Pb Free ROHM Electronic Components
RoHS Directive Compliance

Operational Amplifier Series

Automotive Ground Sense Operational Amplifiers

BA2904Yxxx-M, BA2902Yxx-M

●General Description

Automotive series BA2904Yxxx-M/BA2902Yxx-M integrate two or four independent Op-Amps and ground sense input Amplifier on a single chip and have some features of high-gain, low power consumption, and operating voltage range of 3V to 32V (single power supply). BA2904Yxxx-M, BA2902Yxx-M are manufactured for automotive requirements of car navigation system, car audio, and so on.

●Key Specifications

- Wide operating supply voltage
  - single supply : +3.0V to +32V
  - dual supply : ±1.5V to ±16V
- low supply current
  - BA2904Yxxx-M BA2902Yxx-M 0.7mA(Typ.)
- input bias current : 20nA(Typ.)
- input offset current : 2nA(Typ.)
- Operating temperature range : -40℃ to +125℃

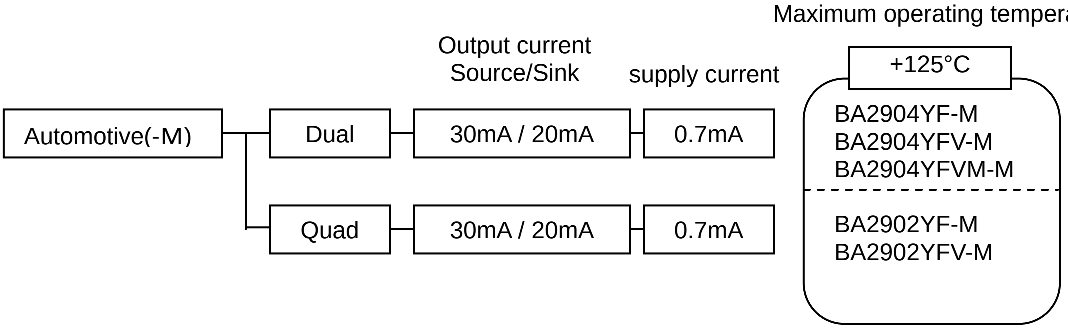
●Features

- Operable with a single power supply
- Wide operating supply voltage
- Standard Op-Amp Pin-assignments
- Input and output are operable GND sense
- Low supply current
- High open loop voltage gain
- Internal ESD protection circuit
- Wide temperature range

●Packages

Package	W(Typ.) x D(Typ.) x H(Max.)
SOP8	5.00mm x 6.20mm x 1.71mm
SOP14	8.70mm x 6.20mm x 1.71mm
SSOP-B8	3.00mm x 6.40mm x 1.35mm
SSOP-B14	5.00mm x 6.40mm x 1.35mm
MSOP8	2.90mm x 4.00mm x 0.90mm

●Selection Guide



○Product structure：Silicon monolithic integrated circuit ○This product is not designed protection against radioactive rays.

●Block Diagram

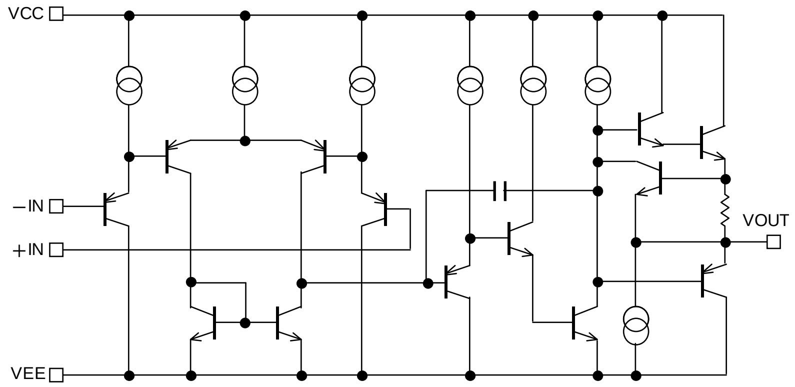
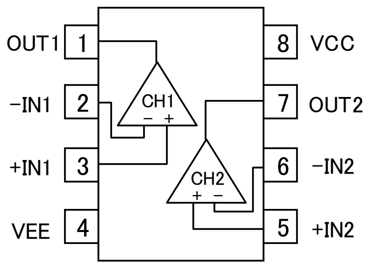
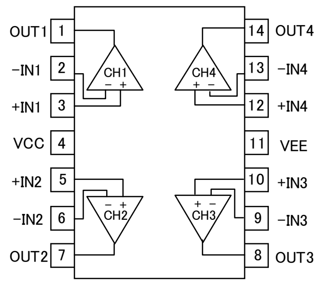


Fig.1 Simplified schematic (one channel only)

●Pin Configuration



SOP8 SSOP-B8 MSOP8



SOP14 SSOP-B14

Package				
SOP8	SSOP-B8	MSOP8	SOP14	SSOP-B14
BA2904YF-M	BA2904YFV-M	BA2904YFVM-M	BA2902YF-M	BA2902YFV-M

●Ordering Information

B A 2 9 0 x Y x x x - M x x

Parts Number.
BA2904Yxxx
BA2902Yxx

Package
F : SOP8
SOP14
FV : SSOP-B8
SSOP-B14
FVM : MSOP8

Packaging and forming specification
E2: Embossed tape and reel
(SOP8/SOP14/SSOP-B8/SSOP-B14)
TR: Embossed tape and reel
(MSOP8)
M: Automotive

●Line-up

Topr	Supply voltage	2channel /4channel	Package		Ordarable Parts Number
-40°C to +125°C	+3 to +32V	Dual	SOP8	Reel of 2500	BA2904YF-ME2
			SSOP-B8	Reel of 2500	BA2904YFV-ME2
			MSOP8	Reel of 3000	BA2904YFVM-MTR
		Quad	SOP14	Reel of 2500	BA2902YF-ME2
			SSOP-B14	Reel of 2500	BA2902YFV-ME2

●**Absolute Maximum Ratings**(Ta=25℃)

Parameter	Symbol		Ratings	Unit
Supply Voltage	VCC-VEE		+36	V
Power Dissipation	Pd	SOP8	780[*1*6]	mW
		SSOP-B8	690[*2*6]	
		MSOP8	590[*3*6]	
		SOP14	610[*4*6]	
		SSOP-B14	870[*5*6]	
Differential Input Voltage [*7]	Vid		+36	V
Input Common-mode Voltage Range	Vicm		(VEE-0.3) to (VEE+36)	V
Operating Supply Voltage	Vopr		+3.0 to +32 (±1.5 to ±16)	V
Operating Temperature Range	Topr		-40 to +125	℃
Storage Temperature Range	Tstg		-55 to +150	℃
Maximum Junction Temperature	Tjmax		+150	℃

Note: Absolute maximum rating item indicates the condition which must not be exceeded.
Application if voltage in excess of absolute maximum rating or use out of absolute maximum rated temperature environment may cause deterioration of characteristics.

*1 To use at temperature above Ta＝25℃ reduce 6.2mW/℃.
*2 To use at temperature above Ta＝25℃ reduce 5.5mW/℃.
*3 To use at temperature above Ta＝25℃ reduce 4.8mW/℃.
*4 To use at temperature above Ta＝25℃ reduce 7.0mW/℃.
*5 To use at temperature above Ta＝25℃ reduce 4.9mW/℃.
*6 Mounted on a FR4 glass epoxy PCB(70mm×70mm×1.6mm).
*7 The voltage difference between inverting input and non-inverting input is the differential input voltage.
Then input terminal voltage is set to more than VEE.

●Electrical Characteristics

○BA2904Yxxx-M (Unless otherwise specified VCC=+5V, VEE=0V)

Parameter	Symbol	Temperature Range	Limits Min.	Limits Typ.	Limits Max.	Unit	Conditions
Input Offset Voltage*8	Vio	25℃	-	2	7	mV	VOUT=1.4V
		Full range	-	-	10		VCC=5 to 30V, VOUT=1.4V
Input Offset Voltage drift	△Vio/△T	-	-	±7	-	μV/℃	VOUT=1.4V
Input Offset Current*8	Iio	25℃	-	2	50	nA	VOUT=1.4V
		Full range	-	-	200		
Input Offset Current drift	ΔIio/ΔT	-	-	±10	-	pA/℃	VOUT=1.4V
Input Bias Current*8	Ib	25℃	-	20	250	nA	VOUT=1.4V
		Full range	-	-	250		
Supply Current	ICC	25℃	-	0.7	1.2	mA	RL=∞, All Op-Amps
		Full range	-	-	2		
High Level Output Voltage	VOH	25℃	3.5	-	-	V	RL=2kΩ
		Full range	27	28	-		VCC=30V, RL=10kΩ
Low Level Output Voltage	VOL	Full range	-	5	20	mV	RL=∞, All Op-Amps
Large Signal Voltage Gain	AV	25℃	25	100	-	V/mV	RL≧2kΩ, VCC=15V VOUT=1.4 to 11.4V
Input Common-mode Voltage range	Vicm	25℃	0	-	VCC-1.5	V	(VCC-VEE)=5V VOUT=VEE+1.4V
Common-mode Rejection Ratio	CMRR	25℃	50	80	-	dB	VOUT=1.4V
Power Supply Rejection Ratio	PSRR	25℃	65	100	-	dB	VCC=5 to 30V
Output Source Current*9	IOH	25℃	20	30	-	mA	VIN+=1V, VIN-=0V VOUT=0V, 1CH is short circuit
		Full range	10	-	-		
Output Sink Current*9	IOL	25℃	10	20	-	mA	VIN+=0V,VIN-=1V VOUT=5V, 1CH is short circuit
		Full range	2	-	-		
	Isink	25℃	12	40	-	μA	VIN+=0V, VIN-=1V VOUT=200mV
Channel Separation	CS	25℃	-	120	-	dB	f=1kHz, input referred
Slew Rate	SR	25℃	-	0.2	-	V/μs	VCC=15V, AV=0dB RL=2kΩ, CL=100pF
Gain bandwidth product	GBW	25℃	-	0.5	-	MHz	VCC=30V, RL=2kΩ CL=100pF
Input Referred Noise Voltage	Vn	25℃	-	40	-	$nV/\sqrt{Hz}$	VCC=15V, VEE=-15V RS=100Ω, Vi=0V, f=1kHz

*8 Absolute value
*9 Under high temperatures, please consider the power dissipation when selecting the output current.
When the output terminal is continuously shorted the output current reduces the internal temperature by flushing.

●**Electrical Characteristics**

○BA2902Yxx-M (Unless otherwise specified VCC=+5V, VEE=0V)

Parameter	Symbol	Temperature Range	Limits Min.	Limits Typ.	Limits Max.	Unit	Conditions
Input Offset Voltage*10	Vio	25℃	-	2	7	mV	VOUT=1.4V
		Full range	-	-	10		VCC=5 to 30V, VOUT=1.4V
Input Offset Voltage drift	ΔVio/ΔT	-	-	±7	-	μV/℃	VOUT=1.4V
Input Offset Current*10	Iio	25℃	-	2	50	nA	VOUT=1.4V
		Full range	-	-	200		
Input Offset Current drift	ΔIio/ΔT	-	-	±10	-	pA/℃	VOUT=1.4V
Input Bias Current*10	Ib	25℃	-	20	250	nA	VOUT=1.4V
		Full range	-	-	250		
Supply Current	ICC	25℃	-	0.7	2	mA	RL=∞, All Op-Amps
		Full range	-	-	3		
High Level Output Voltage	VOH	25℃	3.5	-	-	V	RL=2kΩ
		Full range	27	28	-		VCC=30V, RL=10kΩ
Low Level Output Voltage	VOL	Full range	-	5	20	mV	RL=∞, All Op-Amps
Large Signal Voltage Gain	AV	25℃	25	100	-	V/mV	RL≧2kΩ, VCC=15V VOUT=1.4 to 11.4V
Input Common-mode Voltage range	Vicm	25℃	0	-	VCC-1.5	V	(VCC-VEE)=5V VOUT=VEE+1.4V
Common-mode Rejection Ratio	CMRR	25℃	50	80	-	dB	VOUT=1.4V
Power Supply Rejection Ratio	PSRR	25℃	65	100	-	dB	VCC=5 to 30V
Output Source Current*11	IOH	25℃	20	30	-	mA	VIN+=1V, VIN-=0V VOUT=0V, 1CH is short circuit
		Full range	10	-	-		
Output Sink Current*11	IOL	25℃	10	20	-	mA	VIN+=0V,VIN-=1V VOUT=5V, 1CH is short circuit
		Full range	2	-	-		
	Isink	25℃	12	40	-	μA	VIN+=0V, VIN-=1V VOUT=200mV
Channel Separation	CS	25℃	-	120	-	dB	f=1kHz, input referred
Slew Rate	SR	25℃	-	0.2	-	V/μs	VCC=15V, AV=0dB RL=2kΩ, CL=100pF
Gain bandwidth product	GBW	25℃	-	0.5	-	MHz	VCC=30V, RL=2kΩ CL=100pF
Input Referred Noise Voltage	Vn	25℃	-	40	-	$nV/\sqrt{Hz}$	VCC=15V, VEE=-15V RS=100Ω, Vi=0V, f=1kHz

*10 Absolute value

*11 Under high temperatures, please consider the power dissipation when selecting the output current.
When the output terminal is continuously shorted the output current reduces the internal temperature by flushing.

Description of Electrical Characteristics
Described below are descriptions of the relevant electrical terms
Please note that item names, symbols and their meanings may differ from those on another manufacturer's documents.

1. Absolute maximum ratings
The absolute maximum ratings are values that should never be exceeded, since doing so may result in deterioration of electrical characteristics or damage to the part itself as well as peripheral components.

1.1 Power supply voltage (VCC-VEE)
Expresses the maximum voltage that can be supplied between the positive and negative supply terminals without causing deterioration of the electrical characteristics or destruction of the internal circuitry.

1.2 Differential input voltage (Vid)
Indicates the maximum voltage that can be supplied between the non-inverting and inverting terminals without damaging the IC.

1.3 Input common-mode voltage range (Vicm)
Signifies the maximum voltage that can be supplied to non-inverting and inverting terminals without causing deterioration of the characteristics or damage to the IC itself. Normal operation is not guaranteed within the common-mode voltage range of the maximum ratings - use within the input common-mode voltage range of the electric characteristics instead.

1.4 Operating and storage temperature ranges (Topr,Tstg)
The operating temperature range indicates the temperature range within which the IC can operate. The higher the ambient temperature, the lower the power consumption of the IC. The storage temperature range denotes the range of temperatures the IC can be stored under without causing excessive deterioration of the electrical characteristics.

1.5 Power dissipation (Pd)
Indicates the power that can be consumed by a particular mounted board at ambient temperature (25℃). For packaged products, Pd is determined by the maximum junction temperature and the thermal resistance.

2. Electrical characteristics

2.1 Input offset voltage (Vio)
Indicates the voltage difference between the non-inverting and inverting terminals. It can be thought of as the input voltage difference required for setting the output voltage to 0 V.

2.2 Input offset voltage drift (△Vio/△T)
Denotes the ratio of the input offset voltage fluctuation to the ambient temperature fluctuation.

2.3 Input offset current (Iio)
Indicates the difference of input bias current between the non-inverting and inverting terminals.

2.4 Input offset current drift (△Iio/△T)
Signifies the ratio of the input offset current fluctuation to the ambient temperature fluctuation.

2.5 Input bias current (Ib)
Indicates the current that flows into or out of the input terminal, it is defined by the average of the input bias current at the non-inverting terminal and the input bias current at the inverting terminal.

2.6 Circuit current (ICC)
Indicates the current of the IC itself that flows under specified conditions and during no-load steady state.

2.7 High level output voltage/low level output voltage (VOH/VOL)
Indicates the voltage range that can be output by the IC under specified load condition. It is typically divided into high-level output voltage and low-level output voltage. High-level output voltage indicates the upper limit of output voltage. Low-level output voltage indicates the lower limit.

2.8 Large signal voltage gain (AV)
Indicates the amplifying rate (gain) of output voltage against the voltage difference between non-inverting terminal and inverting terminal. It is normally the amplifying rate (gain) with reference to DC voltage.
Av = (Output voltage fluctuation) / (Input offset fluctuation)

2.9 Input common-mode voltage range (Vicm)
Indicates the input voltage range under which the IC operates normally.

2.10 Common-mode rejection ratio (CMRR)
Indicates the ratio of fluctuation of input offset voltage when in-phase input voltage is changed. It is normally the fluctuation of DC.
CMRR = (Change of Input common-mode voltage)/(Input offset fluctuation)

2.11 Power supply rejection ratio (PSRR)
Indicates the ratio of fluctuation of input offset voltage when supply voltage is changed. It is normally the fluctuation of DC. PSRR= (Change of power supply voltage)/(Input offset fluctuation)

2.12 Output source current/ output sink current (IOH/IOL)
The maximum current that can be output under specific output conditions, it is divided into output source current and output sink current. The output source current indicates the current flowing out of the IC, and the output sink current the current flowing into the IC.

2.13 Channel separation (CS)
Indicates the fluctuation of output voltage with reference to the change of output voltage of driven channel.

2.14 Slew rate (SR)
SR is a parameter that shows movement speed of operational amplifier. It indicates rate of variable output voltage as unit time.

2.15 Gain Band Width (GBW)
Indicates to multiply by the frequency and the gain where the voltage gain decreases 6dB/octave.

2.16 Input referred noise voltage (Vn)
Indicates a noise voltage generated inside the operational amplifier equivalent by ideal voltage source connected in series with input terminal.

●**Typical Performance Curves**

○BA2904Yxxx-M

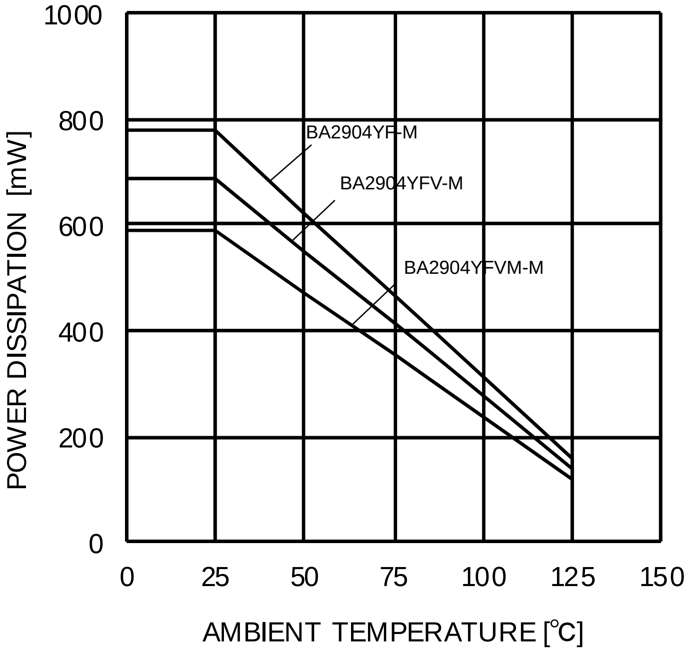


Fig.2
Derating Curve

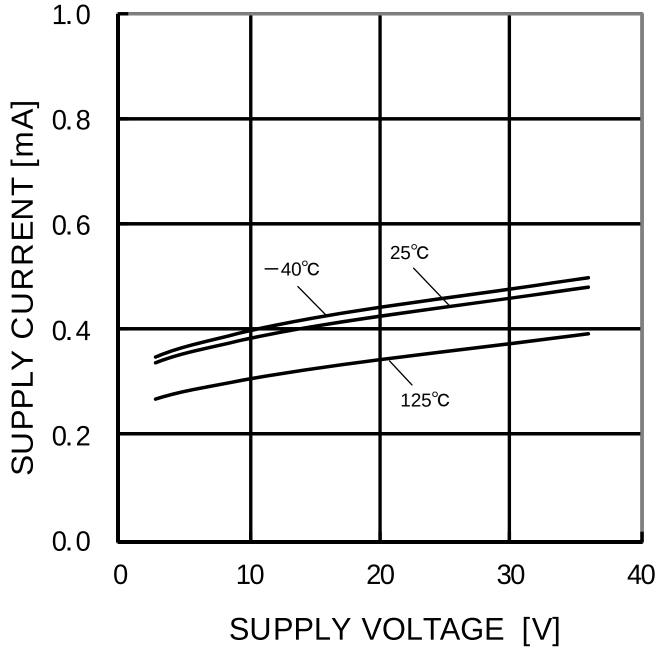


Fig.3
Supply Current – Supply Voltage

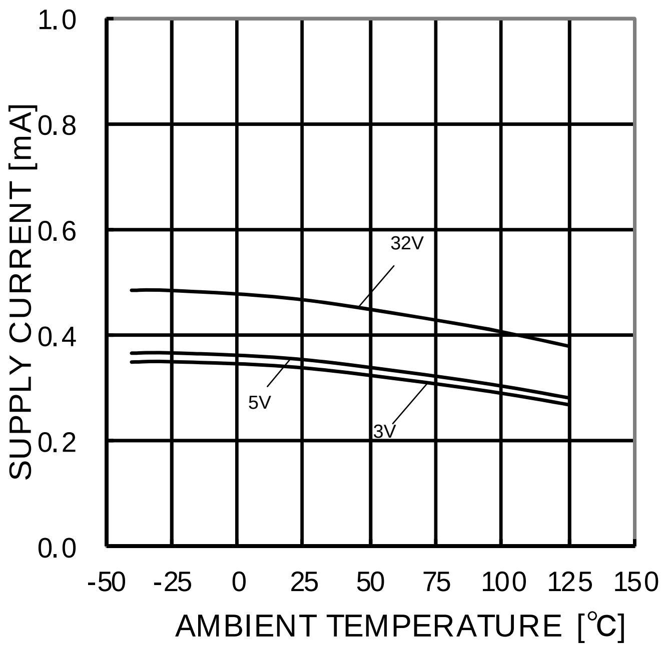


Fig.4
Supply Current – Ambient Temperature

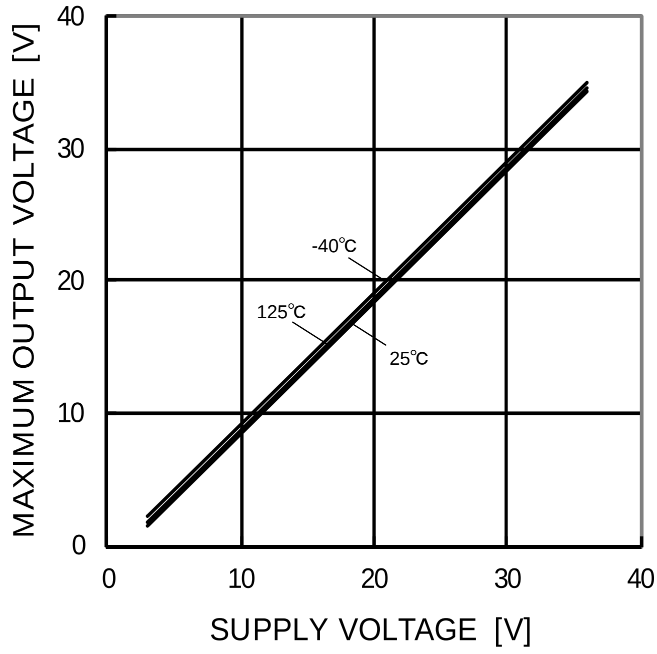


Fig.5
Maximum Output Voltage – Supply Voltage
(RL=10kΩ)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2904Yxxx-M

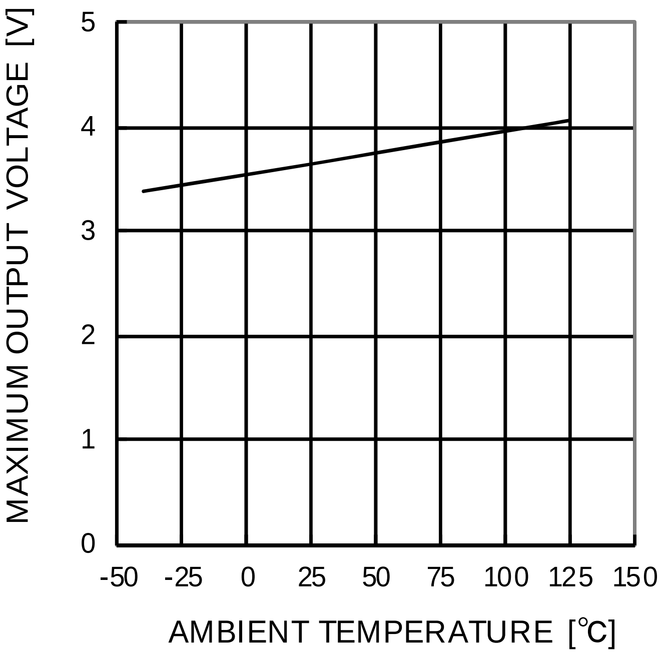


Fig.6
Maximum Output Voltage – Ambient Temperature
(VCC=5V, RL=2kΩ)

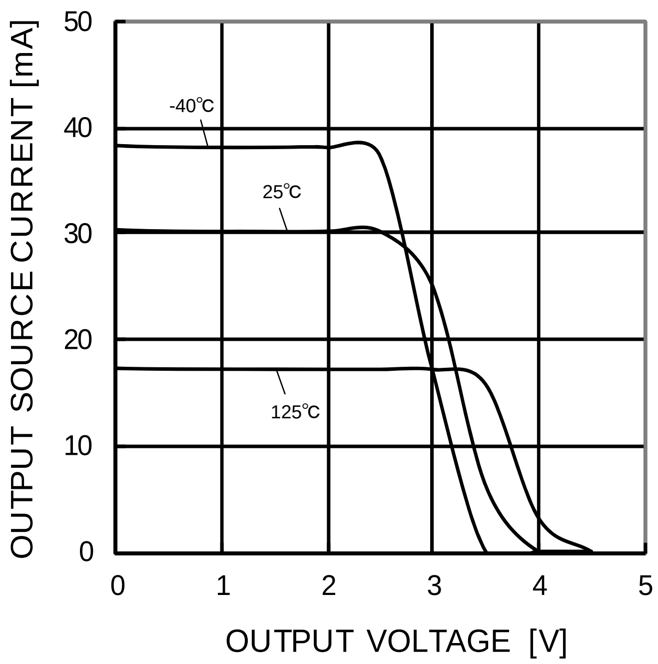


Fig.7
Output Source Current – Output Voltage
(VCC=5V)

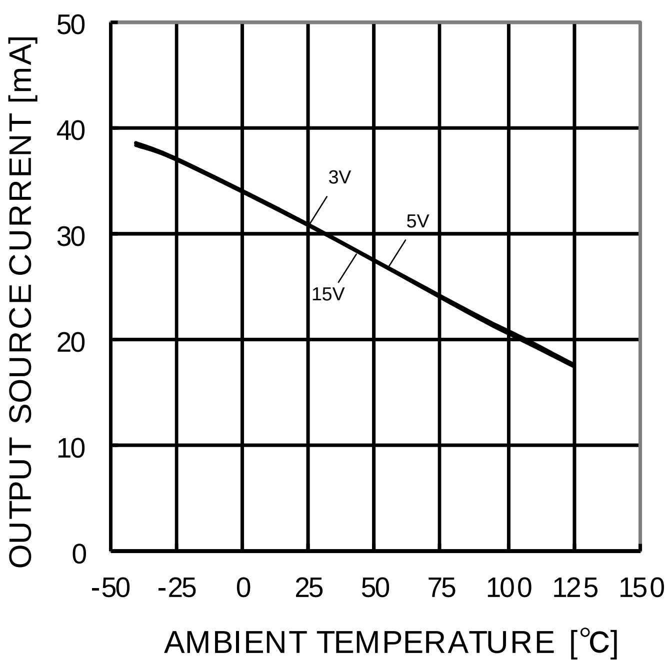


Fig.8
Output Source Current – Ambient Temperature
(VOUT=0V)

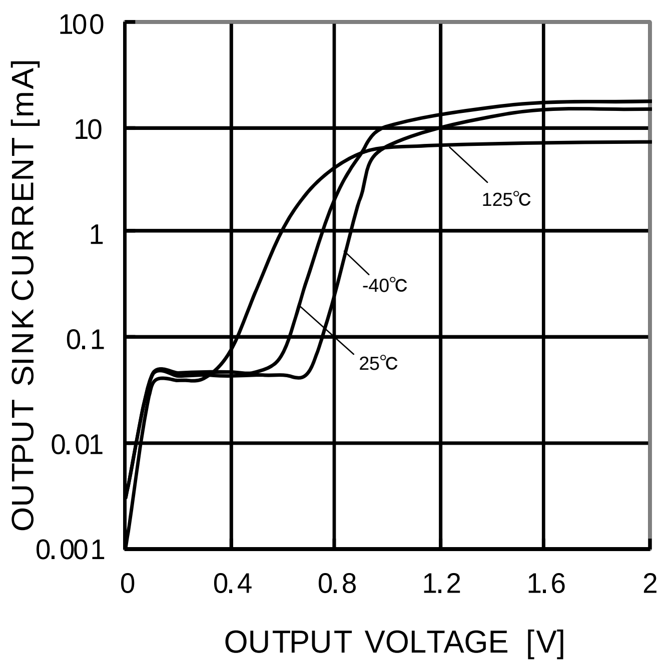


Fig.9
Output Sink Current – Output Voltage
(VCC=5V)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2904Yxxx-M

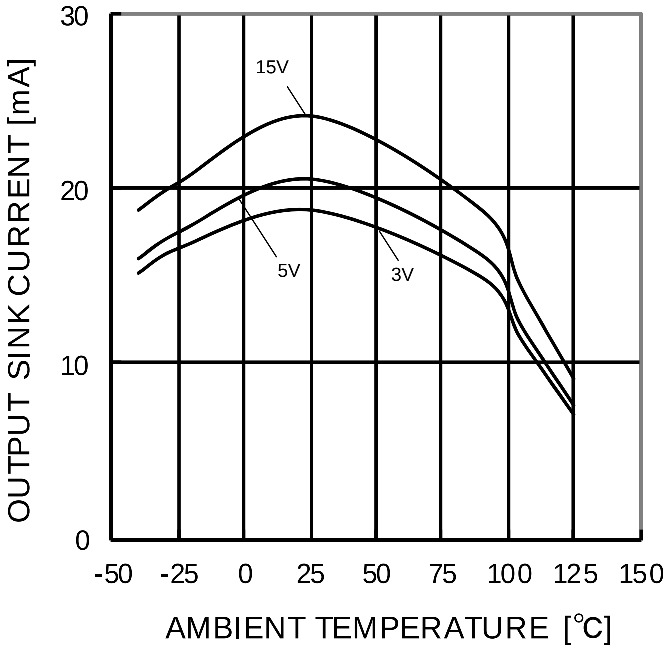


Fig.10
Output Sink Current – Ambient Temperature
(VOUT=VCC)

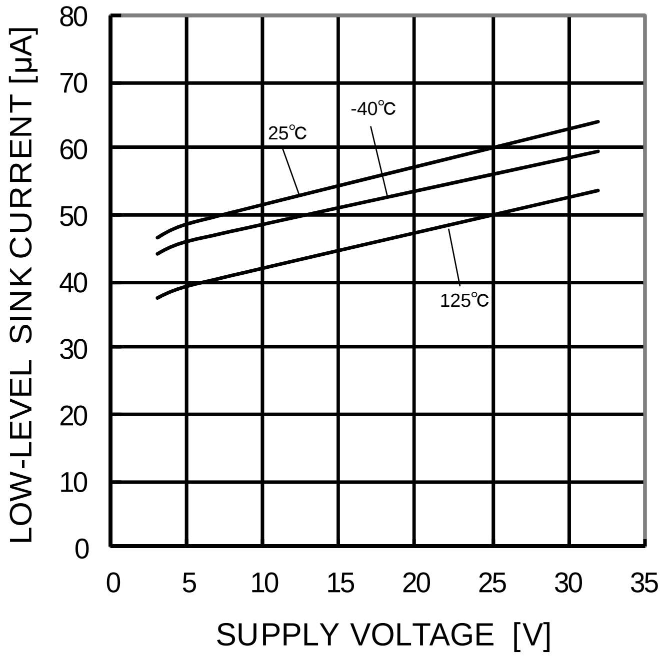


Fig.11
Low Level Sink Current – Supply Voltage
(VOUT=0.2V)

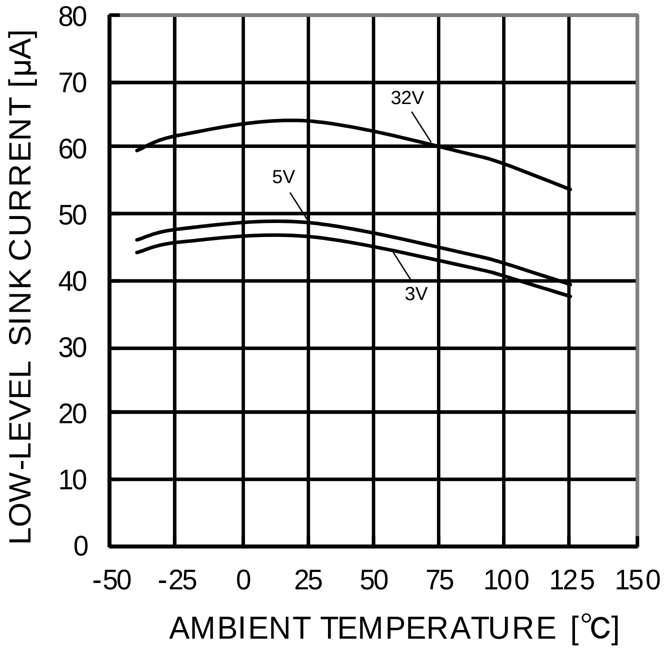


Fig.12
Low Level Sink Current – Ambient Temperature
(VOUT=0.2V)

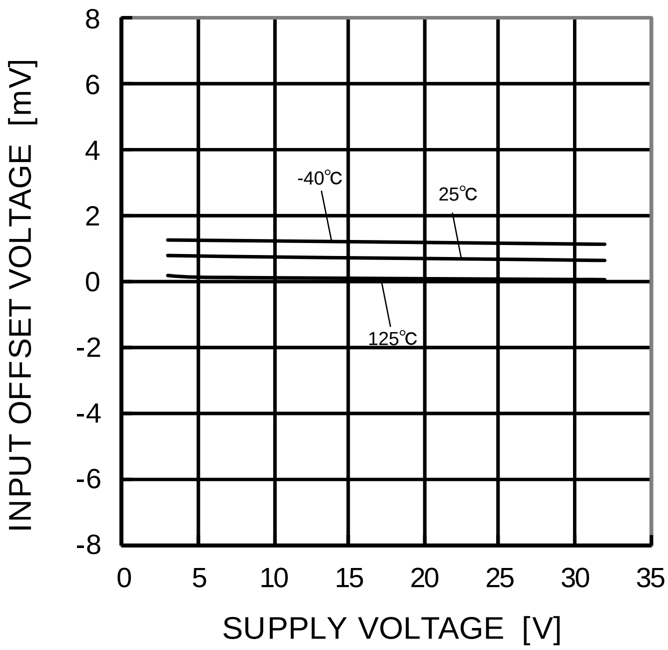


Fig.13
Input Offset Voltage – Supply Voltage
(Vicm=0V, VOUT=1.4V)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2904Yxxx-M

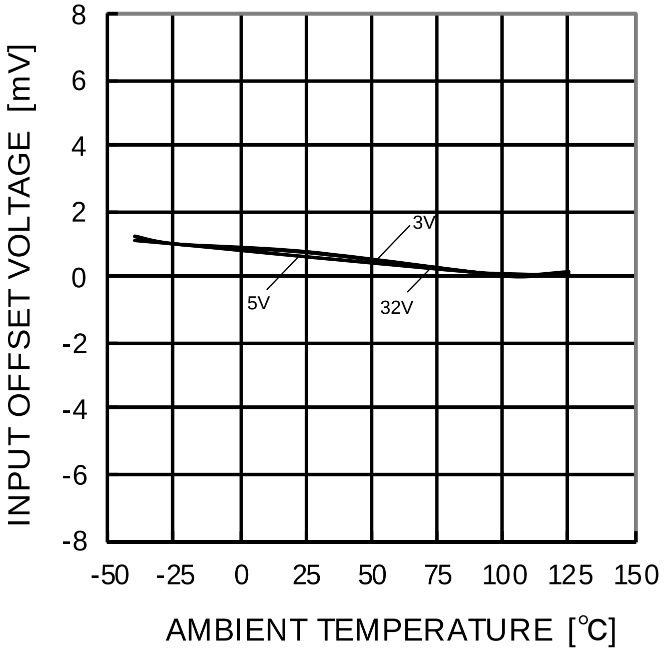


Fig.14
Input Offset Voltage – Ambient Temperature
(Vicm=0V, VOUT=1.4V)

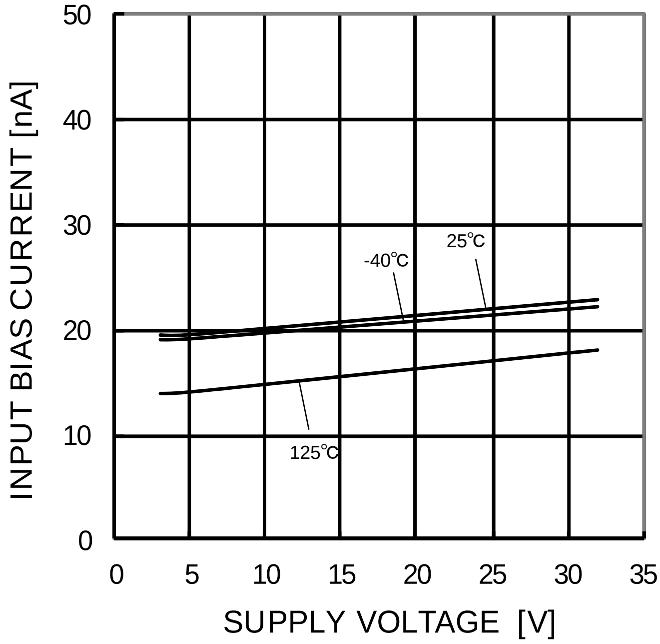


Fig.15
Input Bias Current – Supply Voltage
(Vicm=0V, VOUT=1.4V)

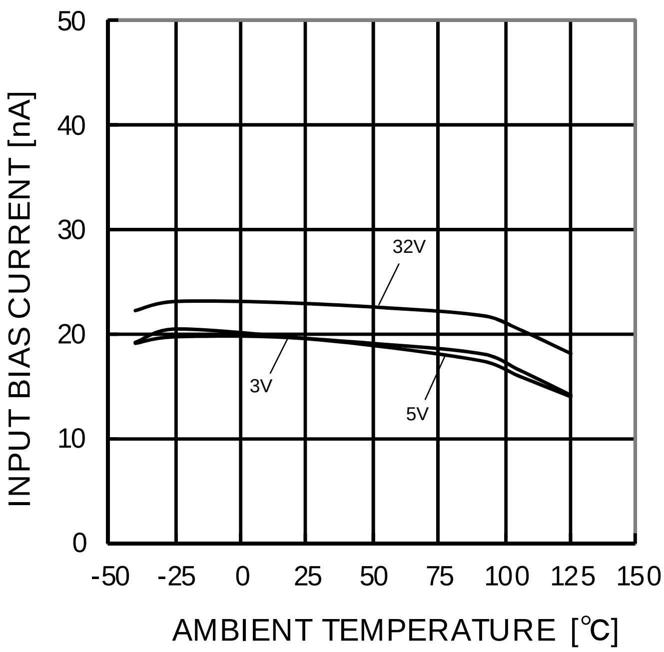


Fig.16
Input Bias Current – Ambient Temperature
(Vicm=0V, VOUT=1.4V)

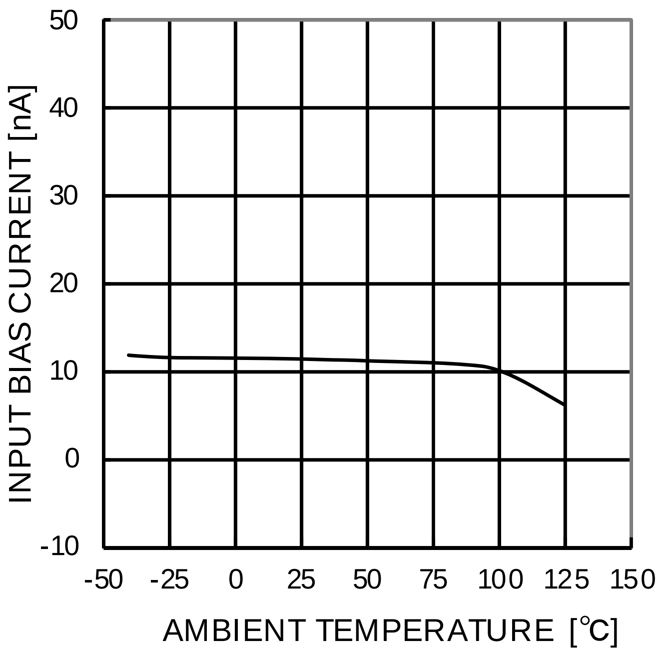


Fig.17
Input Bias Current – Ambient Temperature
(VCC=30V, Vicm=28V, VOUT=1.4V)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2904Yxxx-M

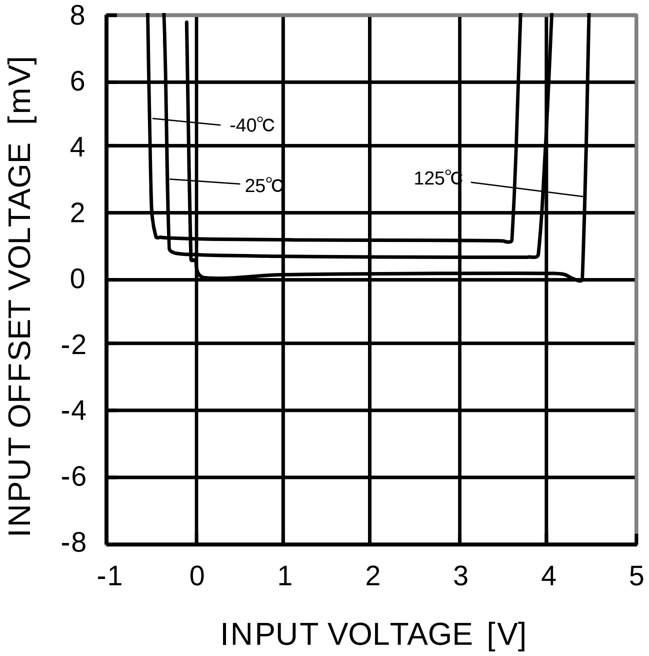


Fig.18
Input Offset Voltage – Input Voltage
(VCC=5V)

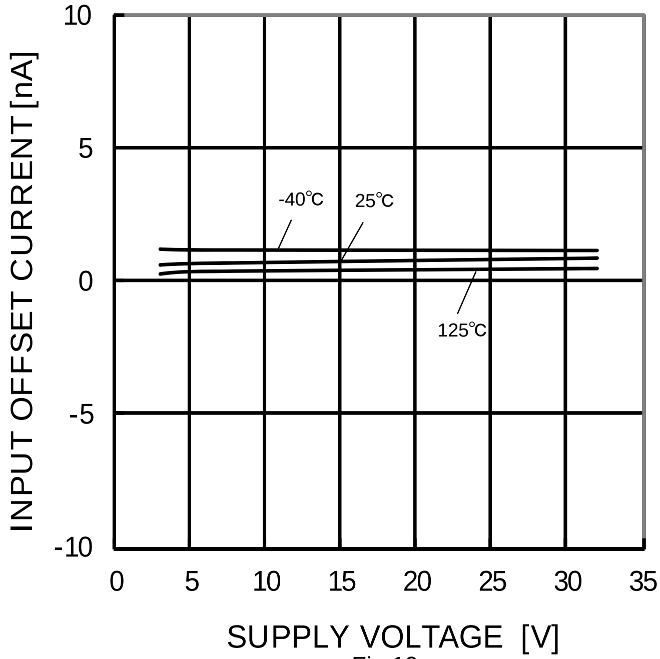


Fig.19
Input Offset Current – Supply Voltage
(Vicm=0V, VOUT=1.4V)

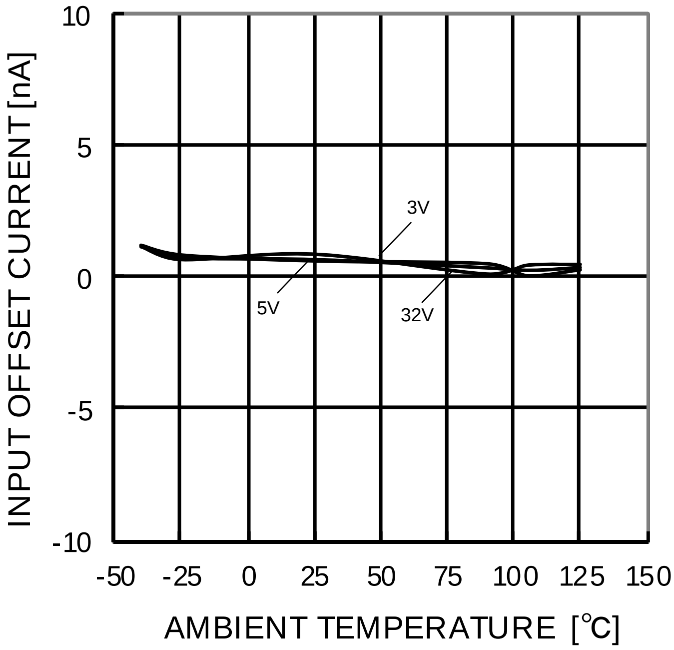


Fig.20
Input Offset Current – Ambient Temperature
(Vicm=0V, VOUT=1.4V)

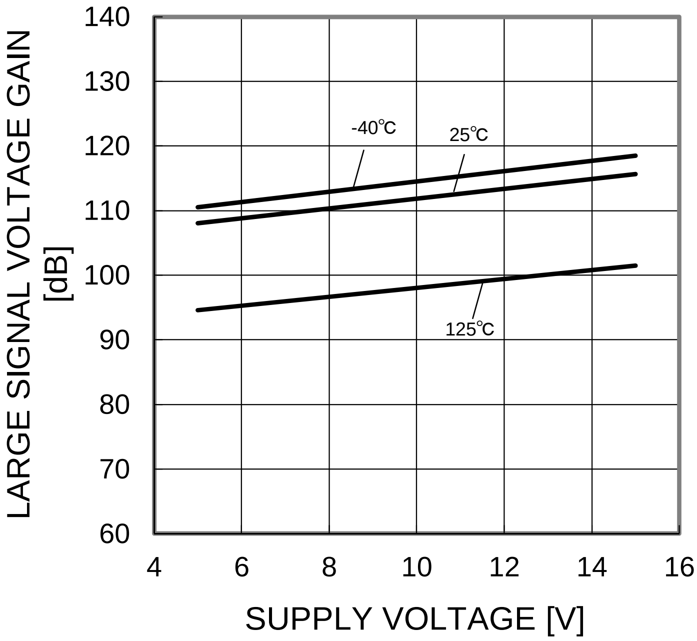


Fig.21
Large Signal Voltage Gain – Supply Voltage
(RL=2kΩ)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2904Yxxx-M

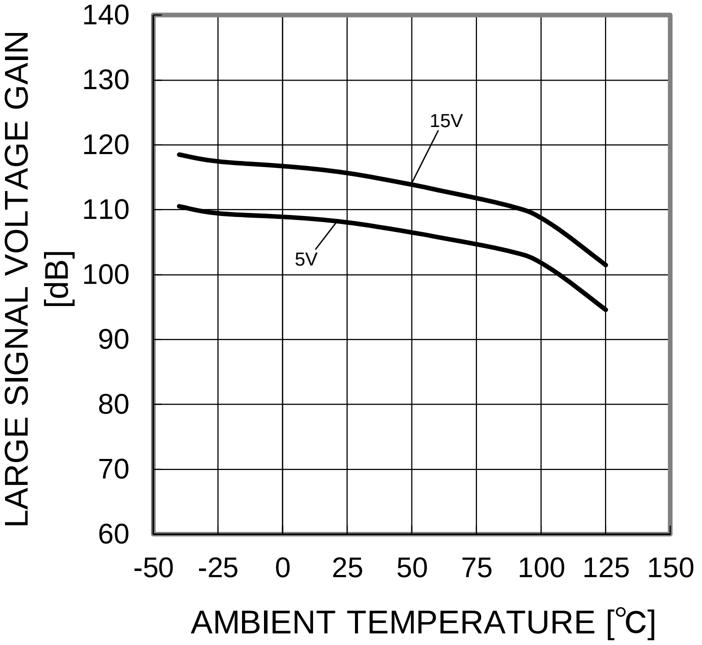


Fig.22
Large Signal Voltage Gain – Ambient Temperature
(RL=2kΩ)

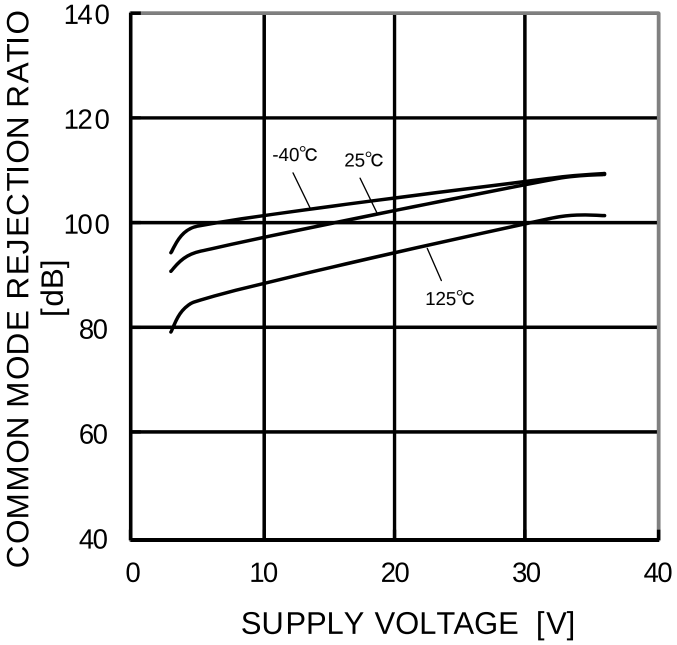


Fig.23
Common Mode Rejection Ratio
– Supply Voltage

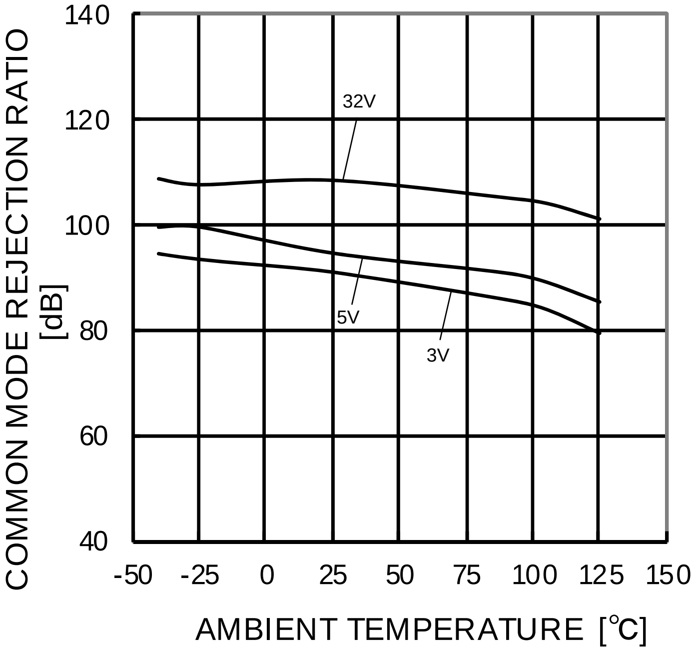


Fig.24
Common Mode Rejection Ratio
– Ambient Temperature

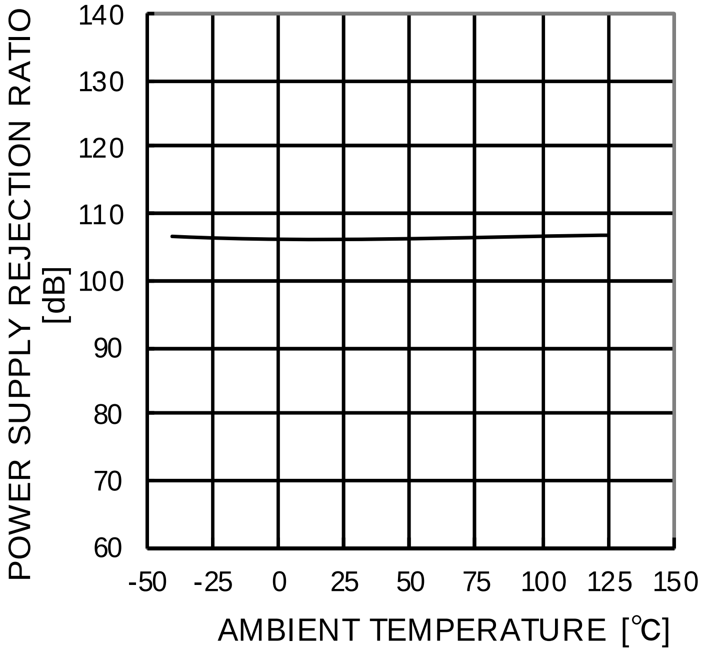


Fig.25
Power Supply Rejection Ratio
– Ambient Temperature

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2902Yxxx-M

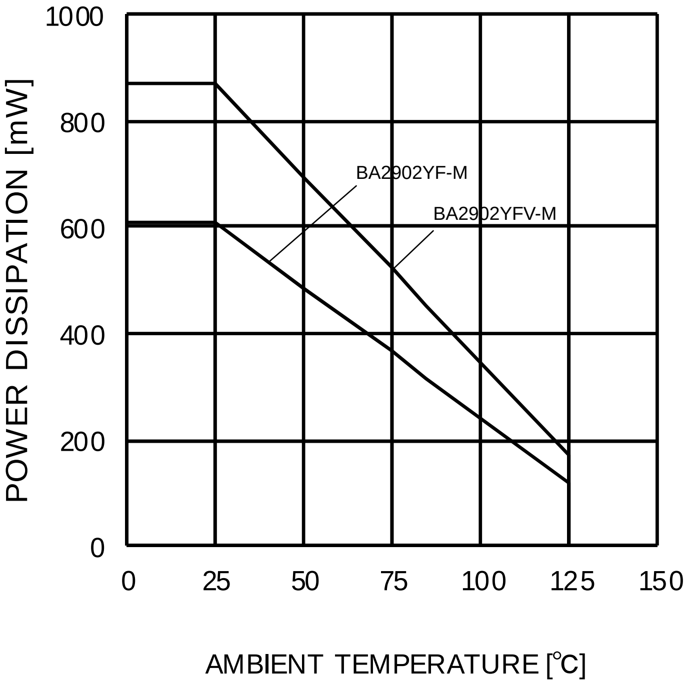


Fig.26
Derating Curve

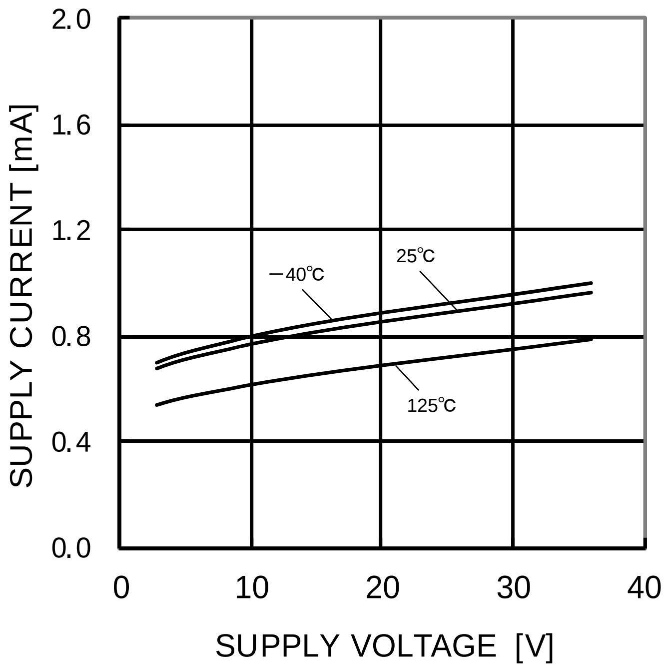


Fig.27
Supply Current – Supply Voltage

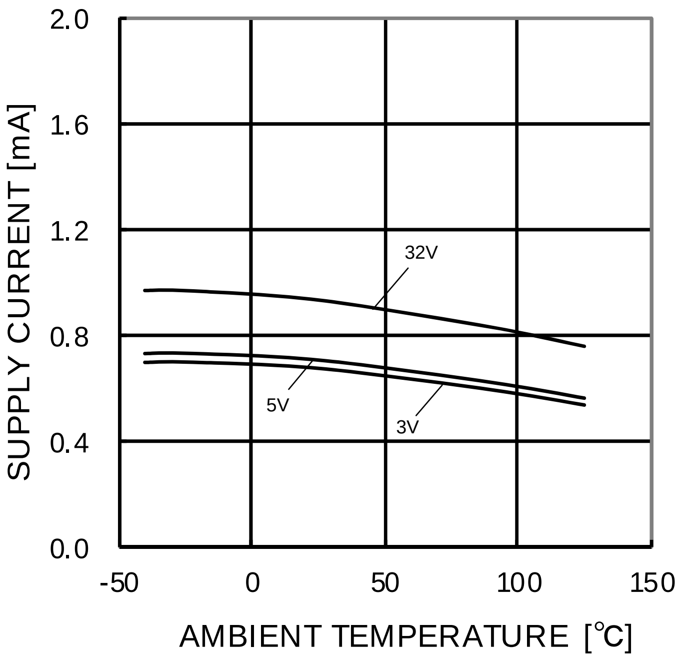


Fig.28
Supply Current – Ambient Temperature

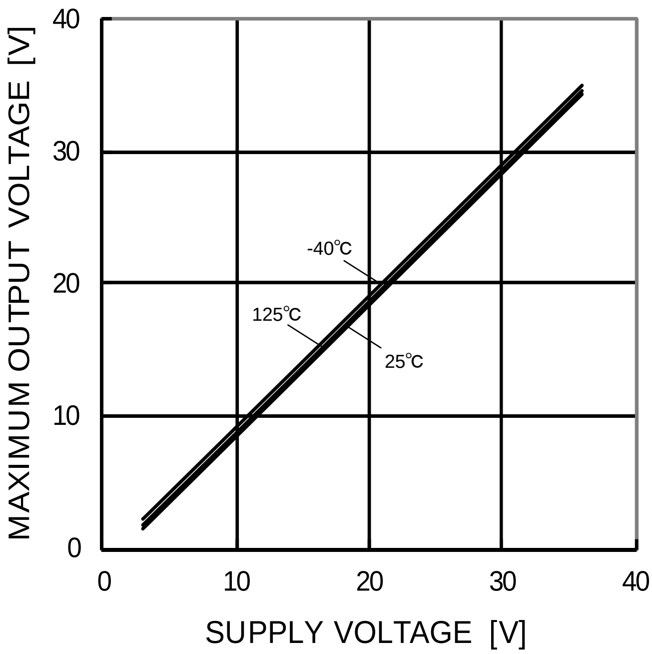


Fig.29
Maximum Output Voltage – Supply Voltage
(RL=10kΩ)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2902Yxxx-M

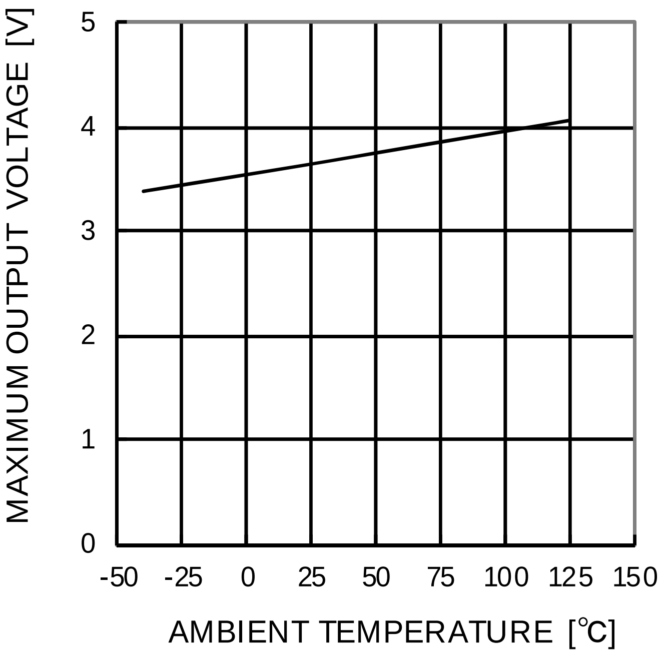


Fig.30
Maximum Output Voltage – Ambient Temperature
(VCC=5V, RL=2kΩ)

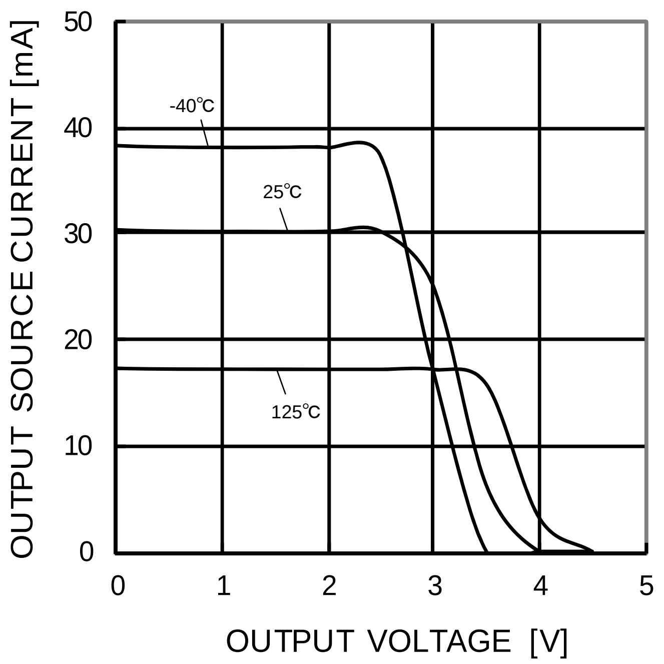


Fig.31
Output Source Current – Output Voltage
(VCC=5V)

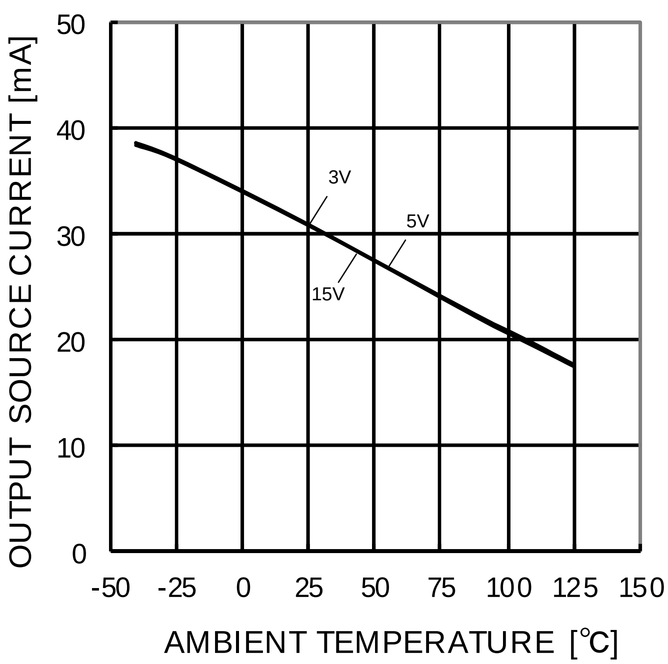


Fig.32
Output Source Current – Ambient Temperature
(VOUT=0V)

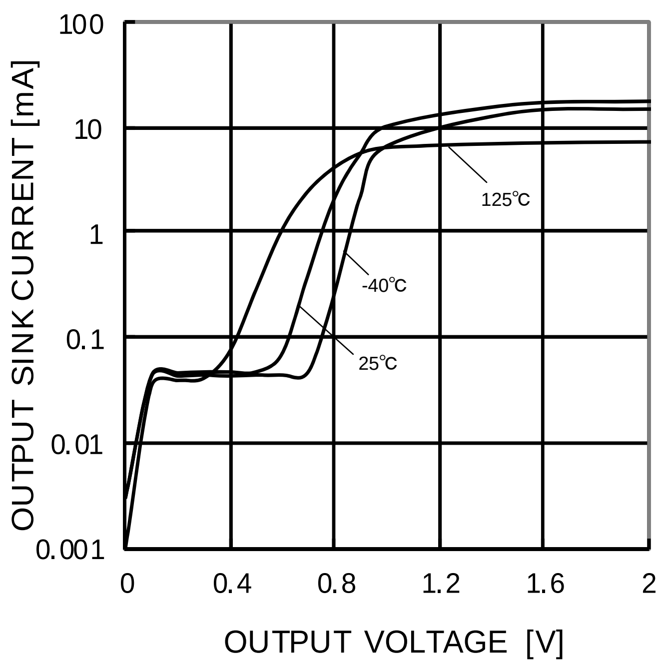


Fig.33
Output Sink Current – Output Voltage
(VCC=5V)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2902Yxxx-M

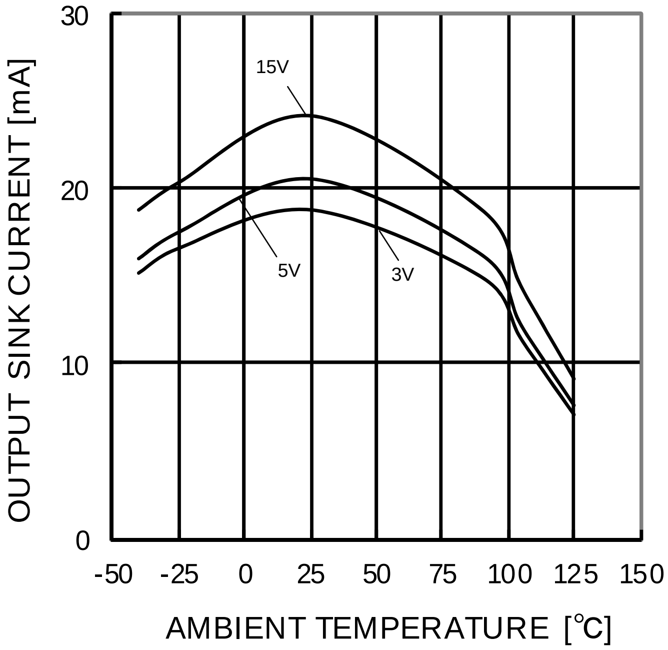


Fig.34
Output Sink Current – Ambient Temperature
(VOUT=VCC)

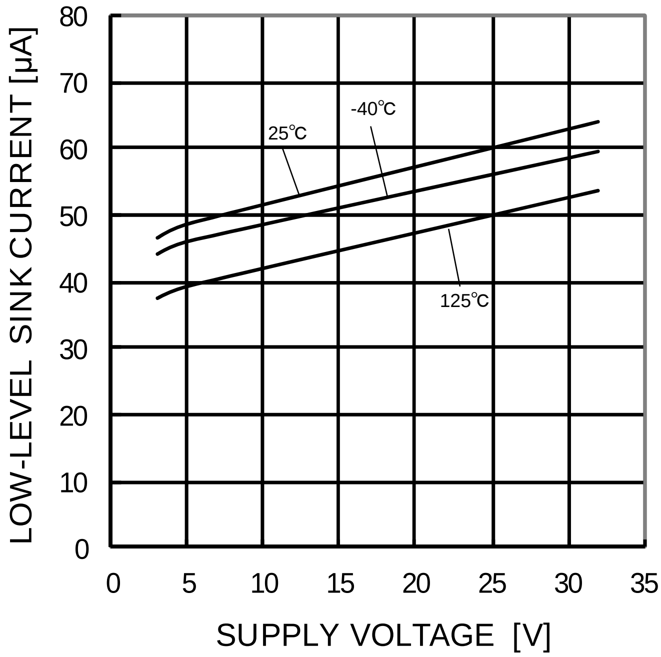


Fig.35
Low Level Sink Current – Supply Voltage
(VOUT=0.2V)

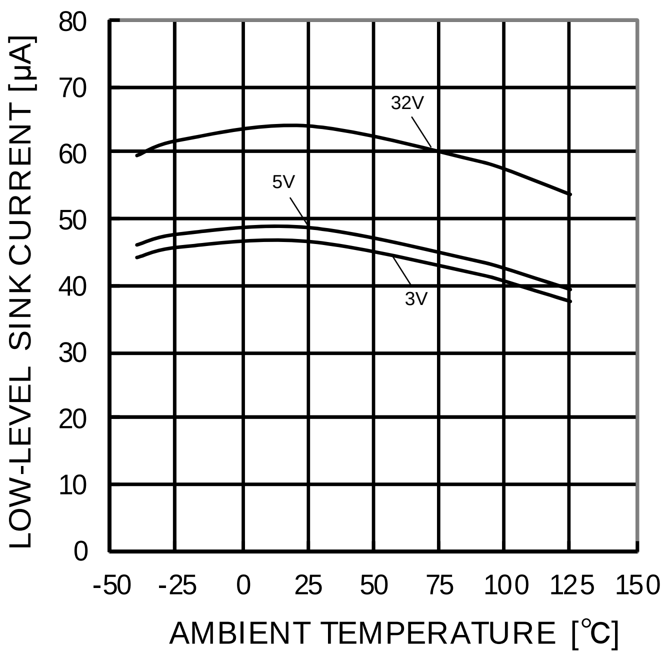


Fig.36
Low Level Sink Current – Ambient Temperature
(VOUT=0.2V)

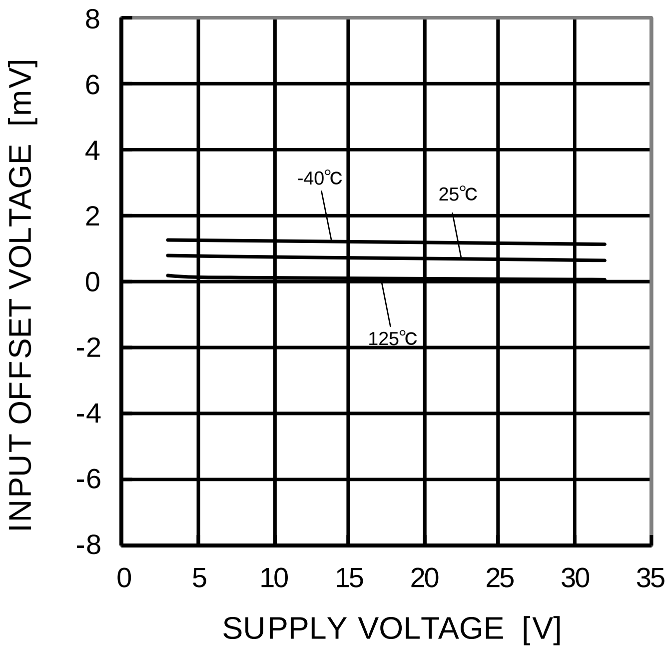


Fig.37
Input Offset Voltage – Supply Voltage
(Vicm=0V, VOUT=1.4V)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2902Yxxx-M

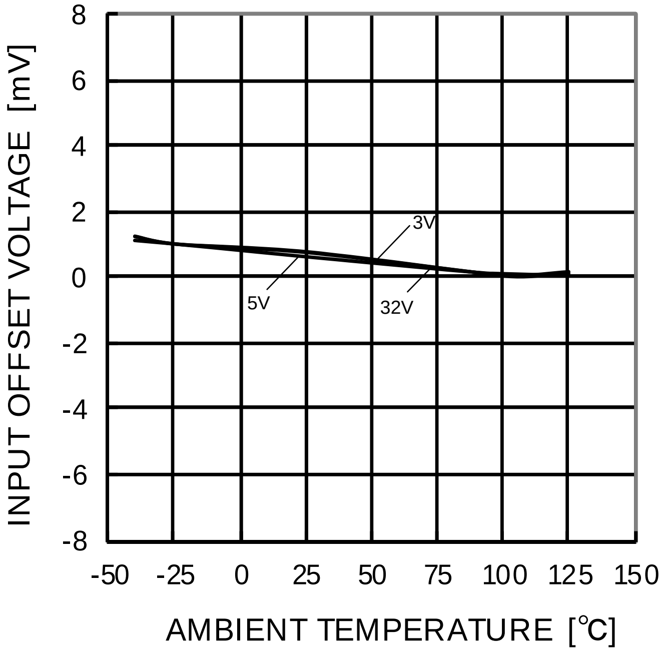


Fig.38
Input Offset Voltage – Ambient Temperature
(Vicm=0V, VOUT=1.4V)

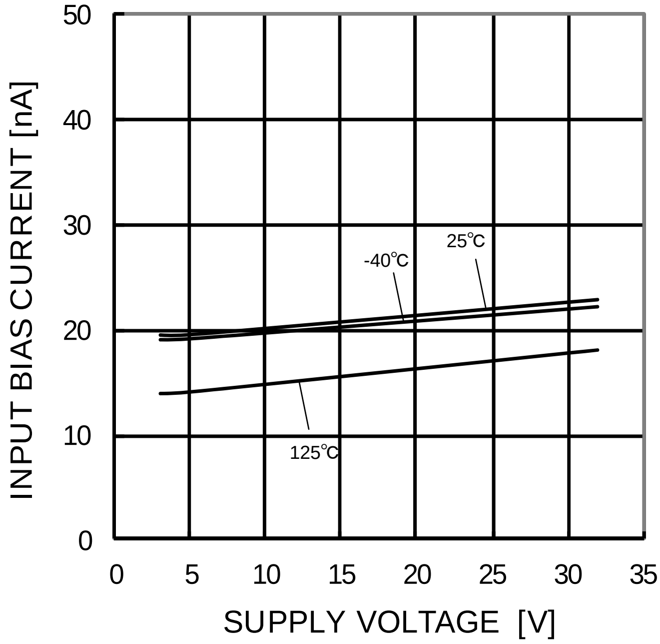


Fig.39
Input Bias Current – Supply Voltage
(Vicm=0V, VOUT=1.4V)

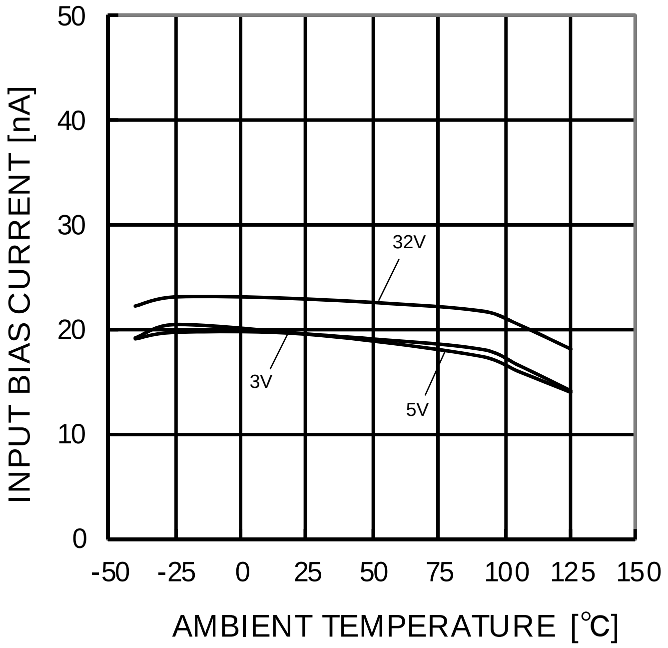


Fig.40
Input Bias Current – Ambient Temperature
(Vicm=0V, VOUT=1.4V)

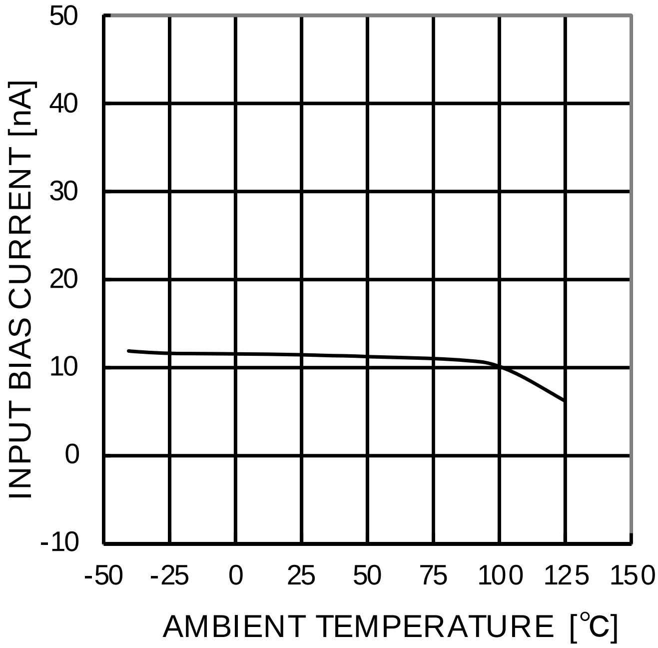


Fig.41
Input Bias Current – Ambient Temperature
(VCC=30V, Vicm=28V, VOUT=1.4V)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2902Yxxx-M

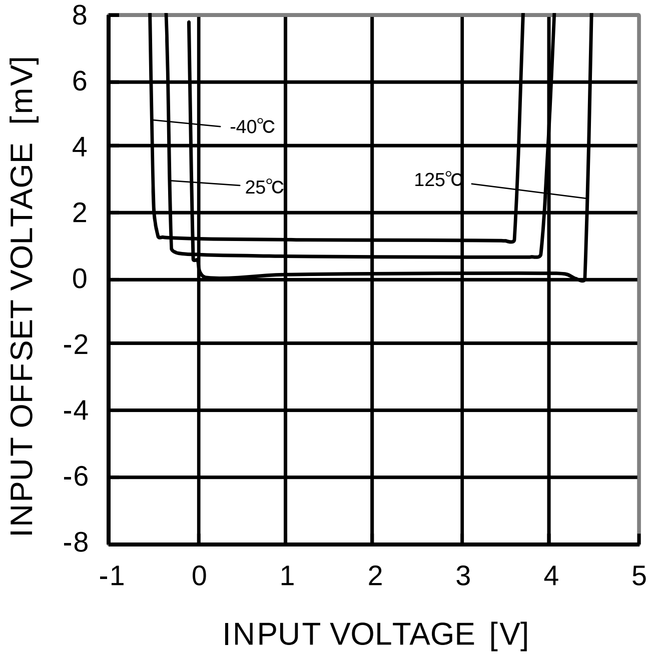


Fig.42
Input Offset Voltage – Input Voltage
(VCC=5V)

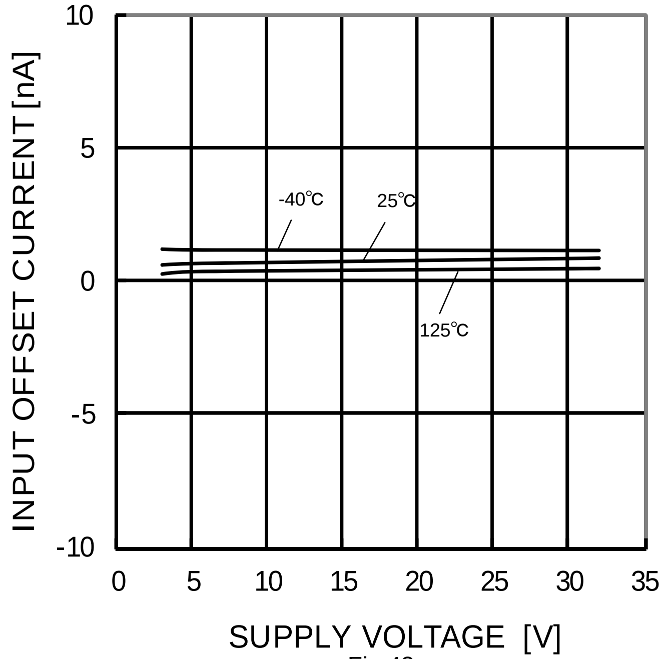


Fig.43
Input Offset Current – Supply Voltage
(Vicm=0V, VOUT=1.4V)

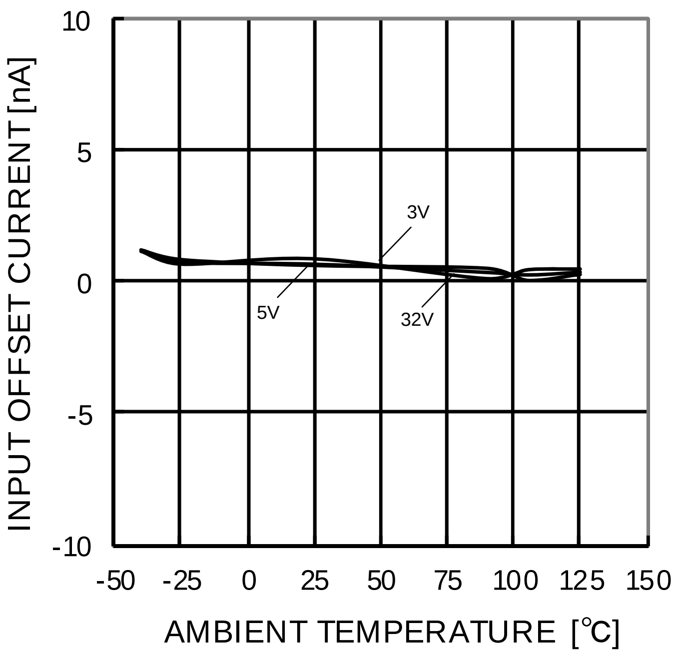


Fig.44
Input Offset Current – Ambient Temperature
(Vicm=0V, VOUT=1.4V)

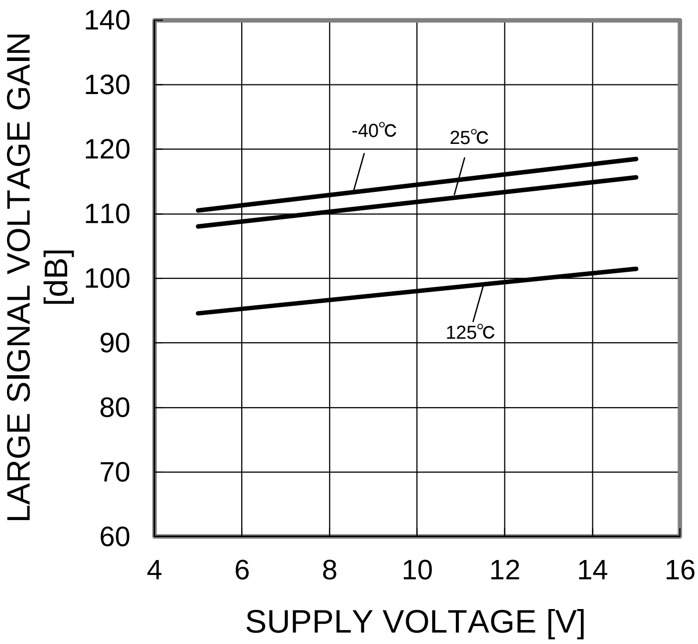


Fig.45
Large Signal Voltage Gain – Supply Voltage
(RL=2kΩ)

(*)The above data is measurement value of typical sample, it is not guaranteed.

○BA2902Yxxx-M

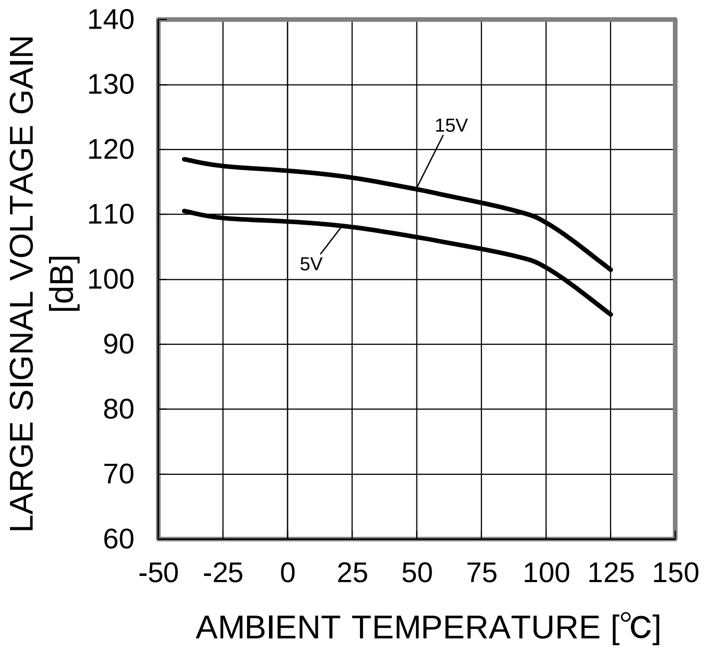


Fig.46
Large Signal Voltage Gain – Ambient Temperature
(RL=2kΩ)

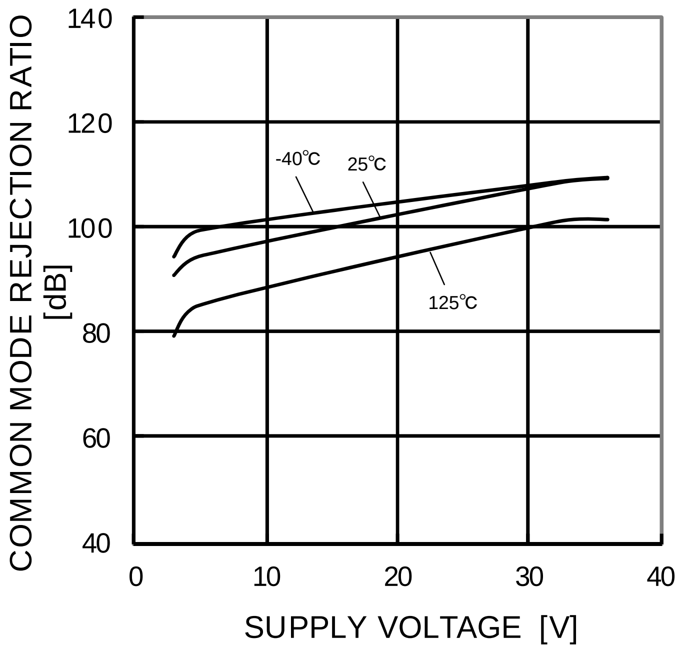


Fig.47
Common Mode Rejection Ratio
– Supply Voltage

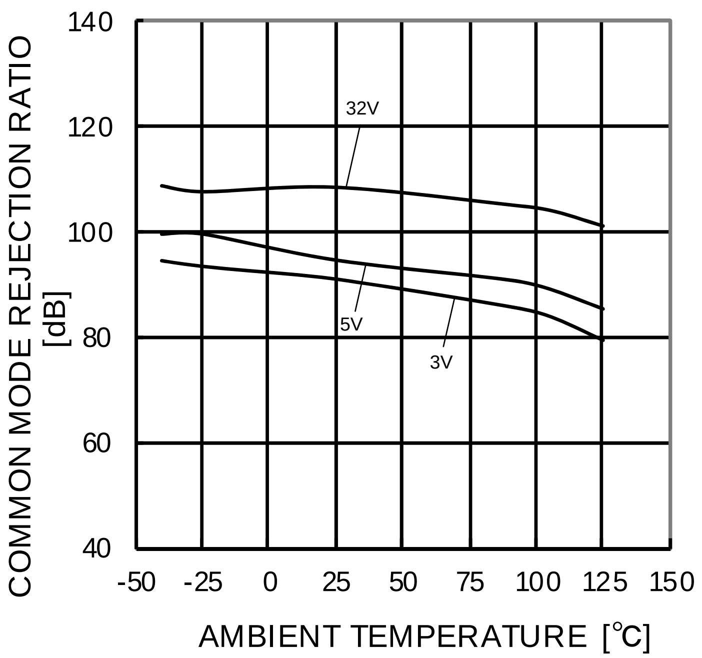


Fig.48
Common Mode Rejection Ratio
– Ambient Temperature

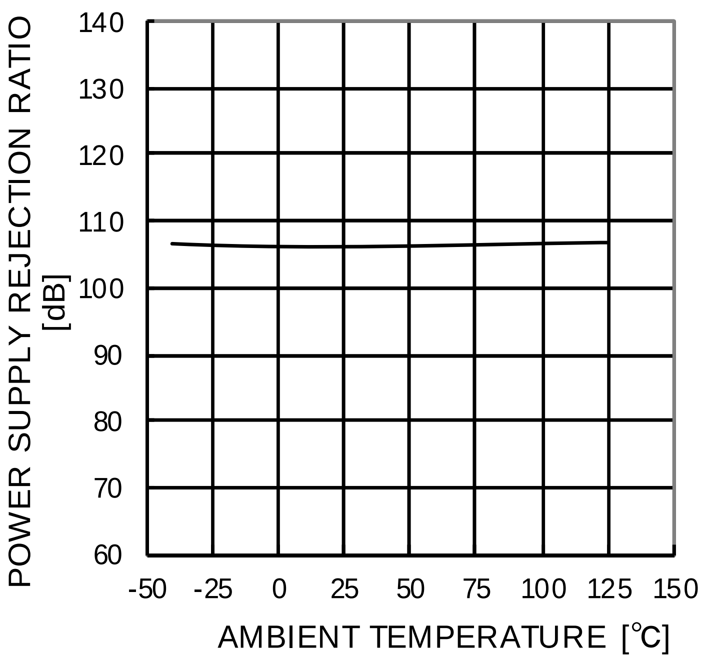


Fig.49
Power Supply Rejection Ratio
– Ambient Temperature

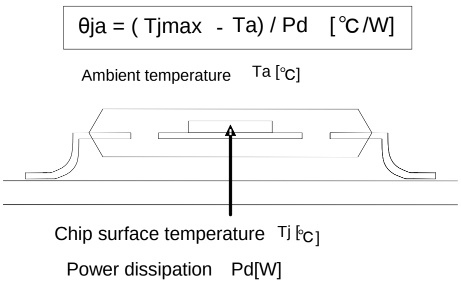
(*)The above data is measurement value of typical sample, it is not guaranteed.

●Power Dissipation

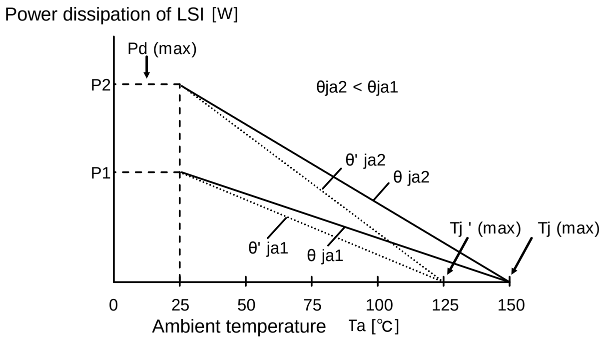
Power dissipation(total loss) indicates the power that can be consumed by IC at Ta=25℃(normal temperature). IC is heated when it consumed power, and the temperature of IC chip becomes higher than ambient temperature. The temperature that can be accepted by IC chip depends on circuit configuration, manufacturing process, and consumable power is limited. Power dissipation is determined by the temperature allowed in IC chip(maximum junction temperature) and thermal resistance of package(heat dissipation capability). The maximum junction temperature is typically equal to the maximum value in the storage temperature range. Heat generated by consumed power of IC radiates from the mold resin or lead frame of the package. The parameter which indicatesthis heat dissipation capability(hardness of heat release)is called thermal resistance, represented by the symbol θja℃/W.The temperature of IC inside the package can be estimated by this thermal resistance. Fig.50(a) shows the model of thermal resistance of the package. Thermal resistance θja, ambient temperature Ta, junction temperature Tj, and power dissipation Pd can be calculated by the equation below:

$$\theta ja = (Tjmax - Ta) / Pd \quad ℃/W \quad ・・・・・ \quad (\mathrm{I})$$

Derating curve in Fig.50(b) indicates power that can be consumed by IC with reference to ambient temperature.Power that can be consumed by IC begins to attenuate at certain ambient temperature. This gradient iis determined by thermal resistance θja. Thermal resistance θja depends on chip size, power consumption, package,ambient temperature, package condition, wind velocity, etc even when the same of package is used.
Thermal reduction curve indicates a reference value measured at a specified condition. Fig.50(c) show a derating curve for an example of BA2904Yxxx-M and BA2902xxY-M.

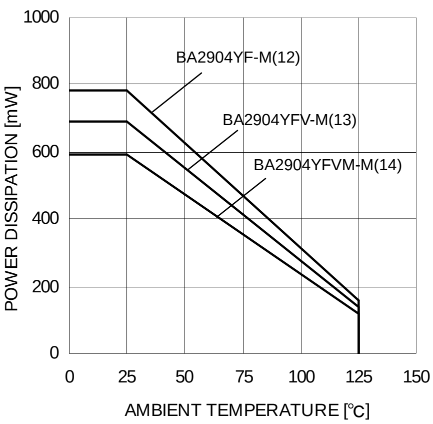


(a) Thermal resistance

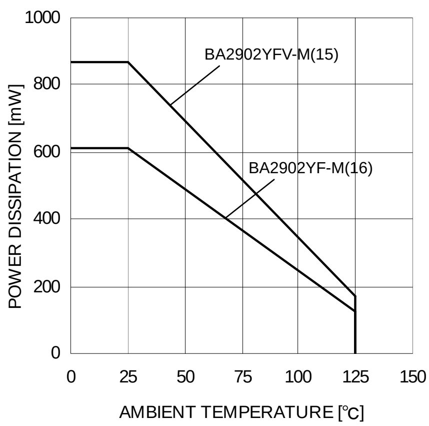


(b) Derating curve

Fig. 50 Thermal resistance and derating



(c) BA2904Yxxx-M



(d) BA2902Yxx-M

(12)	(13)	(14)	(15)	(16)	単位
6.2	5.5	4.8	7.0	4.9	mW/℃

When using the unit above Ta=25℃, subtract the value above per Celsius degree .
Permissible dissipation is the value when FR4 glass epoxy board 70mm×70mm×1.6mm(cooper foil area below 3%) is mounted.

Fig. 51 Derating curve

●Application Information

Test Circuit1 NULL method

VCC, VEE, EK, Vicm Unit V

Parameter	VF	S1	S2	S3	Vcc	VEE	EK	Vicm	calculation
Input Offset Voltage	VF1	ON	ON	OFF	5 to 30	0	-1.4	0	1
Input Offset Current	VF2	OFF	OFF	OFF	5	0	-1.4	0	2
Input Bias Current	VF3	OFF	ON	OFF	5	0	-1.4	0	3
	VF4	ON	OFF						
Large Signal Voltage Gain	VF5	ON	ON	ON	15	0	-1.4	0	4
	VF6				15	0	-11.4	0	
Common-mode Rejection Ratio (Input common-mode Voltage Range)	VF7	ON	ON	OFF	5	0	-1.4	0	5
	VF8				5	0	-1.4	3.5	
Power Supply Rejection Ratio	VF9	ON	ON	OFF	5	0	-1.4	0	6
	VF10				30	0	-1.4	0	

- Calculation -

1. Input Offset Voltage (Vio)

$$Vio = \frac{|VF1|}{1 + Rf / Rs} \quad [V]$$

2. Input Offset Current (Iio)

$$Iio = \frac{|VF2 - VF1|}{Ri \times (1 + Rf / Rs)} \quad [A]$$

3. Input Bias Current (Ib)

$$Ib = \frac{|VF4 - VF3|}{2 \times Ri \times (1 + Rf / Rs)} \quad [A]$$

4. Large Signal Voltage Gain (Av)

$$Av = 20 \times Log \frac{\Delta EK \times (1 + Rf/Rs)}{|VF5 - VF6|} \quad [dB]$$

5. Common-mode Rejection Ration (CMRR)

$$CMRR = 20 \times Log \frac{\Delta Vicm \times (1 + Rf/Rs)}{|VF8 - VF7|} \quad [dB]$$

6. Power supply rejection ratio (PSRR)

$$PSRR = 20 \times Log \frac{\Delta Vcc \times (1 + Rf/Rs)}{|VF10 - VF9|} \quad [dB]$$

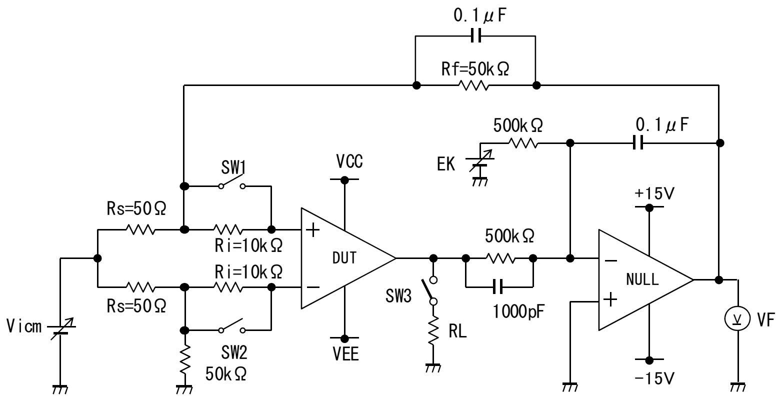


Fig. 52 Test circuit1 (one channel only)

Test Circuit 2 Switch Condition

SW No.	SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7	SW 8	SW 9	SW 10	SW 11	SW 12	SW 13	SW 14
Supply Current	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
High Level Output Voltage	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
Low Level Output Voltage	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
Output Source Current	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
Output Sink Current	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
Slew Rate	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF
Gain Bandwidth Product	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
Equivalent Input Noise Voltage	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF

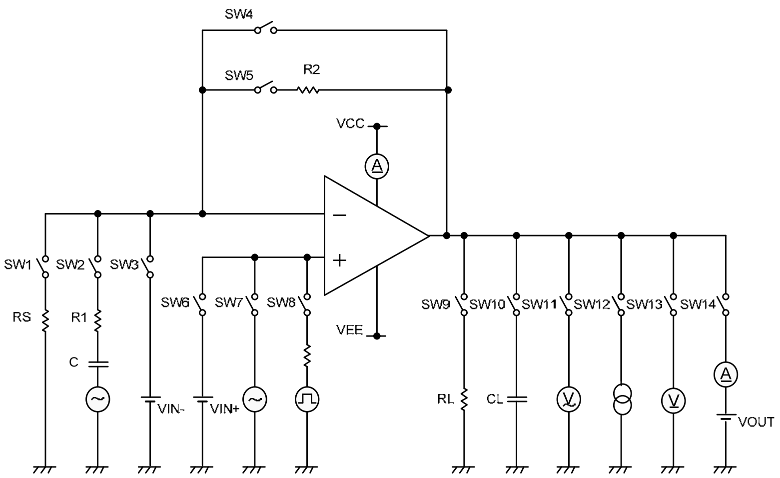


Fig. 53 Test Circuit 2 (each Op-Amp)

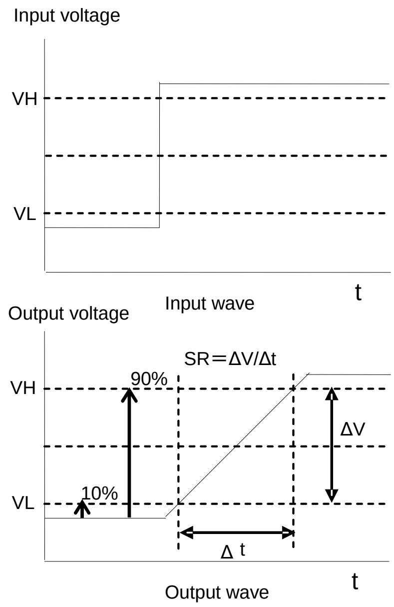
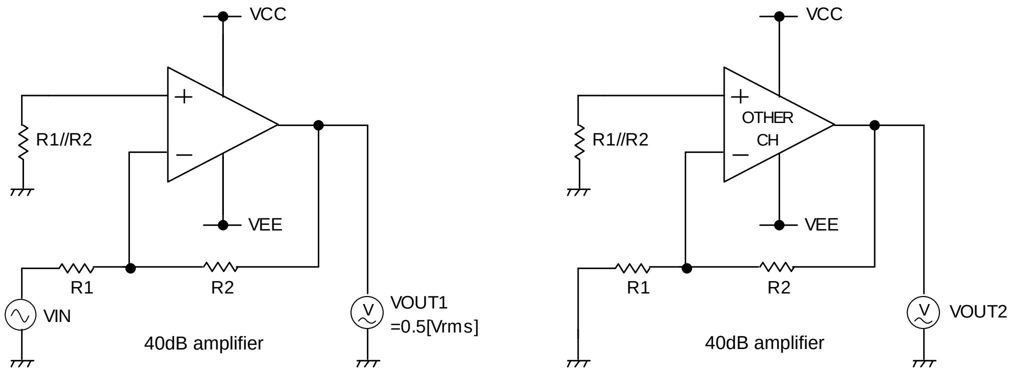


Fig. 54 Slew Rate Input Waveform

Measurement Circuit 3 Amplifier To Amplifier Coupling



$$CS = 20 \times \log \frac{100 \times VOUT1}{VOUT2}$$

(R1=1kΩ, R=100kΩ)

Fig. 55 Test Circuit 3

●**Operational Notes**

1) Unused circuits
When there are unused circuits, it is recommended that they are connected as in Fig.56, setting the non-inverting input terminal to a potential within the in-phase input voltage range (Vicm).

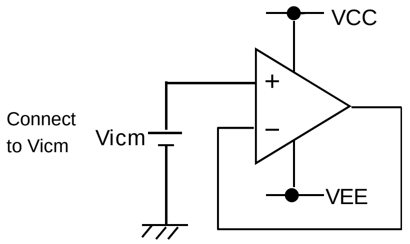


Fig. 56 The example of application circuit for unused op-amp

2) Input voltage
Applying VEE+36V to the input terminal is possible without causing deterioration of the electrical characteristics or destruction, irrespective of the supply voltage. However, this does not ensure normal circuit operation. Please note that the circuit operates normally only when the input voltage is within the common mode input voltage range of the electric characteristics.

3) Power supply (single / dual)
The op-amp operates when the voltage supplied is between VCC and VEE. Therefore, the single supply op-amp can be used as a dual supply op-amp as well.

4) Power dissipation (Pd)
Using the unit in excess of the rated power dissipation may cause deterioration in electrical characteristics due to the rise in chip temperature, including reduced current capability. Therefore, please take into consideration the power dissipation (Pd) under actual operating conditions and apply a sufficient margin in thermal design. Refer to the thermal derating curves for more information.

5) Short-circuit between pins and erroneous mounting
Incorrect mounting may damage the IC. In addition, the presence of foreign substances between the outputs, the output and the power supply, or the output and GND may result in IC destruction.

6) Operation in a strong electromagnetic field
Operation in a strong electromagnetic field may cause malfunctions.

7) Radiation
This IC is not designed to withstand radiation.

8) IC handling
Applying mechanical stress to the IC by deflecting or bending the board may cause fluctuation of the electrical characteristics due to piezo resistance effects.

9) IC operation
The output stage of the IC is configured using Class C push-pull circuits. Therefore, when the load resistor is connected to the middle potential of VCC and VEE, crossover distortion occurs at the changeover between discharging and charging of the output current. Connecting a resistor between the output terminal and GND, and increasing the bias current for Class A operation will suppress crossover distortion.

10) Board inspection
Connecting a capacitor to a pin with low impedance may stress the IC. Therefore, discharging the capacitor after every process is recommended. In addition, when attaching and detaching the jig during the inspection phase, ensure that the power is turned OFF before inspection and removal. Furthermore, please take measures against ESD in the assembly process as well as during transportation and storage.

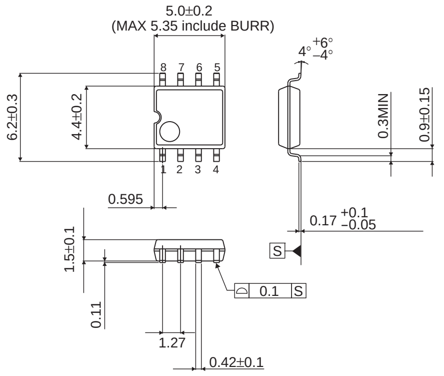
11) Output capacitor
Discharge of the external output capacitor to VCC is possible via internal parasitic elements when VCC is shorted to VEE, causing damage to the internal circuitry due to thermal stress. Therefore, when using this IC in circuits where oscillation due to output capacitive load does not occur, such as in voltage comparators, use an output capacitor with a capacitance less than 0.1μF.

12) Oscillation by output capacitor
Please pay attention to oscillation by output capacitor, designing application of negative feed back loop circuit with these ICs.

Status of this document
The Japanese version of this document is formal specification. A customer may use this translation version only for a reference to help reading the formal version.
If there are any differences in translation version of this document formal version takes priority

●Physical Dimensions Tape and Reel Information

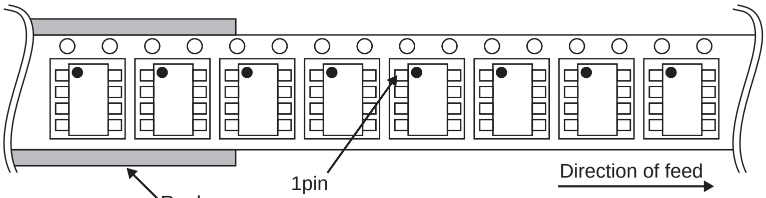
SOP8



(Unit : mm)

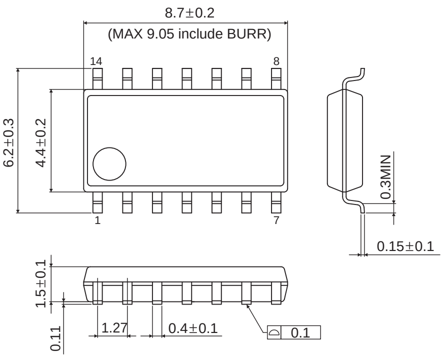
<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



*Order quantity needs to be multiple of the minimum quantity.

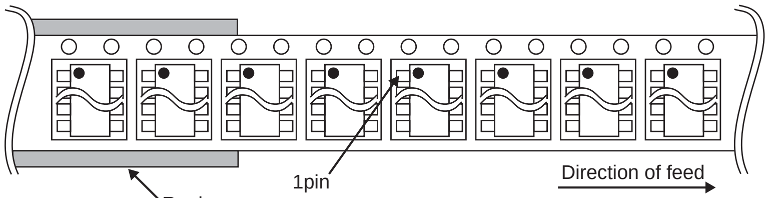
SOP14



(Unit : mm)

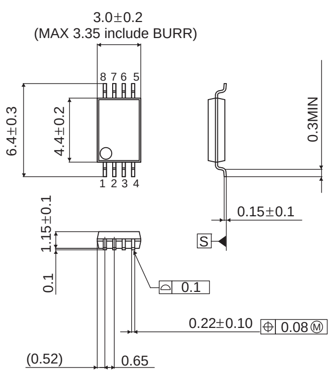
<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



*Order quantity needs to be multiple of the minimum quantity.

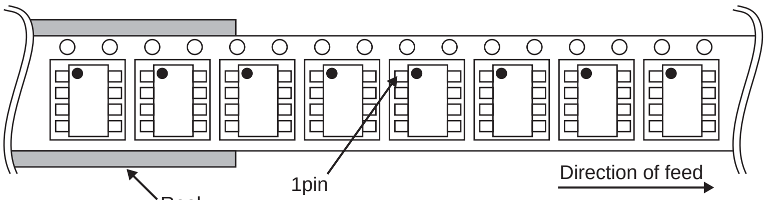
SSOP-B8



(Unit : mm)

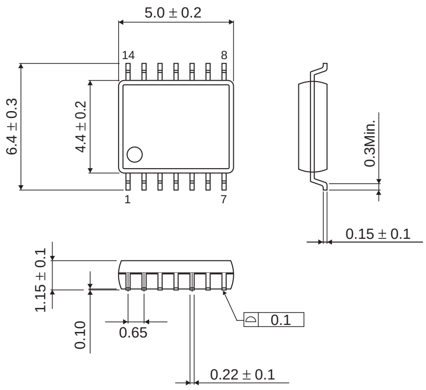
<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



*Order quantity needs to be multiple of the minimum quantity.

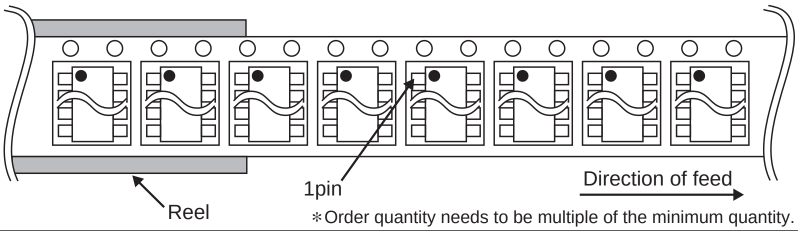
SSOP-B14



(Unit : mm)

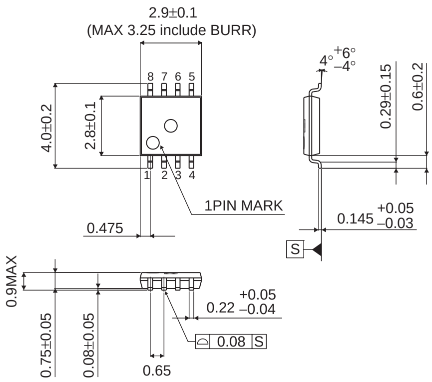
<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



∗Order quantity needs to be multiple of the minimum quantity.

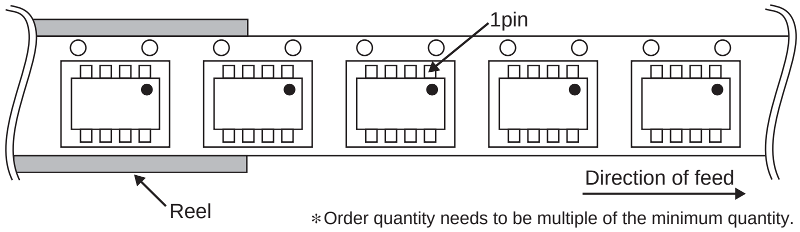
MSOP8



(Unit : mm)

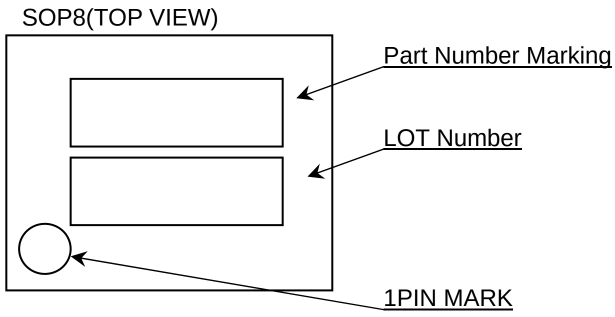
<Tape and Reel information>

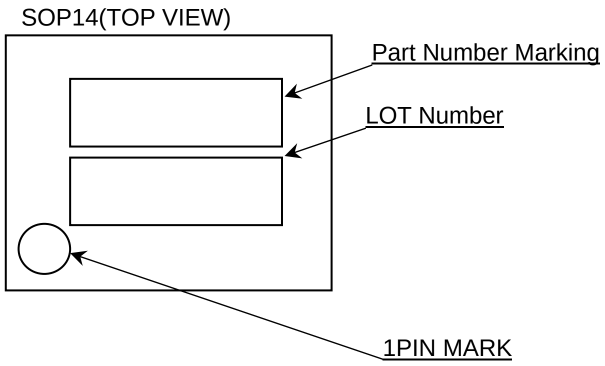
Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)

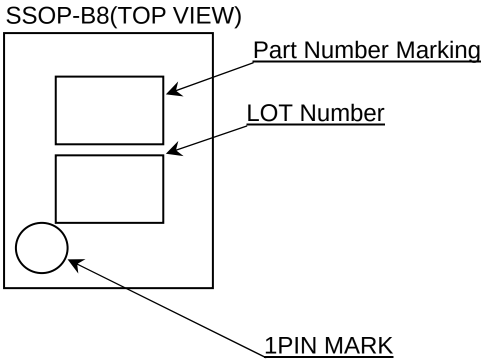


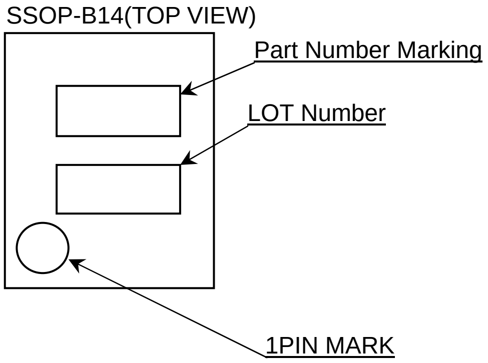
∗Order quantity needs to be multiple of the minimum quantity.

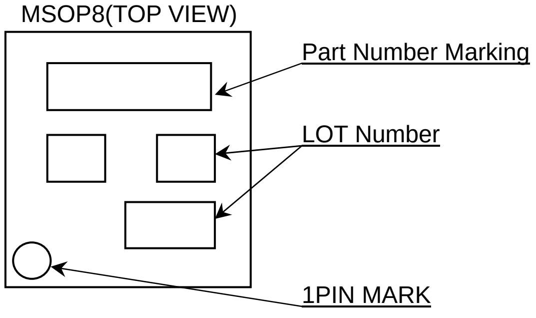
●**Marking Diagram**











Product Name		Package Type	Marking
BA2904Y	F-M	SOP8	04YM
	FV-M	SSOP-B8	04YM
	FVM-M	MSOP8	04YM
BA2902Y	F-M	SOP14	BA2902YFM
	FV-M	SSOP-B14	02YM

Notice

Precaution on using ROHM Products

1. If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), aircraft/spacecraft, nuclear power controllers, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are not designed under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label

QR code printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

Precaution for Foreign Exchange and Foreign Trade act

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

Precaution Regarding Intellectual Property Rights

1. All information and data including but not limited to application example contained in this document is for reference only. ROHM does not warrant that foregoing information or data will not infringe any intellectual property rights or any other rights of any third party regarding such information or data. ROHM shall not be in any way responsible or liable for infringement of any intellectual property rights or other damages arising from use of such information or data.:

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3. In no event shall you use in any way whatsoever the Products and the related technical information contained in the Products or this document for any military purposes, including but not limited to, the development of mass-destruction weapons.

4. The proper names of companies or products described in this document are trademarks or registered trademarks of ROHM, its affiliated companies or third parties.

General Precaution

1. Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.

2. All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.

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