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Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
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-Preliminary-

AP1155ADU

15V Input / 1A Output Adjustable Voltage LDO Regulator

1. Genaral Description

The AP1155ADU is a low dropout linear regulator with ON/OFF control, which can supply 1A load current. The IC is an integrated circuit with a silicon monolithic bipolar structure. The output voltage can be set from 1.3V to 14.0V by external resistors. The output capacitor is available to use a small 0.22μF ceramic capacitor. The over current, thermal and reverse bias protections are integrated, and also the package is high heat radiation type, TO252-5. The IC is designed for high power application.

2. Features

- Available to use a small ceramic capacitor
- Dropout Voltage V_{DROP}=300mV at 1A
- Output Current 1A, Peak 1.4A
- High Precision reference voltage 1.21V ± 35mV
- Programmable output voltage 1.3V to 14.0V
- High ripple rejection ratio 80dB at 1kHz
- Wide operating voltage range 2.4V to 15.0V
- On/Off control (High active)
- Built-in Short circuit protection, thermal shutdown
- Built-in reverse bias over current protection
- Available very low noise application
- High heat radiation package TO252-5

3. Applications

- Automotive accessory equipment
- Power supply for low voltage MPU and the peripherals
- Mobile Communication
- Audio system
- Any Electronic Equipment, etc

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5. Block Diagram

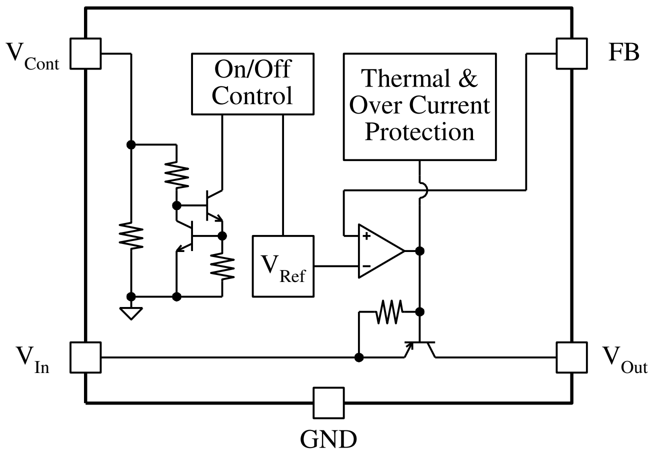


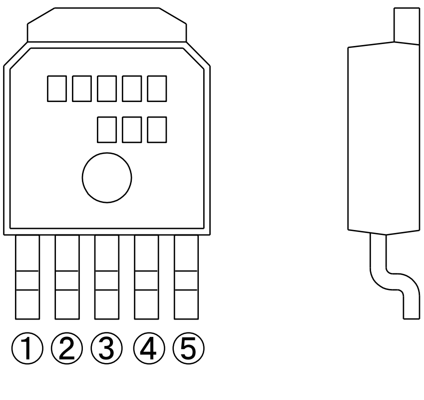
Figure 1. Block Diagram

6. Ordering Information

AP1155ADU	Ta = -40 to 85°C	TO252-5

7. Pin Configurations and Functions

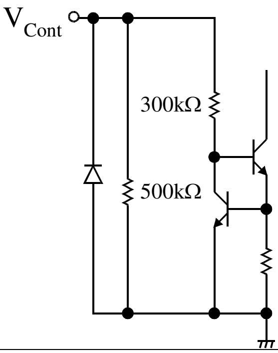
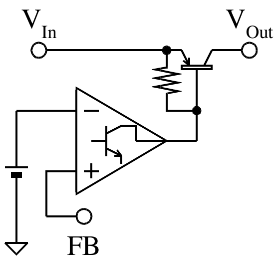
■ Pin Configurations



①:V_{Cont} ②:V_{In} ③:GND

④:V_{Out} ⑤:FB

■ Function

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.

8. Absolute Maximum Ratings

Parameter	Symbol	min	Max	Unit	Condition
Input Voltage	$V_{In,MAX}$	-0.4	16	V	
Reverse Bias Voltage	$V_{Rev,MAX}$	-0.4	14	V	V_{Out}-V_{In}
FB Terminal Voltage	$V_{FB,MAX}$	-0.4	5	V	
Control Voltage	$V_{Cont,MAX}$	-0.4	16	V	
Junction temperature	Tj	-	150	°C	
Storage Temperature Range	T_{Stg}	-55	150	°C	
Power Dissipation	P_D	-	830	mW	Unit, Internal Limited T_j=145°C (Note 1)
		-	2200	-	30mm*30mm*1mm(When Installed On a PCB), Internal Limited (Note 2)

Note 1. P_D must be decreased at the rate of 6.9mW/°C for operation above 25°C.
Note 2. P_D must be decreased at the rate of 18.3mW/°C for operation above 25°C.

WARNING: The maximum ratings are the absolute limitation values with the possibility of the IC breakage. When the operation exceeds this standard quality cannot be guaranteed.

9. Recommended Operating Conditions

Parameter	Symbol	min	typ	max	Unit	Condition
Operating Temperature Range	Ta	-40	-	85	°C	
Operating Voltage Range	V_{OP}	2.4	-	15.0	V	
Output Voltage Range	V_{Out}	1.3	-	14.0	V	

10. Electrical Characteristics

■ Electrical Characteristics of Ta=Tj=25°C

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

(V_{In}=4.0V, R1=53kΩ, R2=36kΩ, Vcont=1.8V, Ta=Tj=25°C, unless otherwise specified.)

Parameter	Symbol	Condition	min	typ	max	Unit
Fb voltage	V_{FB}	I_{Out}=5mA	1.185	1.210	1.245	V
Line Regulation	LinReg	ΔV_{In}=5V, I_{Out}=5mA	-	0	10	mV
Load Regulation (Note 3)	LoaReg	I_{Out}=5~500mA	-	6	20	mV
		I_{Out}=5~1000mA	-	20	35	
Dropout Voltage (Note 4)	V_{Drop}	I_{Out}=500mA	-	150	260	mV
		I_{Out}=1000mA	-	300	490	
		V_{Out}=$V_{Out,TYP}$×0.9		1400	-	mA
Maximum Output Current (Note 5)	$I_{Out,Max}$	I_{Out}=0mA	-	300	480	μA
Quiescent Current	Iq	V_{Cont}=0V	-	-	0.1	μA
Standby Current	$I_{Standby}$	V_{Cont}=1.8V	-	5	10	μA
Control Current	I_{Cont}	V_{Out} On state	1.8	-	-	V
Control Voltage	V_{Cont}	V_{Out} Off state	-	-	0.35	V

Note 3. 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.
Note 4. For $V_{Out,TYP}$≤2.0V , no regulations.
Note 5. The maximum output current is limited by power dissipation
Note 6. Parameters with only typical values are just reference. (Not guaranteed)

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

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

(V_{In}=4.0V, R1=53kΩ, R2=36kΩ, Vcont=1.8V, Ta= -40 ~ 85°C, unless otherwise specified.)

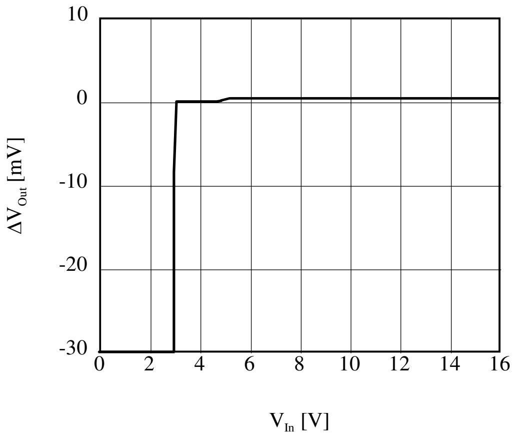
Parameter	Symbol	Condition	min	typ	max	Unit
Fb voltage	V_{FB}	I_{Out}=5mA	1.175	1.210	1.255	V
Line Regulation	LinReg	ΔV_{In}=5V, I_{Out}=5mA	-	0	16	mV
Load Regulation (Note 7)	LoaReg	I_{Out}=5~500mA	-	6	37	mV
		I_{Out}=5~1000mA	-	20	65	
Dropout Voltage (Note 8)	V_{Drop}	I_{Out}=500mA	-	150	335	mV
		I_{Out}=1000mA	-	300	550	
		V_{Out}=$V_{Out,TYP}$×0.9		1400	-	mA
Maximum Output Current (Note 9)	$I_{Out,Max}$	I_{Out}=0mA	-	300	585	μA
Quiescent Current	Iq	V_{Cont}=0V	-	-	0.5	μA
Standby Current	$I_{Standby}$	V_{Cont}=1.8V	-	5	15	μA
Control Current	I_{Cont}	V_{Out} On state	1.8	-	-	V
Control Voltage	V_{Cont}	V_{Out} Off state	-	-	0.35	V

Note 7. 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.
Note 8. For $V_{Out,TYP}$≤2.0V , no regulations.
Note 9. The maximum output current is limited by power dissipation
Note 10. Parameters with only typical values are just reference. (Not guaranteed)

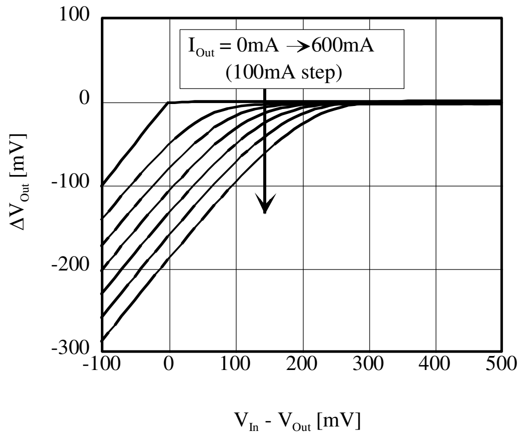
11. Description

11.1 DC Characteristics

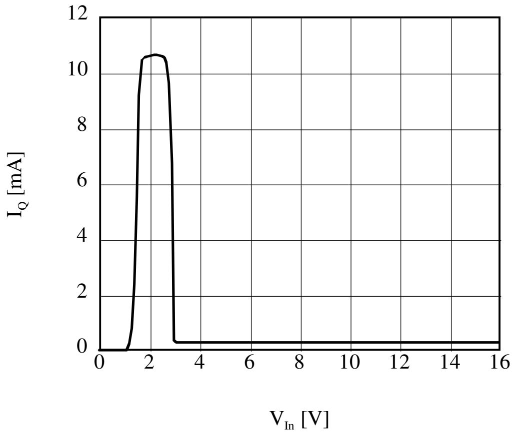
■ ΔV_{Out} vs V_{In} (AP1155ADU)



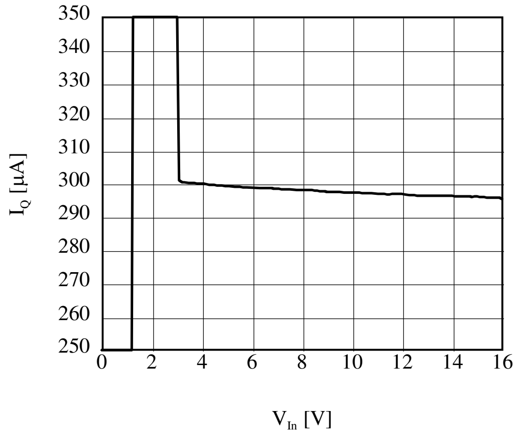
■ ΔV_{Out} vs V_{In} (AP1155ADU)



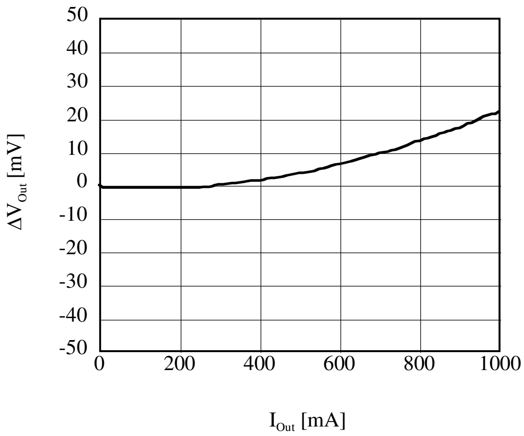
■ I_Q vs V_{In} (AP1155ADU)



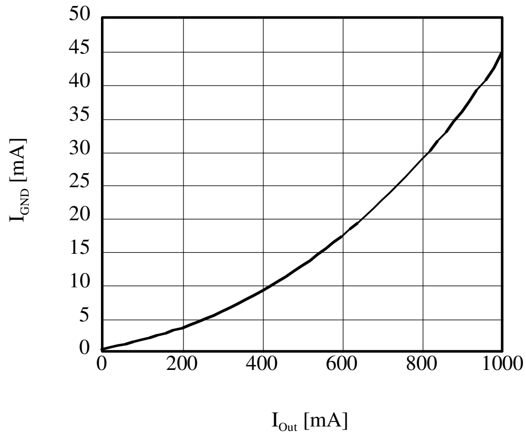
■ I_Q vs V_{In} (AP1155ADU)



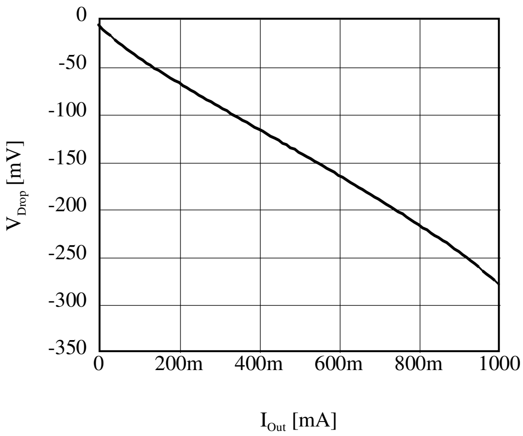
■ ΔV_{Out} vs I_{Out} (AP1155ADU)



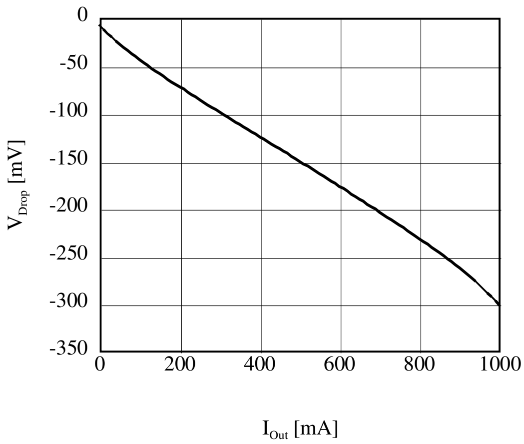
■ I_{GND} vs I_{Out} (AP1155ADU)



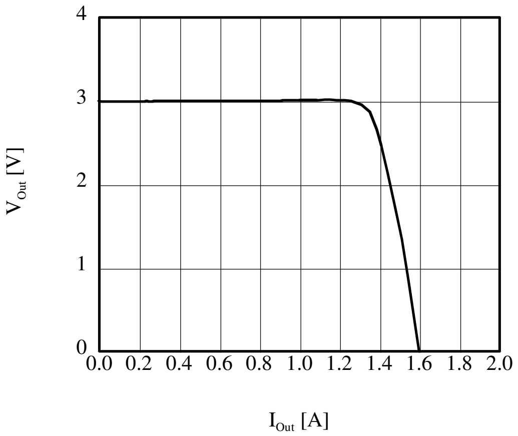
■ V_{Drop} vs I_{Out} (AP1155ADU)



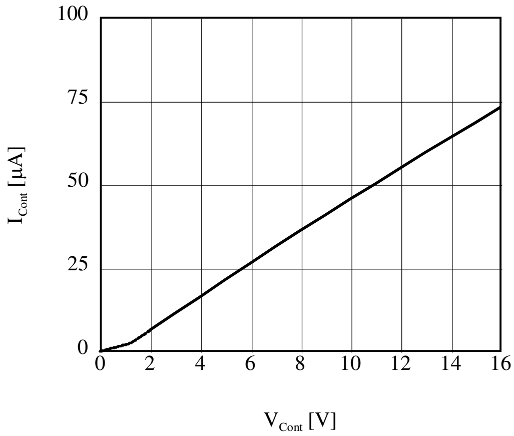
■ V_{Drop} vs I_{Out} (AP1155ADU)



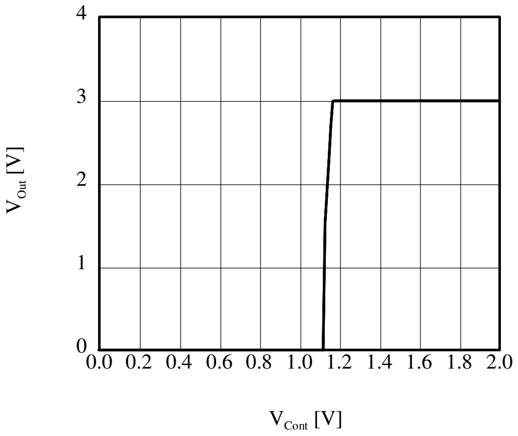
■ V_{Out} vs I_{Out} (AP1155ADU)



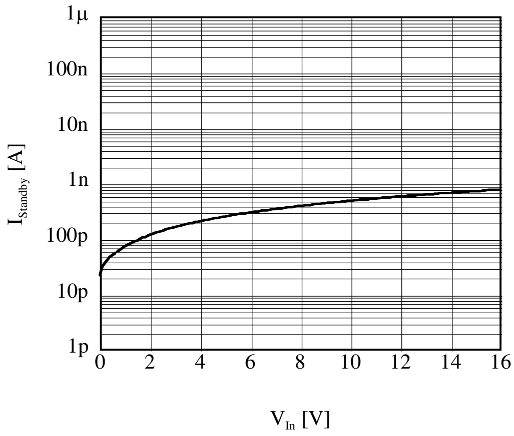
■ I_{Cont} vs V_{Cont} (AP1155ADU)



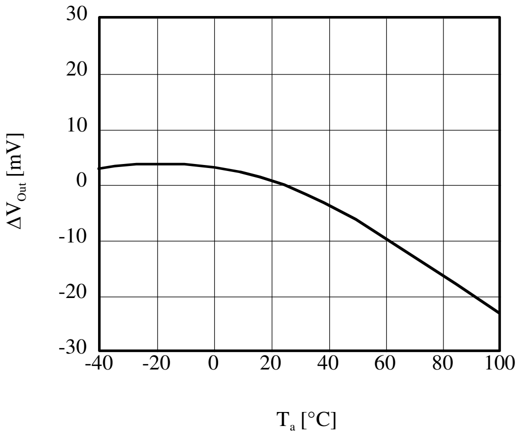
■ V_{Out} vs V_{Cont} (AP1155ADU)



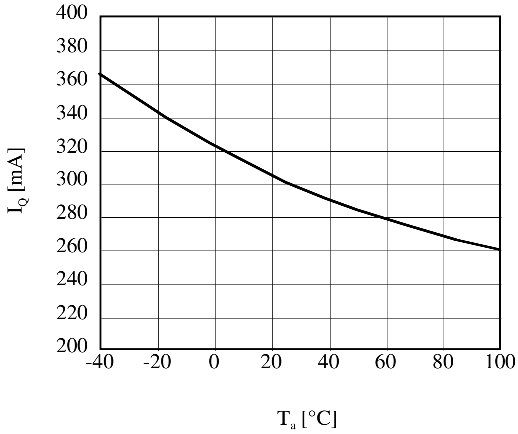
■ $I_{Standby}$ vs V_{In} (AP1155ADU)



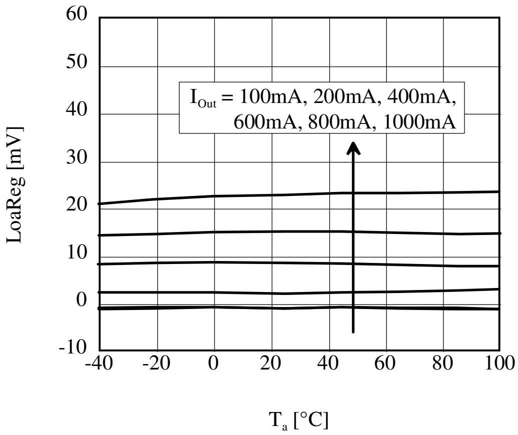
■ ΔV_{Out} vs T_a (AP1155ADU)



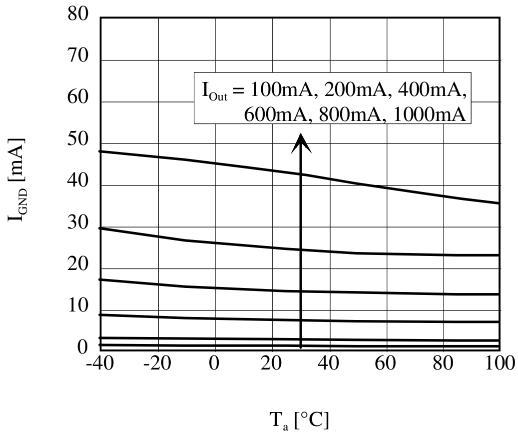
■ I_Q vs T_a (AP1155ADU)



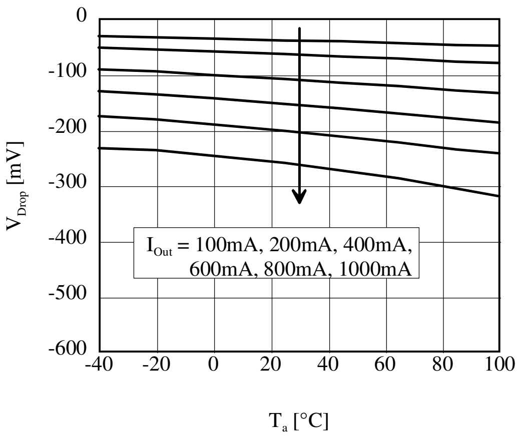
■ LoaReg vs T_a (AP1155ADU)



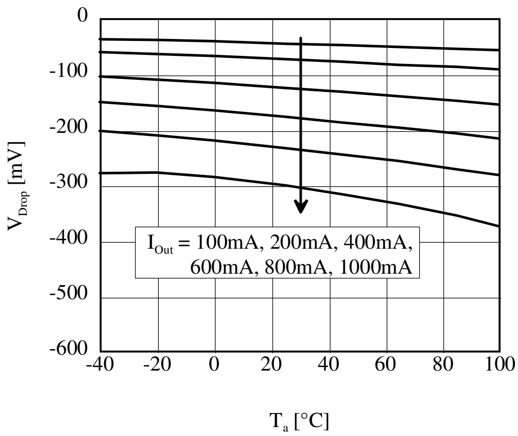
■ I_{GND} vs T_a (AP1155ADU)



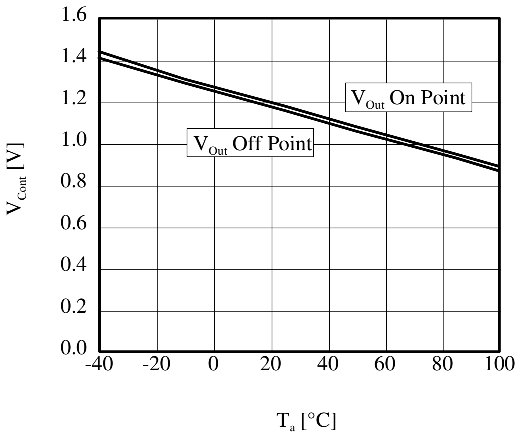
■ V_{Drop} vs T_a (AP1155ADU)



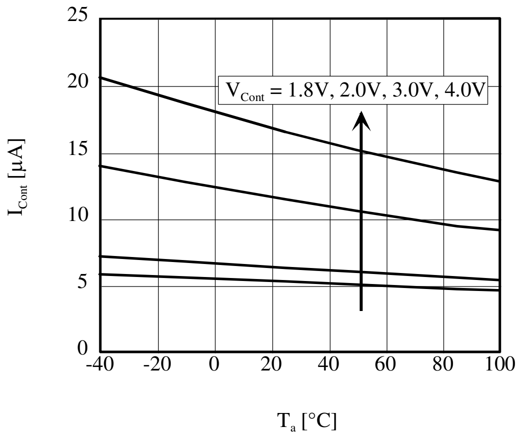
■ V_{Drop} vs T_a (AP1155ADU)



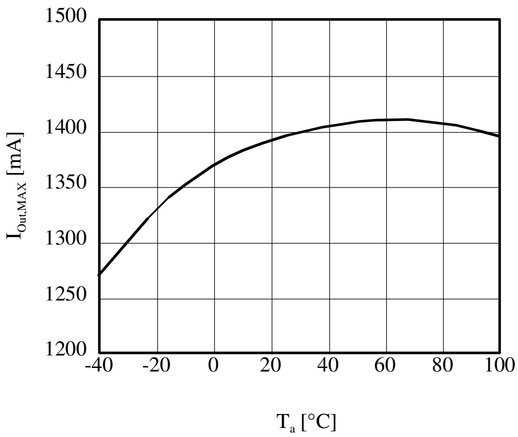
■ V_{Out} On/Off Point vs T_a (AP1155ADU)



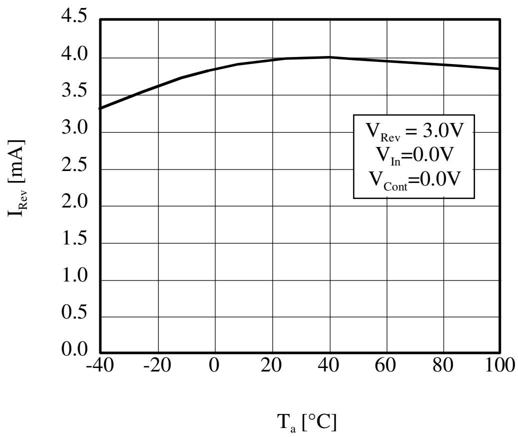
■ I_{Cont} vs T_a (AP1155ADU)



■ $I_{Out,MAX}$ vs T_a (AP1155ADU)

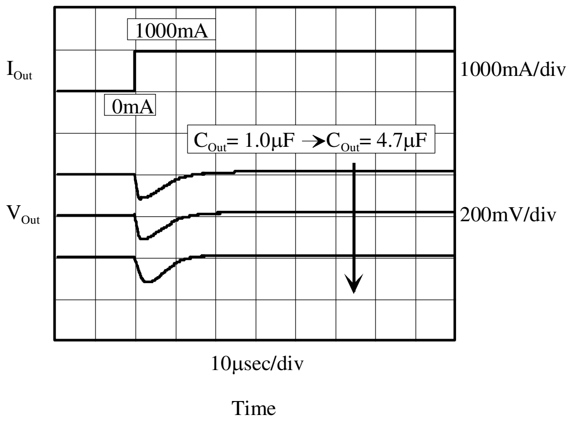


■ Reverse Bias Current(I_{Rev}) vs T_a (AP1155ADU)

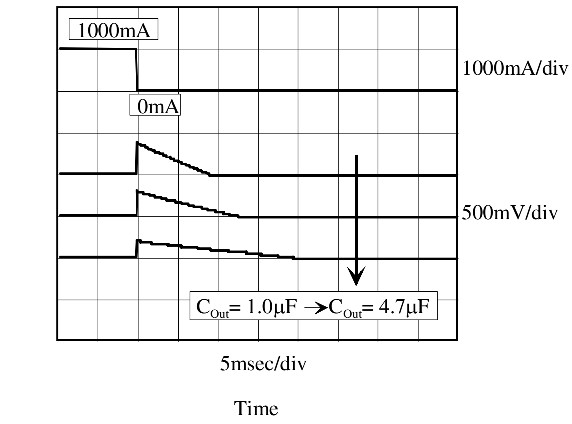


11.2 Load Transient

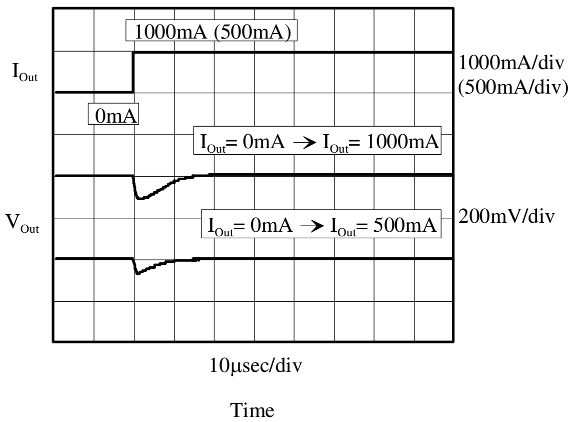
■ I_{Out}=0mA→1000mA, C_{Out}=1.0µF, 2.2µF, 4.7µF



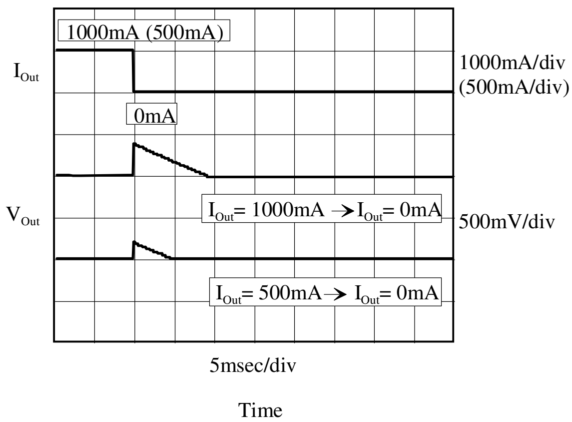
■ I_{Out}=1000mA→0mA, C_{Out}=1.0µF, 2.2µF, 4.7µF



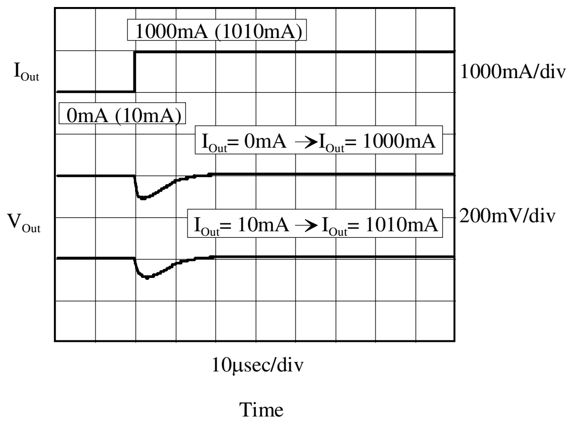
■ I_{Out}=0mA→500mA, 0mA→1000mA



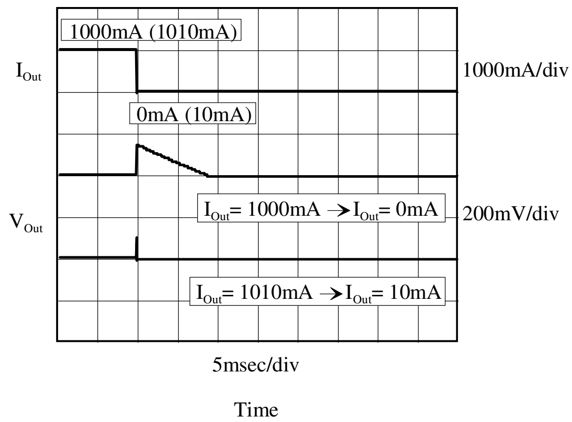
■ I_{Out}=500mA→0mA, 1000mA→0mA



■ I_{Out}=0mA→1000mA, 10mA→1010mA

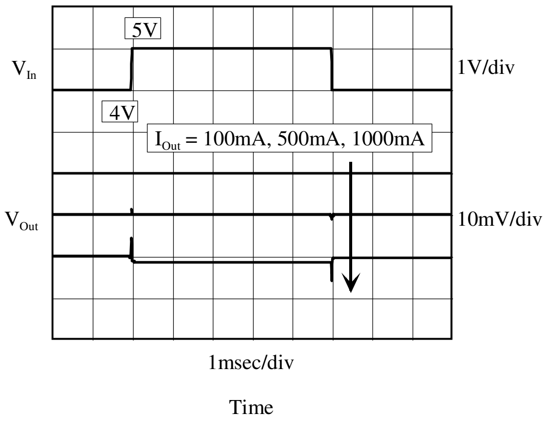


■ I_{Out}=1000mA→0mA, 1010mA→10mA

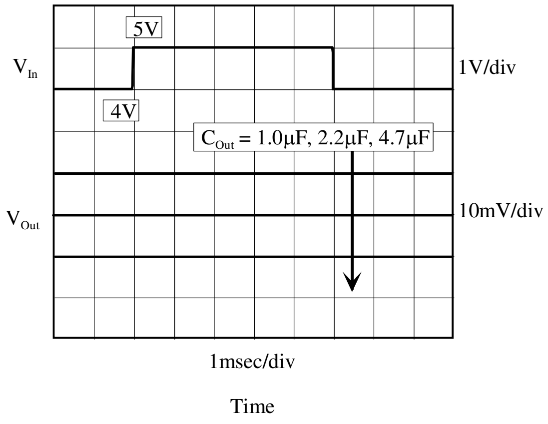


11.3 Line Transient

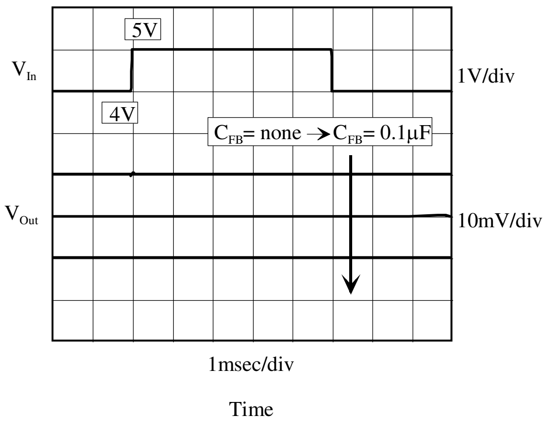
■ I_{Out}=100mA, 500mA, 1000mA



■ C_{Out}=1.0μF, 2.2μF, 4.7μF

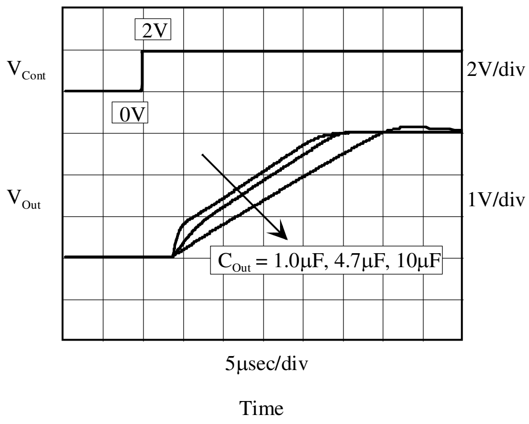


■ C_{Fb}=none, 1000pF, 0.1μF

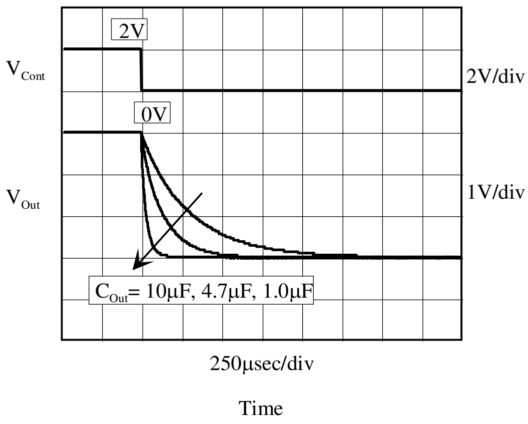


11.4 On / Off Transient

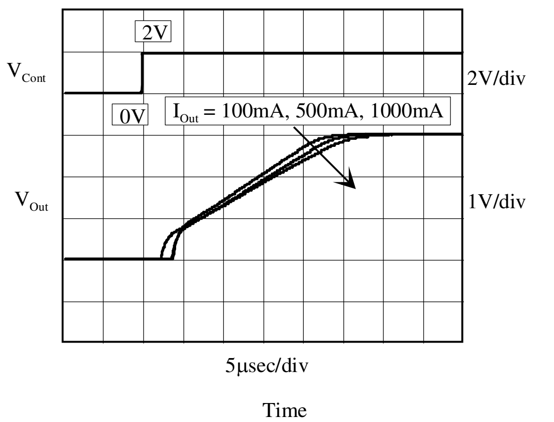
■ V_{Cont}=0.0V→2.0V, C_{Out}=1.0µF, 4.7µF, 10µF



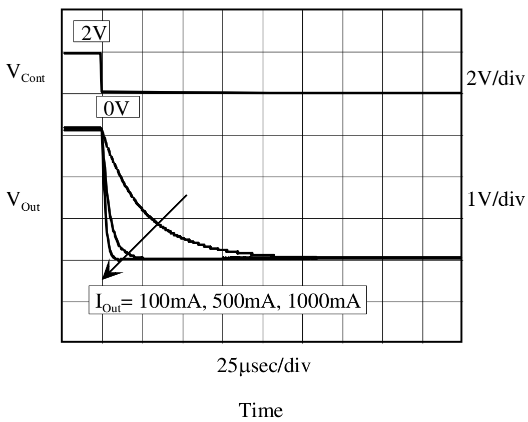
■ V_{Cont}=2.0V→0.0V, C_{Out}=1.0µF, 4.7µF, 10µF



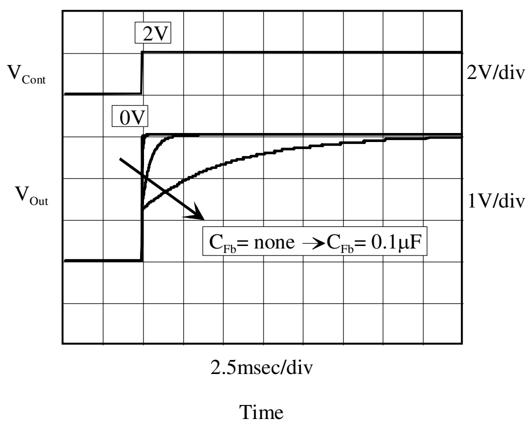
■ V_{Cont}=0.0V→2.0V, I_{Out}=100mA, 500mA, 1000mA



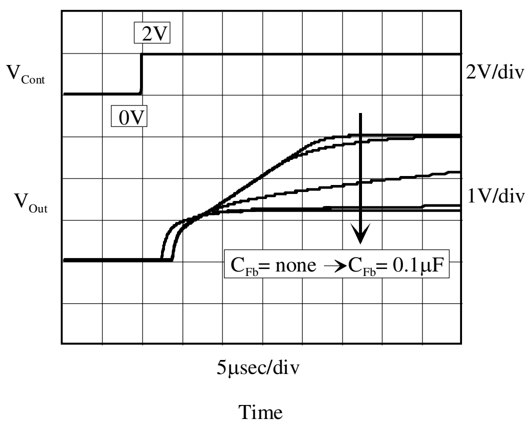
■ V_{Cont}=2.0V→0.0V, I_{Out}=100mA, 500mA, 1000mA



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



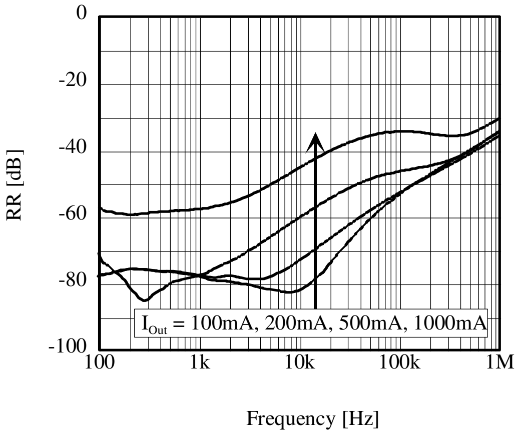
■ V_{Cont}=0.0V→2.0V, C_{Fb}=none~0.1µF*



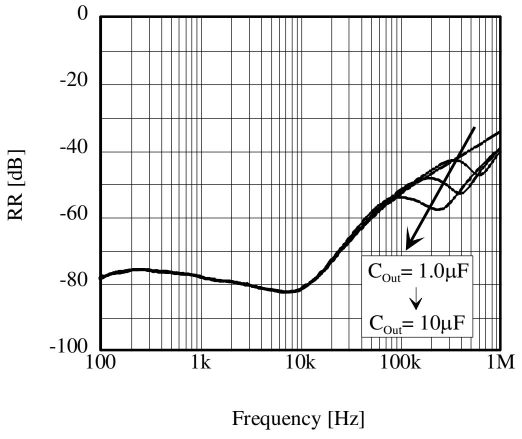
※ C_{Fb}=none, 100pF, 1000pF, 0.001µF, 0.01µF, 0.1µF

11.5 Ripple Rejection

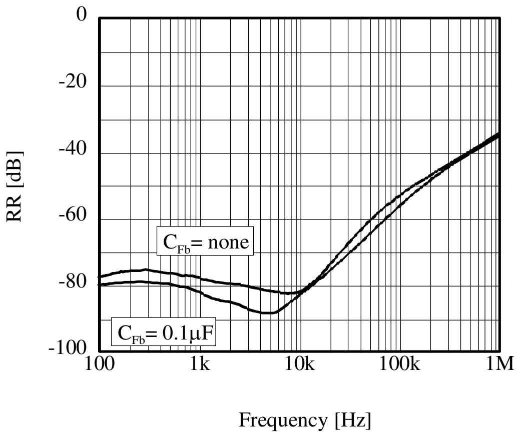
■ I_{Out}=100mA, 200mA, 500mA, 1000mA



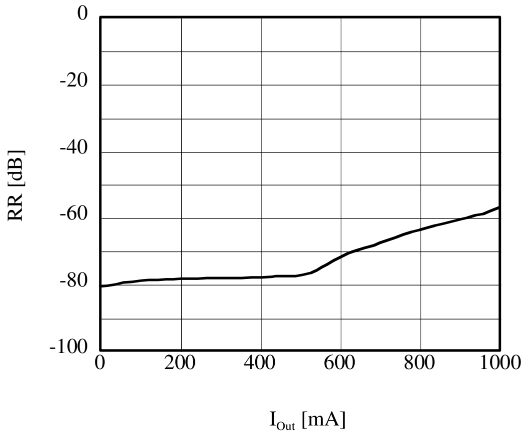
■ C_{Out}=1.0μF, 2.2μF, 4.7μF, 10μF



■ C_{Fb}=none, 0.1μF

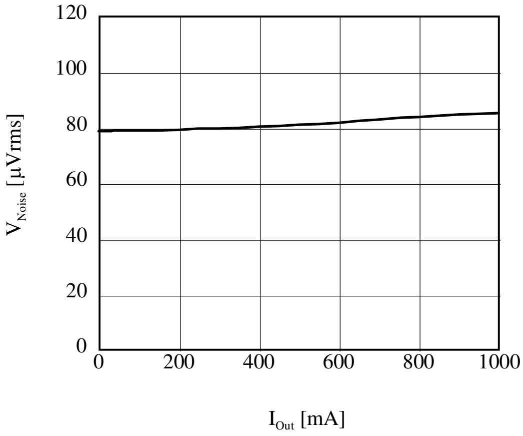


■ I_{Out}=1mA~1000mA, f=1kHz

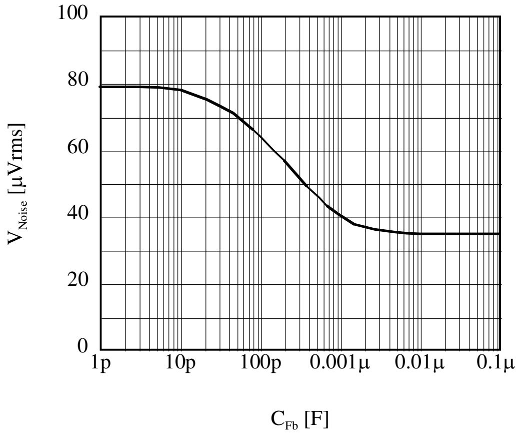


11.6 Output Noise

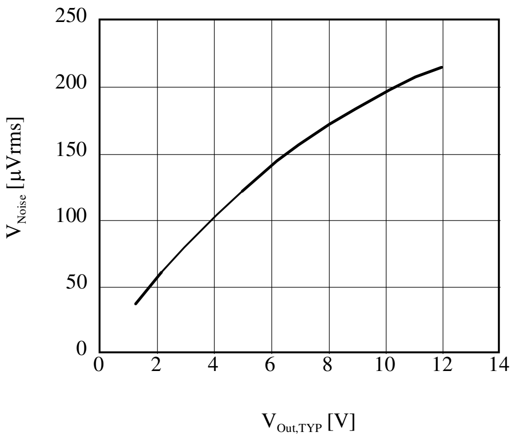
■ $V_{Out,TYP}$=3.0V, I_{Out}=0.1mA~1000mA



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



■ $V_{Out,TYP}$=1.3V ~ 12V



11.7 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.

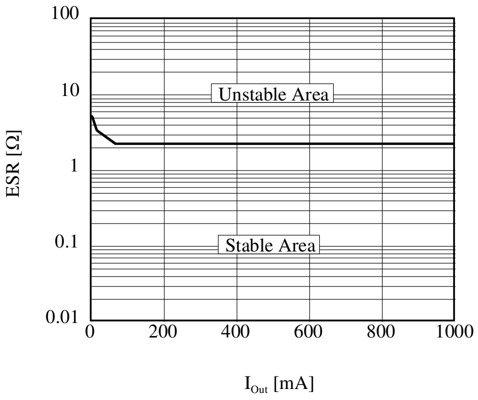


Figure 2. Stable operation area when $V_{Out,TYP}$=3.0V

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.

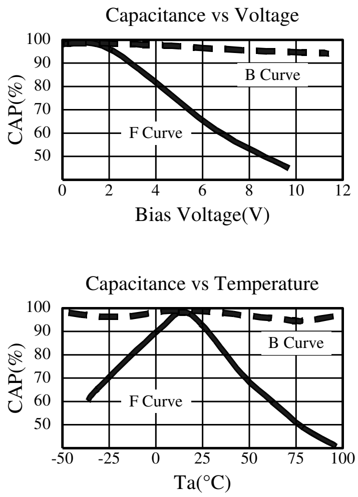


Figure 3. General characteristics of ceramic capacitors

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

11.8 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 AP1155ADU 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.

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

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

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

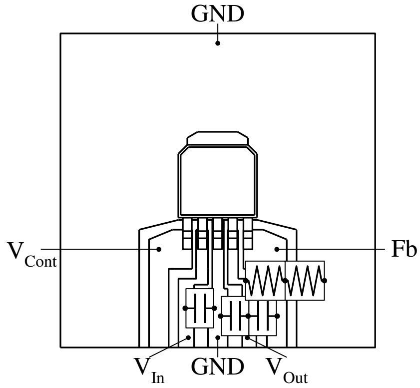


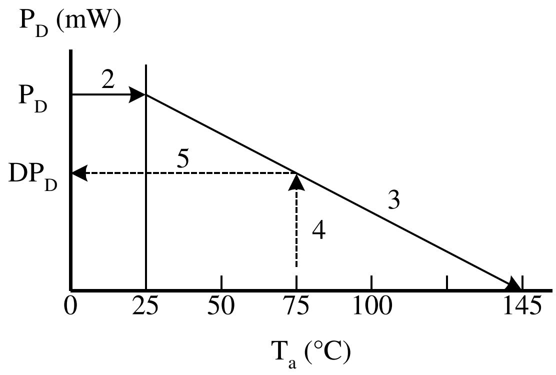
Figure 4. Example of AP1155ADU installation on circuit board
Glass epoxy substrate with double-layer wiring (copper pattern thickness: 35μm)

In the above installation example, P_D is 2200mW. If the temperature exceeds 25°C, be sure to derate at -18.3mW/°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.

12. Definition 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

13. Recommended External Circuits

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

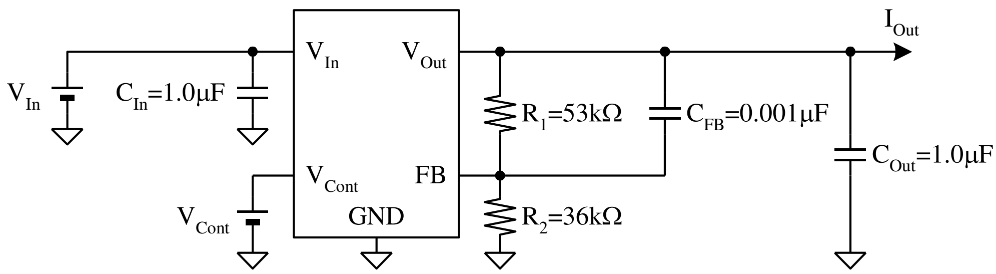


Figure 5. External Circuit

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

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

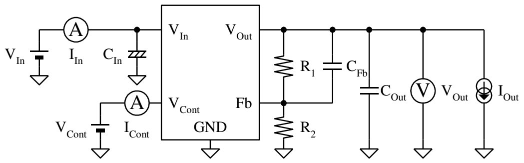
The minimum required current through resistance R_1, R_2 is 30µA, which is determined by $V_{Fb} \div R_2$.

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 11.7 Stability.

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.

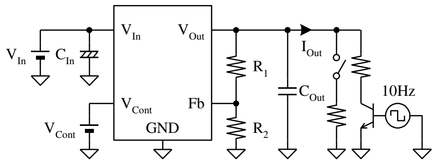
■Test Circuit

■ Test circuit for DC characteristics



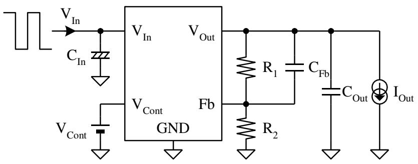
$V_{Out,TYP}$=3.0V(R_1=53kΩ, R_2=36kΩ)
V_{In}=4.0V, V_{Cont}=1.8V, I_{Out}=5mA
C_{In}=1.0μF(Tantalum), C_{Fb}=0.001μF(Ceramic),
C_{Out}=1.0μF(Ceramic), T_a=25°C

■ Test circuit for Load Transient



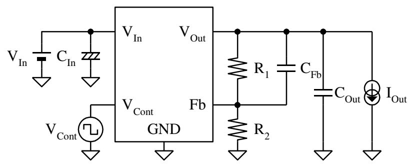
$V_{Out,TYP}$=3.0V(R_1=53kΩ, R_2=36kΩ)
V_{In}=4.0V, V_{Cont}=1.8V
C_{In}=1.0μF(Tantalum), T_a=25°C

■ Test circuit for Line Transient



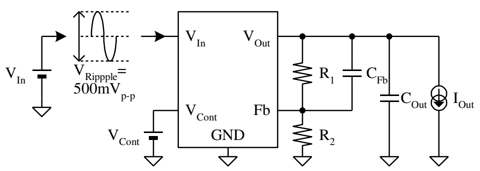
$V_{Out,TYP}$=3.0V(R_1=53kΩ, R_2=36kΩ)
V_{In}=4.0V↔5.0V(100Hz), V_{Cont}=1.8V, I_{Out}=100mA
C_{In}=1.0μF(Tantalum), C_{Fb}=none, T_a=25°C

■ Test circuit for On/Off Transient



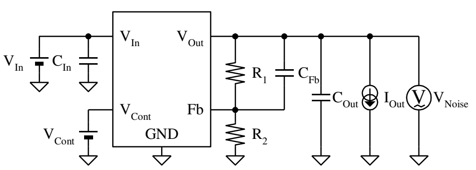
$V_{Out,TYP}$=3.0V(R_1=53kΩ, R_2=36kΩ)
V_{In}=4.0V, V_{Cont}=0.0V↔2.0V(10Hz), I_{Out}=100mA
C_{In}=1.0μF(Tantalum), C_{Fb}=none, T_a=25°C

■ 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}=500m$V_{p\text{-}p}$, I_{Out}=100mA
C_{In}=none, C_{Fb}=none, T_a=25°C

■ Test circuit for Output Noise

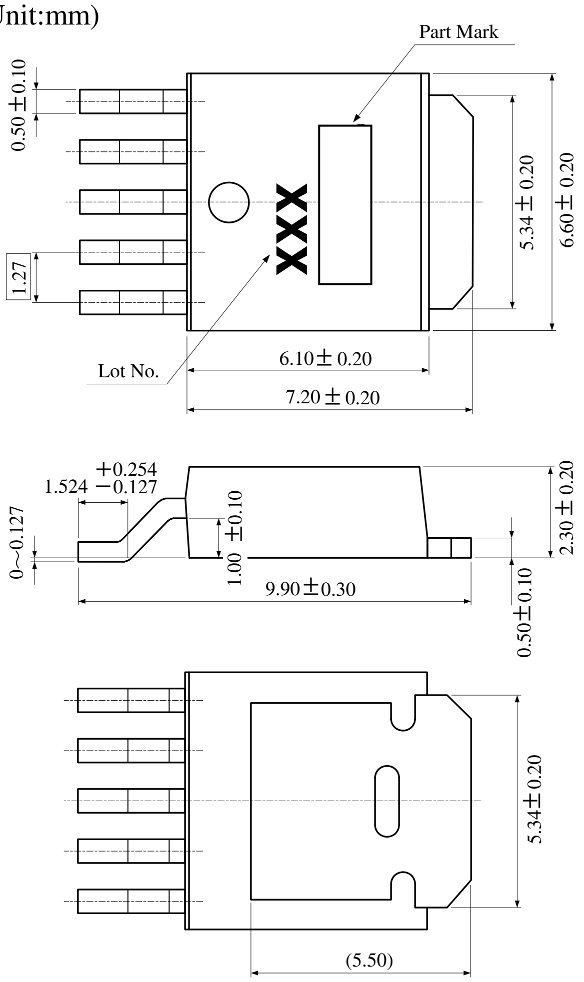


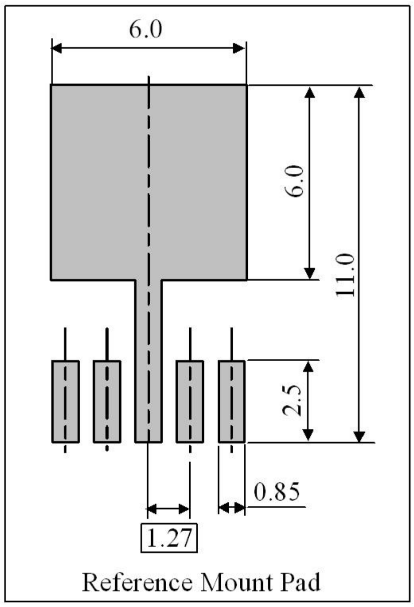
R_2=36kΩ
V_{In}=$V_{Out,TYP}$+1.0V, V_{Cont}=2.0V, I_{Out}=100mA
BPF=400Hz~80kHz
C_{In}=C_{Out}=1.0μF(Ceramic), C_{Fb}=none, T_a=25°C

14. Package

■ Outline Dimensions

(Unit:mm)





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