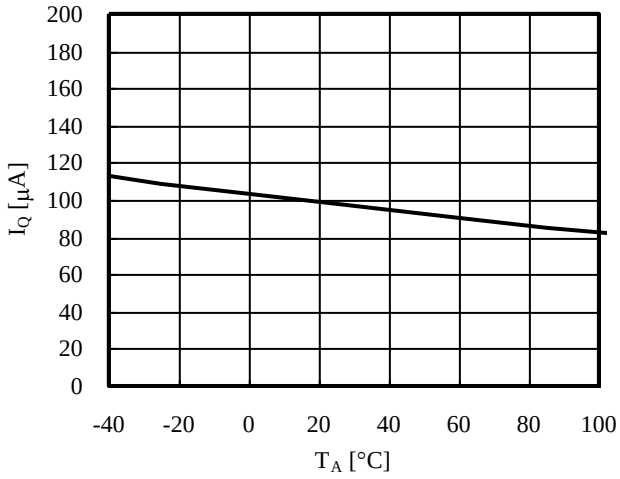
■Load Regulation



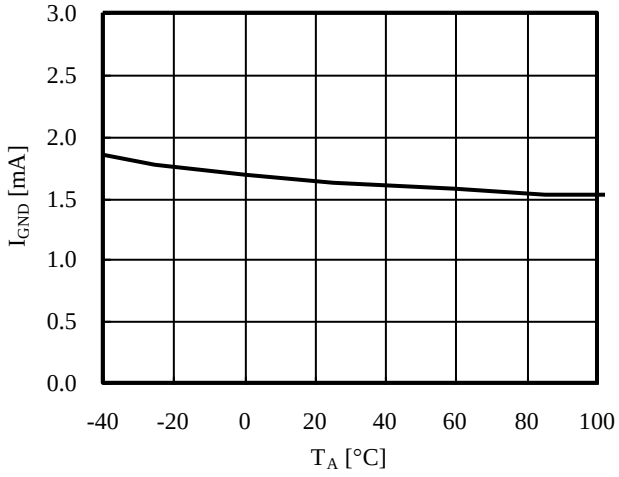
■ Short Circuit Current



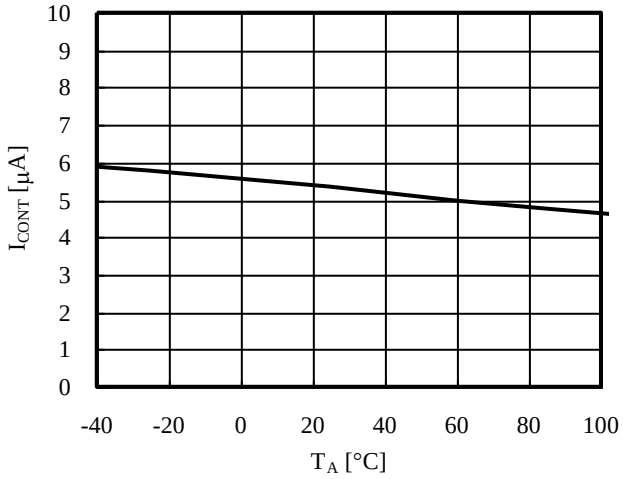
■ Quiescent Current (I_{OUT}=0V)



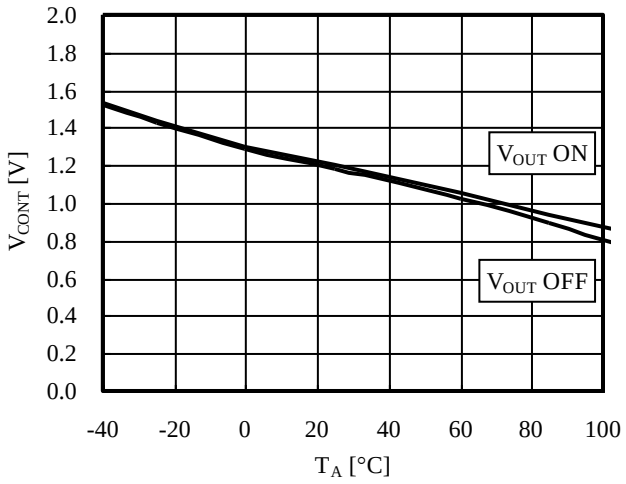
■GND Pin Current



■Control Current

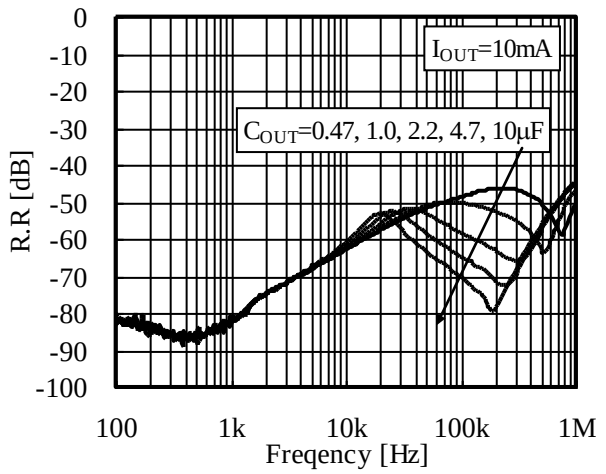


■VOUT ON/OFF Point

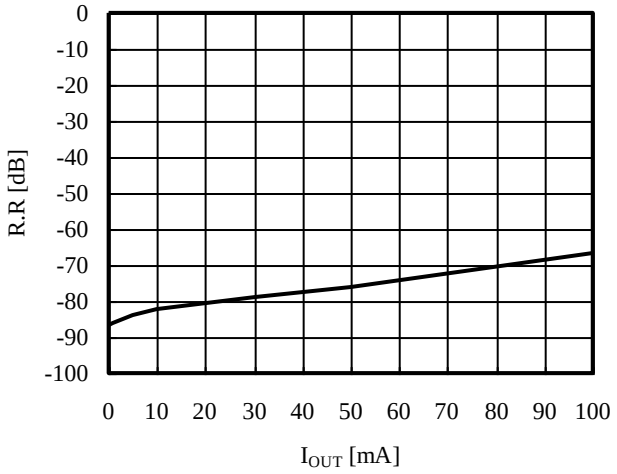


11.3 Ripple Rejection

■C_{OUT}=0.47, 1.0, 2.2, 4.7, 10 μ F

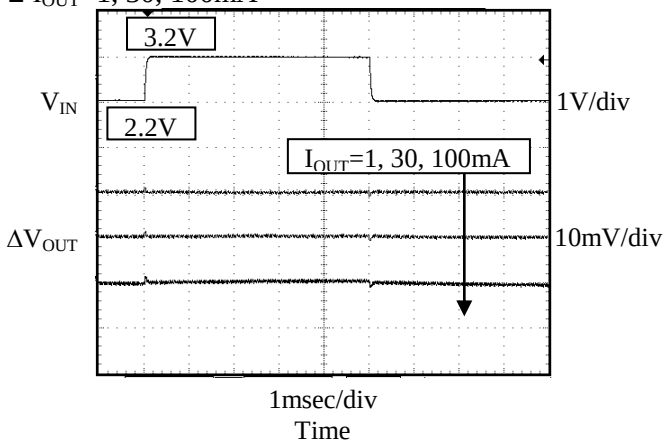


■R.R vs I_{OUT} (Frequency=1kHz)

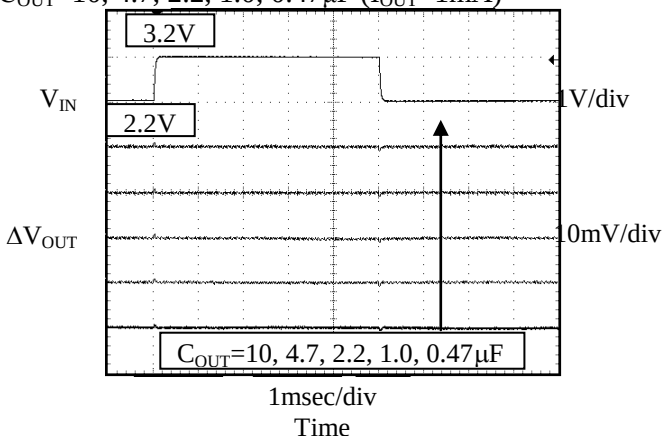


11.4 Line Transient

■ I_{OUT}=1, 30, 100mA

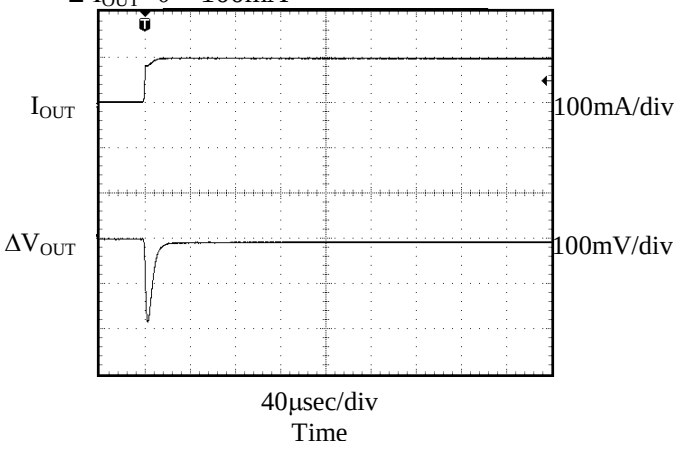


■ C_{OUT}=10, 4.7, 2.2, 1.0, 0.47µF (I_{OUT}=1mA)

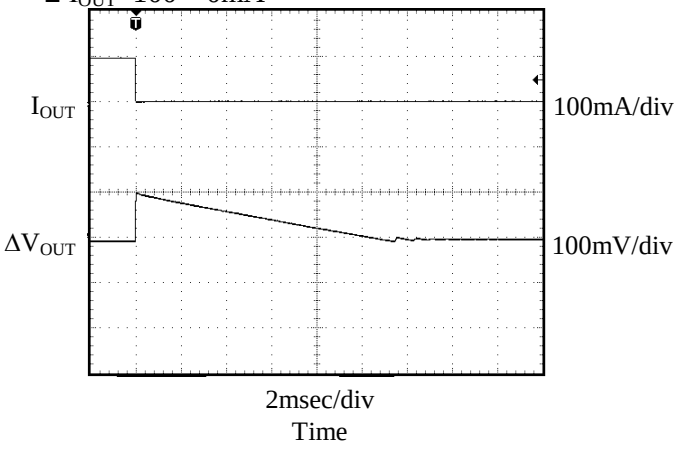


11.5 Load Transient

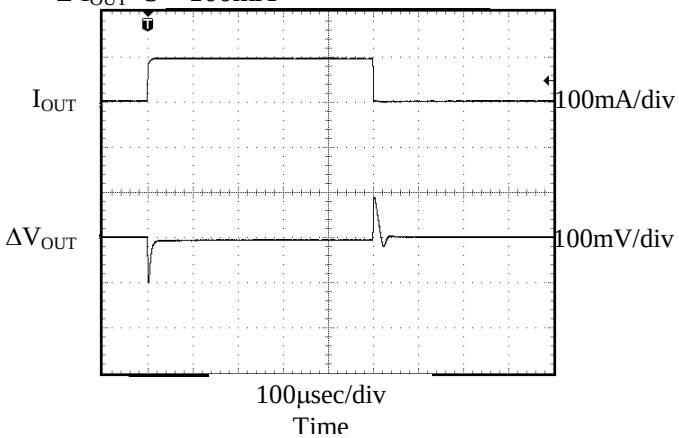
■ I_{OUT}=0→100mA



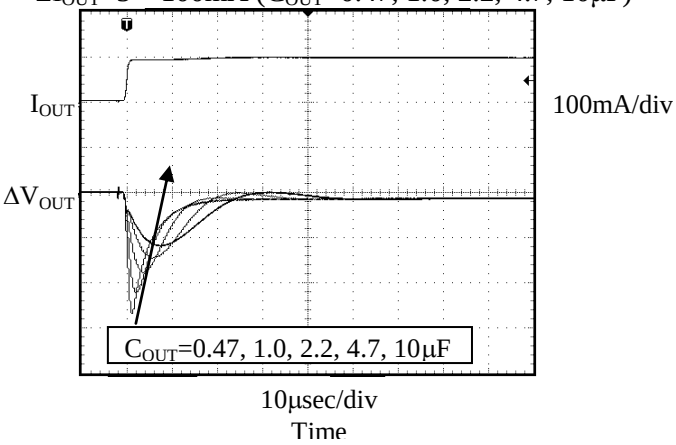
■ I_{OUT}=100→0mA



■ I_{OUT}=5→100mA

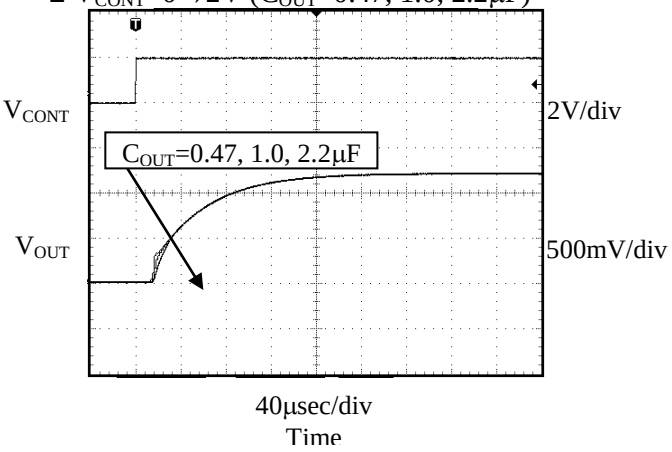


■I_{OUT}=5→100mA (C_{OUT}=0.47, 1.0, 2.2, 4.7, 10µF)

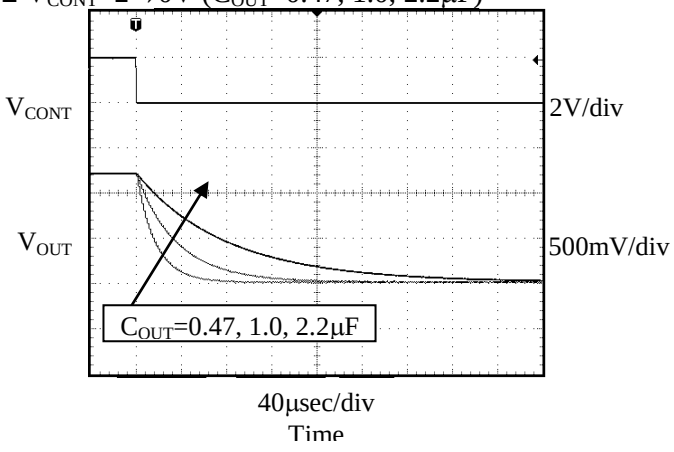


11.6 On/Off Transient

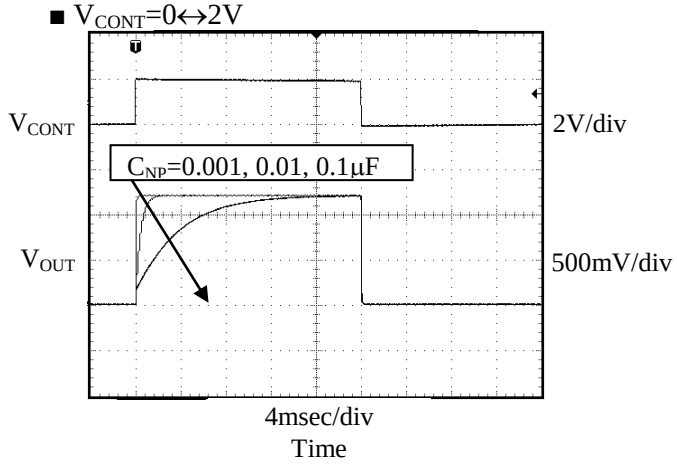
■ V_{CONT}=0→2V (C_{OUT}=0.47, 1.0, 2.2μF)



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

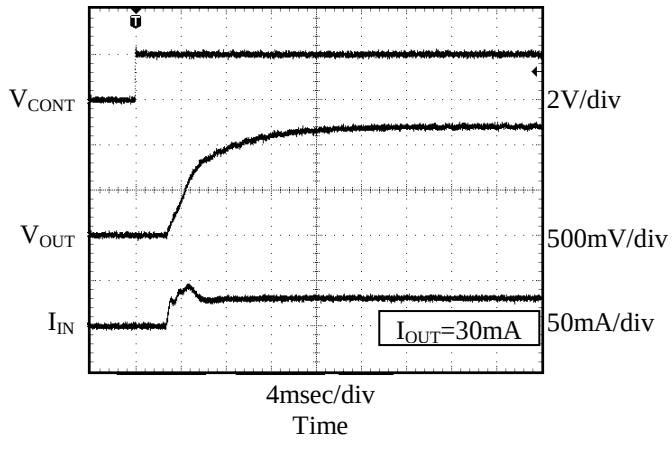


■ V_{CONT}=0↔2V

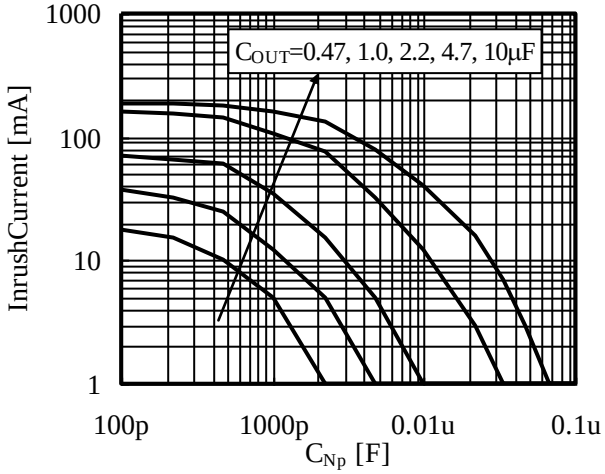


11.7 Inrush Current

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

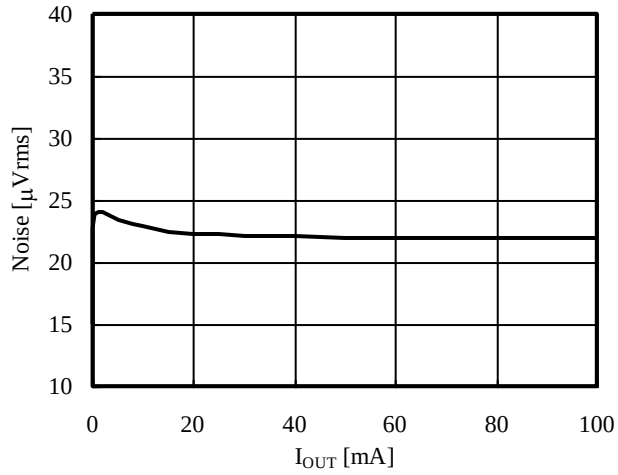


■ InRush Current vs C_{NP}

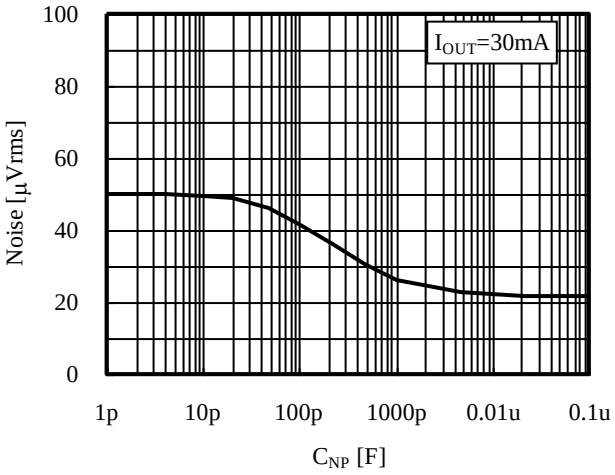


11.8 Output Noise

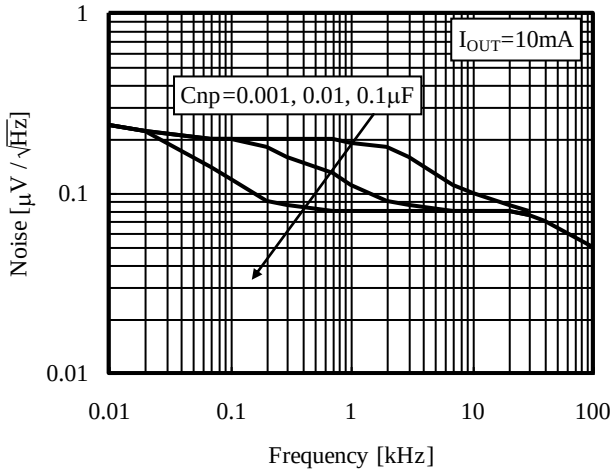
■ Noise vs I_{OUT} (BPF=100Hz～80kHz)



■ Noise vs C_{NP} (BPF=100Hz～80kHz)



■ Noise vs Frequency

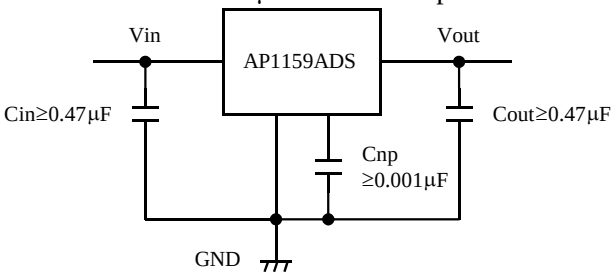


11.9 Stability

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 ($0.9V \leq Vout_{TYP} \leq 1.2V$). (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

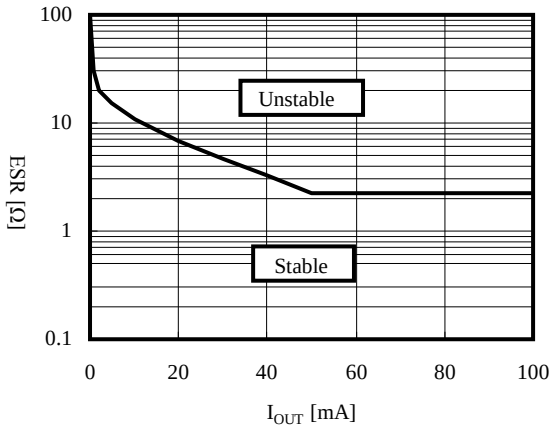


Figure 3. Cout=0.47μF

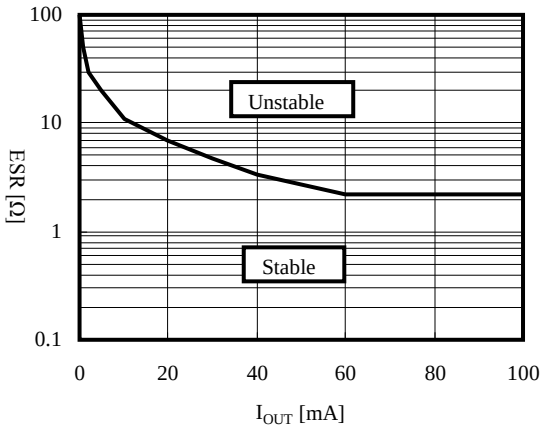


Figure 4. Cout=0.68μF

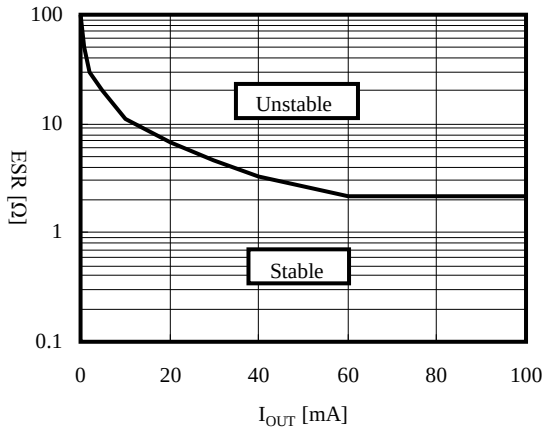


Figure 5. C_{OUT}=1.0μF

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

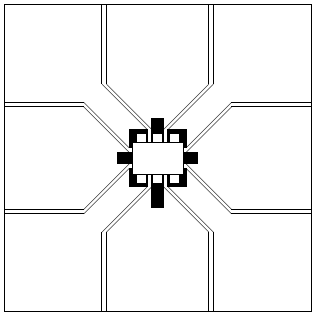


Figure 6. PCB Material: Glass epoxy (t=1.0mm)

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 200mV_{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

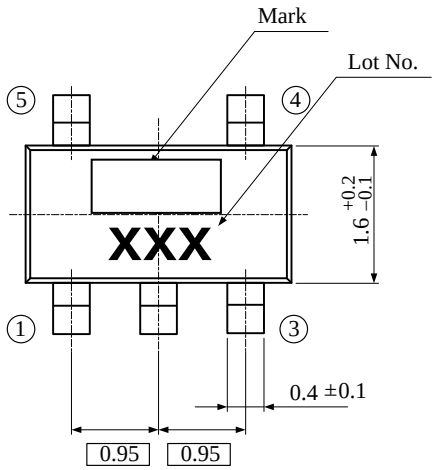
Reverse voltage protection prevents damage due to the output voltage being higher than the input voltage. This fault condition can occur when the output capacitor remains charged and the input is reduced to zero, or when an external voltage higher than the input voltage is applied to the output side

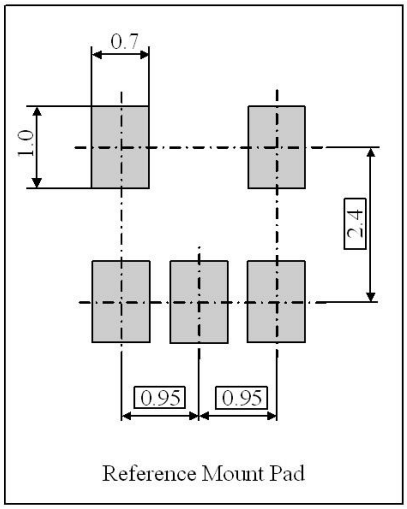
・ESD

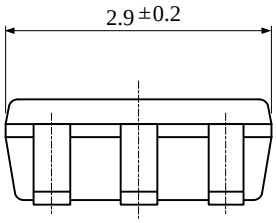
MM: 200pF 0Ω 200V or more HBM: 100pF 1.5kΩ 2000V or more

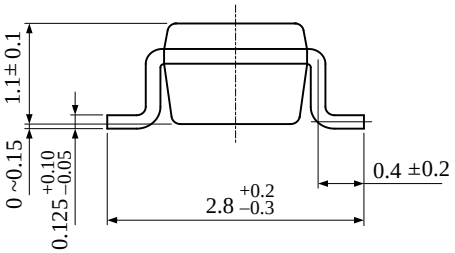
13. Package

■ Outline Dimensions









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