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Operational Amplifiers

Ground Sense Operational Amplifiers

BA10358xx, BA10324Axx, BA2904xxx, BA2904Sxxx, BA2904Wxx
BA2902xx, BA2902Sxx

General Description

General purpose BA10358 / BA10324A and high reliability BA2904 / BA2902 integrate two or four independent Op-Amps on a single chip and have some features of high-gain, low power consumption, and wide operating voltage range of 3V to 36V (single power supply).
BA2904W have low input offset voltage(2mV max.).

Features

- Operable with a single power supply
- Wide operating supply voltage range
- Input and output are operable GND sense
- Low supply current
- High open loop voltage gain
- Wide temperature range

Application

- Current sense application
- Buffer application amplifier
- Active filter
- Consumer electronics

Key Specification

- Wide Operating Supply Voltage (single supply):

BA10358/BA10324A	+3.0V to +32.0V
BA2904/BA2902	+3.0V to +36.0V

- Wide Temperature Range:

BA10358/ BA10324A	-40°C~+85°C
BA2904S/ BA2902S	-40°C~+105°C
BA2904/ BA2902	-40°C~+125°C
BA2904W	-40°C~+125°C

- Input Offset Voltage:

BA10358/ BA10324A	7mV (Max)
BA2904S/ BA2902S	7mV (Max)
BA2904/ BA2902	7mV (Max)
BA2904W	2mV (Max)

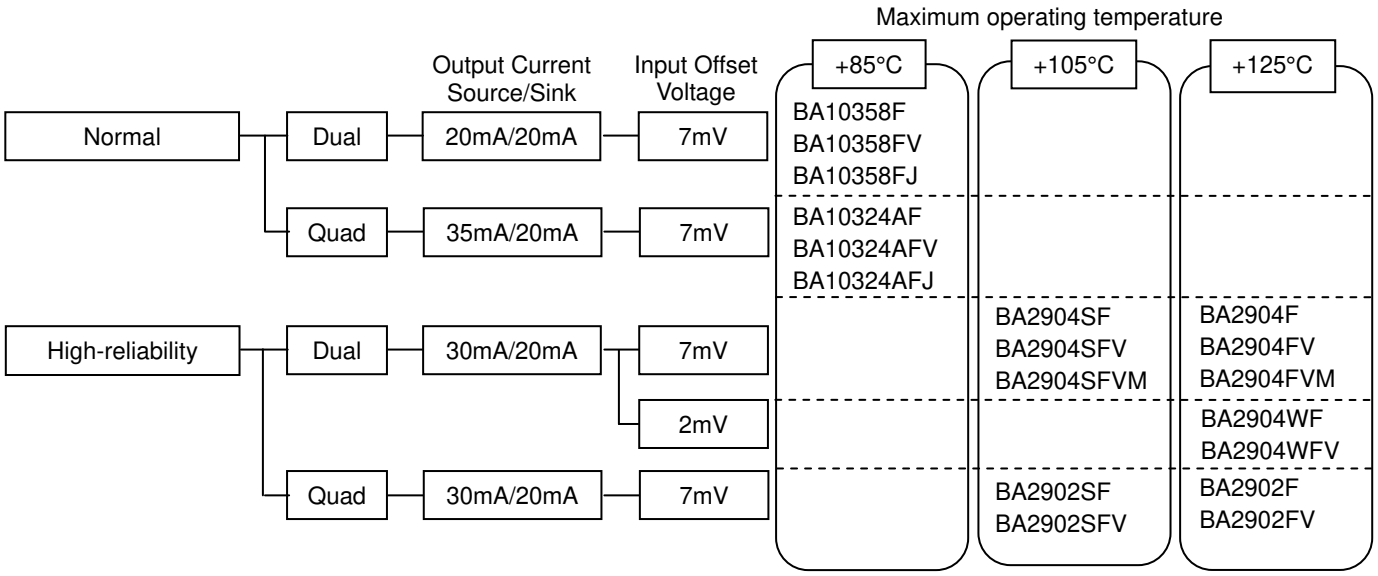
- Low Input Bias Current:

BA10358	45nA (Typ)
BA10324A	20nA (Typ)
BA2904S/ BA2902S	20nA (Typ)
BA2904/ BA2902	20nA (Typ)
BA2904W	20nA (Typ)

Packages

	W(Typ) x D(Typ) x H(Max)
SOP8	5.00mm x 6.20mm x 1.71mm
SOP-J8	4.90mm x 6.00mm x 1.65mm
SSOP-B8	3.00mm x 6.40mm x 1.35mm
MSOP8	2.90mm x 4.00mm x 0.90mm
SOP14	8.70mm x 6.20mm x 1.71mm
SOP-J14	8.65mm x 6.00mm x 1.65mm
SSOP-B14	5.00mm x 6.40mm x 1.35mm

Selection Guide



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

Simplified schematic

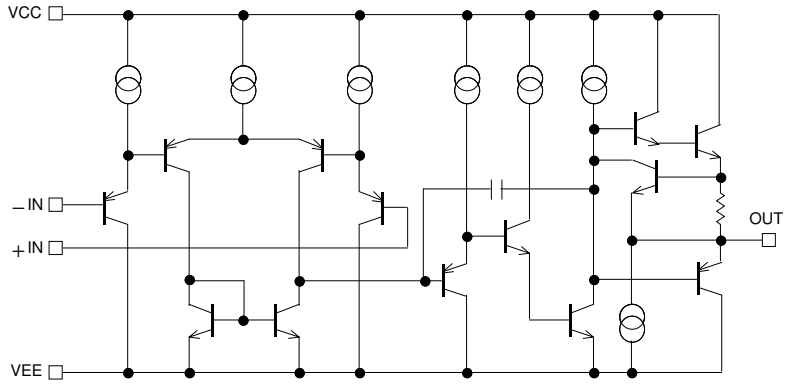
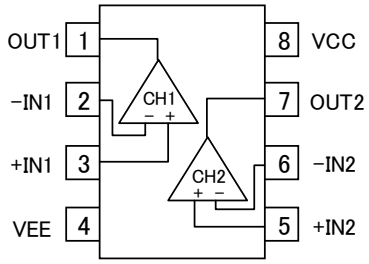


Figure 1. Simplified schematic（one channel only）

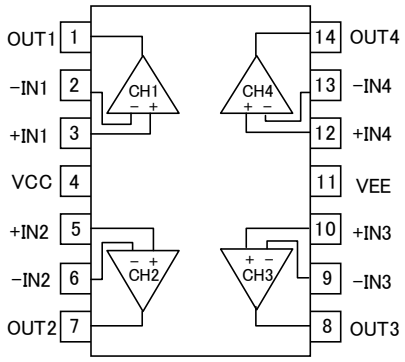
Pin Configuration

BA10358F,BA2904SF,BA2904F,BA2904WF :SOP8
BA10358FV,BA2904SFV,BA2904FV,BA2904WFV :SSOP-B8
BA2904SFVM,BA2904FVM :MSOP8
BA10358FJ :SOP-J8



Pin No.	Pin Name
1	OUT1
2	-IN1
3	+IN1
4	VEE
5	+IN2
6	-IN2
7	OUT2
8	VCC

BA10324AF,BA2902SF,BA2902F :SOP14
BA10324AFV,BA2902SFV,BA2902FV :SSOP-B14
BA10324AFJ :SOP-J14



Pin No.	Pin Name
1	OUT1
2	-IN1
3	+IN1
4	VCC
5	+IN2
6	-IN2
7	OUT2
8	OUT3
9	-IN3
10	+IN3
11	VEE
12	+IN4
13	-IN4
14	OUT4

Package						
SOP8	SSOP-B8	MSOP8	SOP-J8	SOP14	SSOP-B14	SOP-J14
BA10358F BA2904SF BA2904F BA2904WF	BA10358FV BA2904SFV BA2904FV BA2904WFV	BA2904SFVM BA2904FVM	BA10358FJ	BA10324AF BA2902SF BA2902F	BA10324AFV BA2902SFV BA2902FV	BA10324AFJ

Ordering Information

B A x x x x x x x x - x x

Part Number.
BA10358xx
BA10324Axx
BA2904xxx
BA2904Sxxx
BA2904Wxx
BA2902xx
BA2902Sxx

Package
F : SOP8
SOP14
FV : SSOP-B8
SSOP-B14
FVM : MSOP8
FJ : SOP-J8
SOP-J14

Packaging and forming specification
E2: Embossed tape and reel
(SOP8/SOP14/SSOP-B8/
SSOP-B14/SOP-J8/SOP-J14)
TR: Embossed tape and reel
(MSOP8)

Line-up

Topr	Input Offset Voltage (Max)	Supply Current (Typ)	Package		Orderable Part Number
-40°C to +85°C	7mV	0.5mA	SOP8	Reel of 2500	BA10358F-E2
			SOP-J8	Reel of 2500	BA10358FJ-E2
			SSOP-B8	Reel of 2500	BA10358FV-E2
		0.6mA	SOP14	Reel of 2500	BA10324AF-E2
			SOP-J14	Reel of 2500	BA10324AFJ-E2
			SSOP-B14	Reel of 2500	BA10324AFV-E2
-40°C to +105°C		0.5mA	SOP8	Reel of 2500	BA2904SF-E2
			SSOP-B8	Reel of 2500	BA2904SFV-E2
			MSOP8	Reel of 3000	BA2904SFVM-TR
		0.7mA	SOP14	Reel of 2500	BA2902SF-E2
			SSOP-B14	Reel of 2500	BA2902SFV-E2
-40°C to +125°C		0.5mA	SOP8	Reel of 2500	BA2904F-E2
			SSOP-B8	Reel of 2500	BA2904FV-E2
			MSOP8	Reel of 3000	BA2904FVM-TR
		0.7mA	SOP14	Reel of 2500	BA2902F-E2
			SSOP-B14	Reel of 2500	BA2902FV-E2
	2mV	0.5mA	SOP8	Reel of 2500	BA2904WF-E2
			SSOP-B8	Reel of 2500	BA2904WFV-E2

Absolute Maximum Ratings (T_A=25°C)

○BA10358, BA10324A

Parameter	Symbol		Ratings	Unit
Supply Voltage	VCC-VEE		+32	V
Power dissipation	P_D	SOP8	620(Note 1,7)	mW
		SOP-J8	540(Note 2,7)	
		SSOP-B8	500(Note 3,7)	
		SOP14	450(Note 4,7)	
		SOP-J14	820(Note 5,7)	
		SSOP-B14	700(Note 6,7)	
Differential Input Voltage(Note 8)	V_{ID}		+32	V
Input Common-mode Voltage Range	V_{ICM}		(VEE-0.3) to (VEE+32)	V
Input Current(Note 9)	I_I		-10	mA
Wide Operating Supply Voltage	V_{opr}		+3.0 to +32.0	V
Operating Temperature Range	T_{opr}		-40 to +85	°C
Storage Temperature Range	T_{stg}		-55 to +125	°C
Maximum Junction Temperature	T_{Jmax}		+125	°C

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.

(Note 1) To use at temperature above T_A=25°C reduce 6.2mW.
(Note 2) To use at temperature above T_A=25°C reduce 5.4mW
(Note 3) To use at temperature above T_A=25°C reduce 5.0mW.
(Note 4) To use at temperature above T_A=25°C reduce 4.5mW.
(Note 5) To use at temperature above T_A=25°C reduce 8.2mW
(Note 6) To use at temperature above T_A=25°C reduce 7.0mW.
(Note 7) Mounted on a FR4 glass epoxy PCB 70mm×70mm×1.6mm (Copper foil area less than 3%).
(Note 8) 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.
(Note 9) An excessive input current will flow when input voltages of less than VEE-0.6V are applied. The input current can be set to less than the rated current by adding a limiting resistor.

Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Absolute Maximum Ratings (T_A=25°C)

○BA2904, BA2902

Parameter	Symbol		Ratings		Unit
			BA2904S BA2902S	BA2904, BA2904W BA2902	
Supply Voltage	VCC-VEE		+36		V
Power dissipation	P_D	SOP8	775(Note 10,15)		mW
		SSOP-B8	625(Note 11,15)		
		MSOP8	600(Note 12,15)		
		SOP14	560(Note 13,15)		
		SSOP-B14	870(Note 14,15)		
Differential Input Voltage(Note 16)	V_{ID}		+36		V
Input Common-mode Voltage Range	V_{ICM}		(VEE-0.3) to (VEE+36)		V
Input Current(Note 17)	I_I		-10		mA
Wide Operating Supply Voltage	V_{opr}		+3.0 to +36.0		V
Operating Temperature Range	T_{opr}		-40 to +105	-40 to +125	°C
Storage Temperature Range	T_{stg}		-55 to +150		°C
Maximum Junction Temperature	T_{Jmax}		+150		°C

(Note 10) To use at temperature above T_A=25°C reduce 6.2mW.
(Note 11) To use at temperature above T_A=25°C reduce 5.0mW.
(Note 12) To use at temperature above T_A=25°C reduce 4.8mW.
(Note 13) To use at temperature above T_A=25°C reduce 4.5mW.
(Note 14) To use at temperature above T_A=25°C reduce 7.0mW.
(Note 15) Mounted on a FR4 glass epoxy PCB 70mm×70mm×1.6mm (Copper foil area less than 3%).
(Note 16) 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.
(Note 17) An excessive input current will flow when input voltages of less than VEE-0.6V are applied.
The input current can be set to less than the rated current by adding a limiting resistor.

Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Electrical Characteristics

○BA10358 (Unless otherwise specified VCC=+5V, VEE=0V, T_A=25°C)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Input Offset Voltage (Note 18)	V_{IO}	-	2	7	mV	OUT=1.4V
Input Offset Current (Note 18)	I_{IO}	-	5	50	nA	OUT=1.4V
Input Bias Current (Note 19)	I_B	-	45	250	nA	OUT=1.4V
Supply Current	I_{CC}	-	0.5	1.2	mA	RL=∞, All Op-Amps
Maximum Output Voltage(High)	V_{OH}	3.5	-	-	V	RL=2kΩ
Maximum Output Voltage(Low)	V_{OL}	-	-	250	mV	RL=∞, All Op-Amps
Large Signal Voltage Gain	A_V	25	100	-	V/mV	RL≧2kΩ, VCC=15V OUT=1.4 to 11.4V
		88	100	-	dB	
Input Common-mode Voltage Range	V_{ICM}	0	-	VCC-1.5	V	(VCC-VEE)=5V OUT=VEE+1.4V
Common-mode Rejection Ratio	CMRR	65	80	-	dB	OUT=1.4V
Power Supply Rejection Ratio	PSRR	65	100	-	dB	VCC=5 to 30V
Output Source Current	I_{SOURCE}	10	20	-	mA	VIN+=1V, VIN-=0V OUT=0V, 1CH is short circuit
Output Sink Current	I_{SINK}	10	20	-	mA	VIN+=0V, VIN-=1V OUT=5V, 1CH is short circuit
Channel Separation	CS	-	120	-	dB	f=1kHz, input referred
Slew Rate	SR	-	0.2	-	V/μs	VCC=15V, Av=0dB RL=2kΩ, CL=100pF
Gain Band Width	GBW	-	0.5	-	MHz	VCC=30V, RL=2kΩ CL=100pF

(Note 18) Absolute value
(Note 19) Current direction: Since first input stage is composed with PNP transistor, input bias current flows out of IC.

○BA10324A (Unless otherwise specified VCC=+5V, VEE=0V, T_A=25°C)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Input Offset Voltage (Note 20)	V_{IO}	-	2	7	mV	OUT=1.4V
Input Offset Current (Note 20)	I_{IO}	-	5	50	nA	OUT=1.4V
Input Bias Current (Note 21)	I_B	-	20	250	nA	OUT=1.4V
Supply Current	I_{CC}	-	0.6	2	mA	RL=∞, All Op-Amps
Maximum Output Voltage(High)	V_{OH}	3.5	-	-	V	RL=2kΩ
Maximum Output Voltage(Low)	V_{OL}	-	-	250	mV	RL=∞, All Op-Amps
Large Signal Voltage Gain	A_V	25	100	-	V/mV	RL≧2kΩ, VCC=15V OUT=1.4 to 11.4V
		88	100	-	dB	
Input Common-mode Voltage range	V_{ICM}	0	-	VCC-1.5	V	(VCC-VEE)=5V OUT=VEE+1.4V
Common-mode Rejection Ratio	CMRR	65	75	-	dB	OUT=1.4V
Power Supply Rejection Ratio	PSRR	65	100	-	dB	VCC=5 to 30V
Output Source Current	I_{SOURCE}	20	35	-	mA	VIN+=1V, VIN-=0V OUT=0V, 1CH is short circuit
Output Sink Current	I_{SINK}	10	20	-	mA	VIN+=0V, VIN-=1V OUT=5V, 1CH is short circuit
Channel Separation	CS	-	120	-	dB	f=1kHz, input referred
Slew Rate	SR	-	0.2	-	V/μs	VCC=15V, Av=0dB RL=2kΩ, CL=100pF
Gain Band Width	GBW	-	0.5	-	MHz	VCC=30V, RL=2kΩ CL=100pF

(Note 20) Absolute value
(Note 21) Current direction: Since first input stage is composed with PNP transistor, input bias current flows out of IC.

○BA2904, BA2904S (Unless otherwise specified VCC=+5V, VEE=0V)

Parameter	Symbol	Temperature Range	Limits			Unit	Condition
			Min.	Typ.	Max.		
Input Offset Voltage (Note 22,23)	V_{IO}	25°C	-	2	7	mV	OUT=1.4V
		Full range	-	-	10		VCC=5 to 30V, OUT=1.4V
Input Offset Voltage Drift	$\triangle V_{IO}/\triangle T$	-	-	±7	-	μV/°C	OUT=1.4V
Input Offset Current (Note 22,23)	I_{IO}	25°C	-	2	50	nA	OUT=1.4V
		Full range	-	-	200		
Input Offset Current Drift	$\triangle I_{IO}/\triangle T$	-	-	±10	-	pA/°C	OUT=1.4V
Input Bias Current (Note 22,23)	I_B	25°C	-	20	250	nA	OUT=1.4V
		Full range	-	-	250		
Supply Current (Note 23)	I_{CC}	25°C	-	0.5	1.2	mA	RL=∞, All Op-Amps
		Full range	-	-	2		
Maximum Output Voltage(High) (Note 23)	V_{OH}	25°C	3.5	-	-	V	RL=2kΩ
		Full range	27	28	-		VCC=30V, RL=10kΩ
Maximum Output Voltage(Low) (Note 23)	V_{OL}	Full range	-	5	20	mV	RL=∞, All Op-Amps
Large Signal Voltage Gain	A_V	25°C	25	100	-	V/mV	RL≧2kΩ, VCC=15V OUT=1.4 to 11.4V
			88	100	-	dB	
Input Common-mode Voltage Range	V_{ICM}	25°C	0	-	VCC-1.5	V	(VCC-VEE)=5V OUT=VEE+1.4V
Common-mode Rejection Ratio	CMRR	25°C	50	80	-	dB	OUT=1.4V
Power Supply Rejection Ratio	PSRR	25°C	65	100	-	dB	VCC=5 to 30V
Output Source Current (Note 23,24)	I_{SOURCE}	25°C	20	30	-	mA	VIN+=1V, VIN-=0V OUT=0V, 1CH is short circuit
		Full range	10	-	-		
Output Sink Current (Note 23,24)	I_{SINK}	25°C	10	20	-	mA	VIN+=0V, VIN-=1V OUT=5V, 1CH is short circuit
		Full range	2	-	-		
		25°C	12	40	-	μA	VIN+=0V, VIN-=1V OUT=200mV
Channel Separation	CS	25°C	-	120	-	dB	f=1kHz, input referred
Slew rate	SR	25°C	-	0.2	-	V/μs	VCC=15V, Av=0dB RL=2kΩ, CL=100pF
Gain Band Width	GBW	25°C	-	0.5	-	MHz	VCC=30V, RL=2kΩ CL=100pF
Input referred noise voltage	V_N	25°C	-	40	-	$nV/\sqrt{Hz}$	VCC=15V, VEE=-15V RS=100Ω, Vi=0V, f=1kHz

(Note 22) Absolute value
(Note 23) BA2904S :Full range -40 to +105°C BA2904 :Full range -40 to +125°C
(Note 24) 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.

○BA2904W (Unless otherwise specified VCC=+5V, VEE=0V)

Parameter	Symbol	Temperature Range	Limits			Unit	Condition
			Min.	Typ.	Max.		
Input Offset Voltage (Note 25)	V_{IO}	25°C	-	0.5	2	mV	OUT=1.4V
Input Offset Voltage Drift	$\triangle V_{IO}/\triangle T$	-	-	±7	-	μV/°C	OUT=1.4V
Input Offset Current (Note 25)	I_{IO}	25°C	-	2	50	nA	OUT=1.4V
Input Offset Current Drift	$\triangle I_{IO}/\triangle T$	-	-	±10	-	pA/°C	OUT=1.4V
Input Bias Current (Note 25)	I_B	25°C	-	20	250	nA	OUT=1.4V
		Full range	-	-	250		
Supply Current	I_{CC}	25°C	-	0.5	1.2	mA	RL=∞, All Op-Amps
		Full range	-	-	1.2		
Maximum Output Voltage(High)	V_{OH}	25°C	3.5	-	-	V	RL=2kΩ
		Full range	27	28	-		VCC=30V, RL=10kΩ
Maximum Output Voltage(Low)	V_{OL}	Full range	-	5	20	mV	RL=∞, All Op-Amps
Large Signal Voltage Gain	A_V	25°C	25	100	-	V/mV	RL≧2kΩ, VCC=15V OUT=1.4 to 11.4V
			88	100	-	dB	
Input Common-mode Voltage Range	V_{ICM}	25°C	0	-	VCC-1.5	V	(VCC-VEE)=5V OUT=VEE+1.4V
Common-mode Rejection Ratio	CMRR	25°C	50	80	-	dB	OUT=1.4V
Power Supply Rejection Ratio	PSRR	25°C	65	100	-	dB	VCC=5 to 30V
Output Source Current (Note 26)	I_{SOURCE}	25°C	20	30	-	mA	VIN+=1V, VIN-=0V OUT=0V, 1CH is short circuit
		Full range	10	-	-		
Output Sink Current (Note 26)	I_{SINK}	25°C	10	20	-	mA	VIN+=0V, VIN-=1V OUT=5V, 1CH is short circuit
		Full range	2	-	-		
		25°C	12	40	-	μA	VIN+=0V, VIN-=1V OUT=200mV
Channel Separation	CS	25°C	-	120	-	dB	f=1kHz, input referred
Slew rate	SR	25°C	-	0.2	-	V/μs	VCC=15V, Av=0dB RL=2kΩ, CL=100pF
Gain Band Width	GBW	25°C	-	0.5	-	MHz	VCC=30V, RL=2kΩ CL=100pF
Input referred noise voltage	V_N	25°C	-	40	-	$nV/\sqrt{Hz}$	VCC=15V, VEE=-15V RS=100Ω, Vi=0V, f=1kHz

(Note 25) Absolute value

(Note 26) 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.

○BA2902, BA2902S (Unless otherwise specified VCC=+5V, VEE=0V)

Parameter	Symbol	Temperature Range	Limits			Unit	Condition
			Min.	Typ.	Max.		
Input Offset Voltage (Note 27,28)	V_{IO}	25°C	-	2	7	mV	OUT=1.4V
		Full range	-	-	10		VCC=5 to 30V, OUT=1.4V
Input Offset Voltage Drift	$\triangle V_{IO}/\triangle T$	-	-	±7	-	μV/°C	OUT=1.4V
Input Offset Current (Note 27,28)	I_{IO}	25°C	-	2	50	nA	OUT=1.4V
		Full range	-	-	200		
Input Offset Current Drift	$\triangle I_{IO}/\triangle T$	-	-	±10	-	pA/°C	OUT=1.4V
Input Bias Current (Note 27,28)	I_B	25°C	-	20	250	nA	OUT=1.4V
		Full range	-	-	250		
Supply Current (Note 28)	I_{CC}	25°C	-	0.7	2	mA	RL=∞, All Op-Amps
		Full range	-	-	3		
Maximum Output Voltage(High) (Note 28)	V_{OH}	25°C	3.5	-	-	V	RL=2kΩ
		Full range	27	28	-		VCC=30V, RL=10kΩ
Maximum Output Voltage(Low) (Note 28)	V_{OL}	Full range	-	5	20	mV	RL=∞, All Op-Amps
Large Signal Voltage Gain	A_V	25°C	25	100	-	V/mV	RL≧2kΩ, VCC=15V OUT=1.4 to 11.4V
			88	100	-	dB	
Input Common-mode Voltage Range	V_{ICM}	25°C	0	-	VCC-1.5	V	(VCC-VEE)=5V OUT=VEE+1.4V
Common-mode Rejection Ratio	CMRR	25°C	50	80	-	dB	OUT=1.4V
Power Supply Rejection Ratio	PSRR	25°C	65	100	-	dB	VCC=5 to 30V
Output Source Current (Note 28,29)	I_{SOURCE}	25°C	20	30	-	mA	VIN+=1V, VIN-=0V OUT=0V 1CH is short circuit
		Full range	10	-	-		
Output Sink Current (Note 28,29)	I_{SINK}	25°C	10	20	-	mA	VIN+=0V, VIN-=1V OUT=5V, 1CH is short circuit
		Full range	2	-	-		
		25°C	12	40	-	μA	VIN+=0V, VIN-=1V OUT=200mV
Channel Separation	CS	25°C	-	120	-	dB	f=1kHz, input referred
Slew rate	SR	25°C	-	0.2	-	V/μs	VCC=15V, Av=0dB RL=2kΩ, CL=100pF
Gain Band Width	GBW	25°C	-	0.5	-	MHz	VCC=30V, RL=2kΩ CL=100p
Input referred noise voltage	V_N	25°C	-	40	-	$nV/\sqrt{Hz}$	VCC=15V, VEE=-15V RS=100Ω, Vi=0V, f=1kHz

(Note 27) Absolute value
(Note 28) BA2902S :Full range -40 to +105°C ,BA2902 :Full range -40 to +125°C
(Note 29) 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 used in this datasheet. Items and symbols used are also shown. Note that item name and symbol and their meaning may differ from those on another manufacturer's document or general document.

1. Absolute maximum ratings

Absolute maximum rating items indicate the condition which must not be exceeded. Application of voltage in excess of absolute maximum rating or use out of absolute maximum rated temperature environment may cause deterioration of characteristics.

(1) Supply Voltage (VCC/VEE)
Indicates the maximum voltage that can be applied between the positive power supply terminal and negative power supply terminal without deterioration or destruction of characteristics of internal circuit.

(2) Differential Input Voltage (V_{ID})
Indicates the maximum voltage that can be applied between non-inverting and inverting terminals without damaging the IC.

(3) Input Common-mode Voltage Range (V_{ICM})
Indicates the maximum voltage that can be applied to the non-inverting and inverting terminals without deterioration or destruction of electrical characteristics. Input common-mode voltage range of the maximum ratings does not assure normal operation of IC. For normal operation, use the IC within the input common-mode voltage range characteristics.

(4) Power dissipation (P_D)
Indicates the power that can be consumed by the IC when mounted on a specific board at the ambient temperature 25℃ (normal temperature). As for package product, Pd is determined by the temperature that can be permitted by the IC in the package (maximum junction temperature) and the thermal resistance of the package.

2. Electrical characteristics

(1) Input Offset Voltage (V_{IO})
Indicates the voltage difference between non-inverting terminal and inverting terminals. It can be translated into the input voltage difference required for setting the output voltage at 0 V.

(2) Input Offset Voltage drift ($\triangle V_{IO}/\triangle T$)
Denotes the ratio of the input offset voltage fluctuation to the ambient temperature fluctuation.

(3) Input Offset Current (I_{IO})
Indicates the difference of input bias current between the non-inverting and inverting terminals.

(4) Input Offset Current Drift ($\triangle$Iio/$\triangle$T)
Signifies the ratio of the input offset current fluctuation to the ambient temperature fluctuation.

(4) Input Bias Current (I_B)
Indicates the current that flows into or out of the input terminal. It is defined by the average of input bias currents at the non-inverting and inverting terminals.

(5) Supply Current (ICC)
Indicates the current that flows within the IC under specified no-load conditions.

(7) Maximum Output Voltage(High) / Maximum Output Voltage(Low) (VOH/VOL)
Indicates the voltage range of the output under specified load condition. It is typically divided into maximum output voltage High and low. Maximum output voltage high indicates the upper limit of output voltage. Maximum output voltage low indicates the lower limit.

(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) / (Differential Input voltage)

(9) Input Common-mode Voltage Range (V_{ICM})
Indicates the input voltage range where IC normally operates.

(10) Common-mode Rejection Ratio (CMRR)
Indicates the ratio of fluctuation of input offset voltage when the input common mode voltage is changed. It is normally the fluctuation of DC.
CMRR = (Change of Input common-mode voltage)/(Input offset fluctuation)

(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)

(12) Output Source Current/ Output Sink Current (I_{source} / I_{sink})
The maximum current that can be output from the IC under specific output conditions. The output source current indicates the current flowing out from the IC, and the output sink current indicates the current flowing into the IC.
indicates the current flowing out from the IC, and the output sink current indicates the current flowing into the IC.

(13) Channel Separation (CS)
Indicates the fluctuation in the output voltage of the driven channel with reference to the change of output voltage of the channel which is not driven.

(14) Slew Rate (SR)
Indicates the ratio of the change in output voltage with time when a step input signal is applied.

(15) Gain Bandwidth (GBW)
The product of the open-loop voltage gain and the frequency at which the voltage gain decreases 6dB/octave.

(16) Input Referred Noise Voltage (V_N)
Indicates a noise voltage generated inside the operational amplifier equivalent by ideal voltage source connected in series with input terminal.

Typical Performance Curves

OBA10358

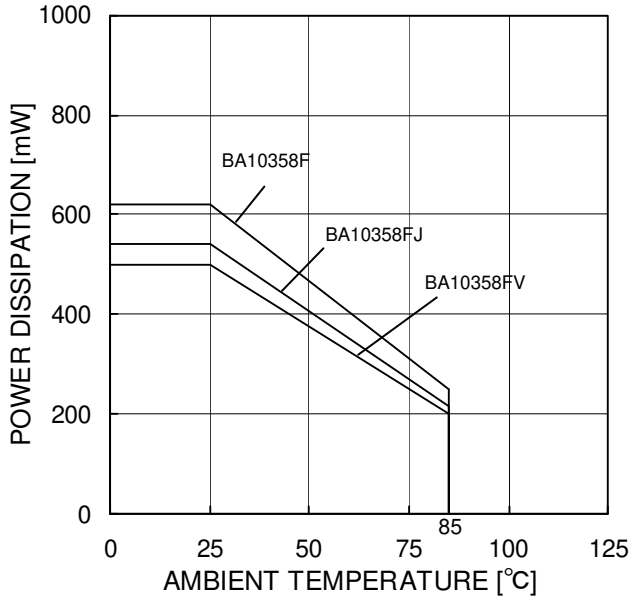


Figure 2.
Derating Curve

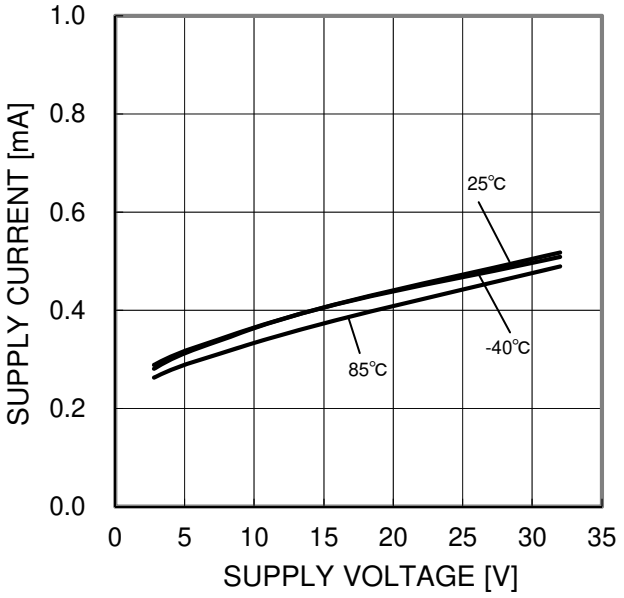


Figure 3.
Supply Current – Supply Voltage

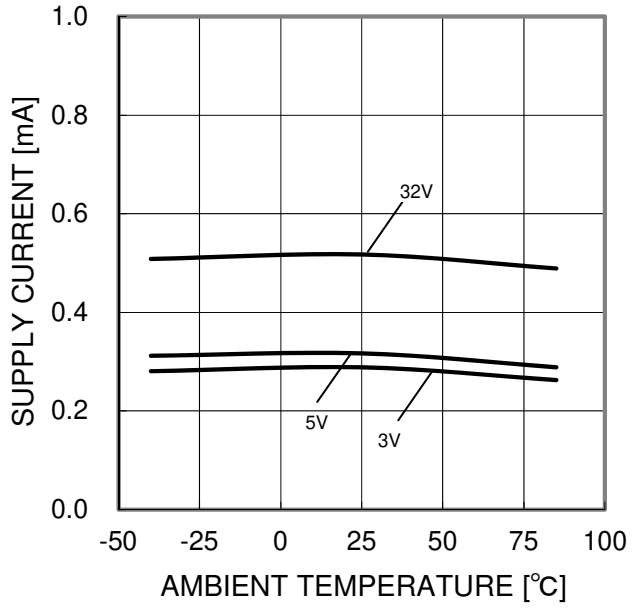


Figure 4.
Supply Current – Ambient Temperature

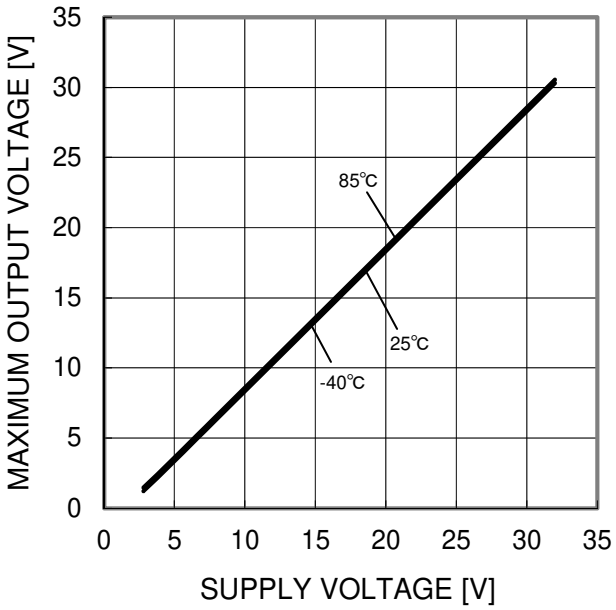


Figure 5.
Maximum Output Voltage - Supply Voltage
(RL=10kΩ)

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

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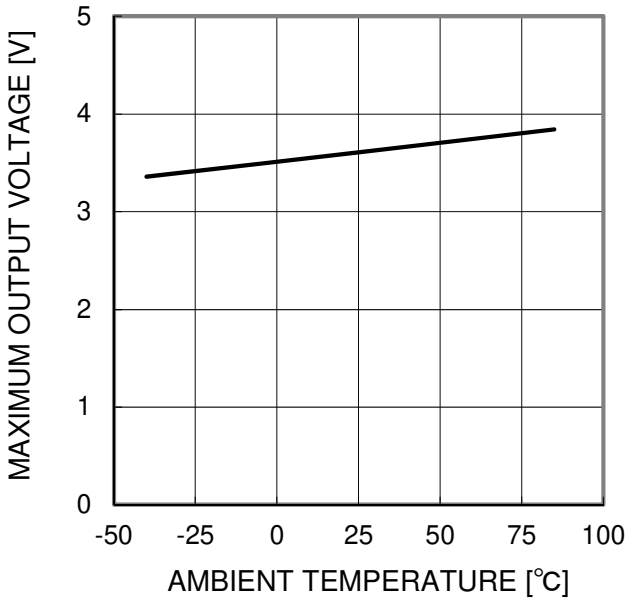

Figure 6.
Maximum Output Voltage - Ambient Temperature
(VCC=5V, RL=2kΩ)

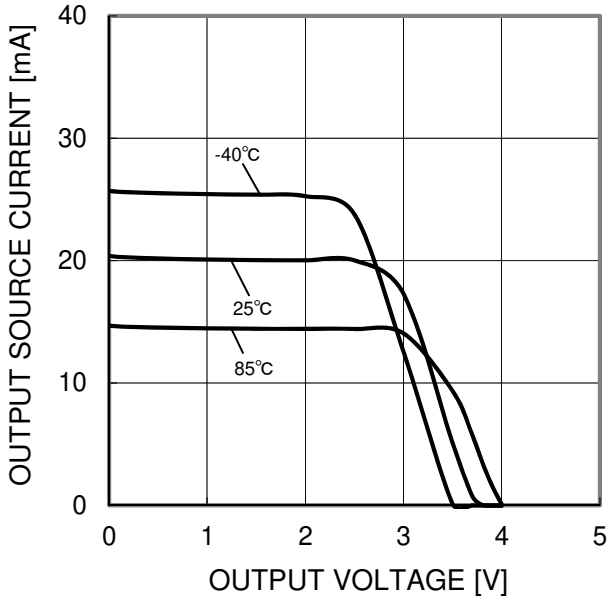

Figure 7.
Output Source Current - Output Voltage
(VCC=5V)

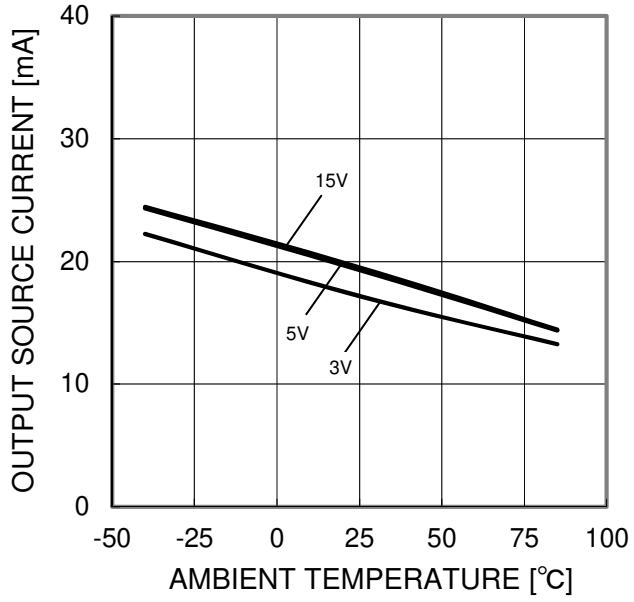

Figure 8.
Output Source Current - Ambient Temperature
(OUT=0V)

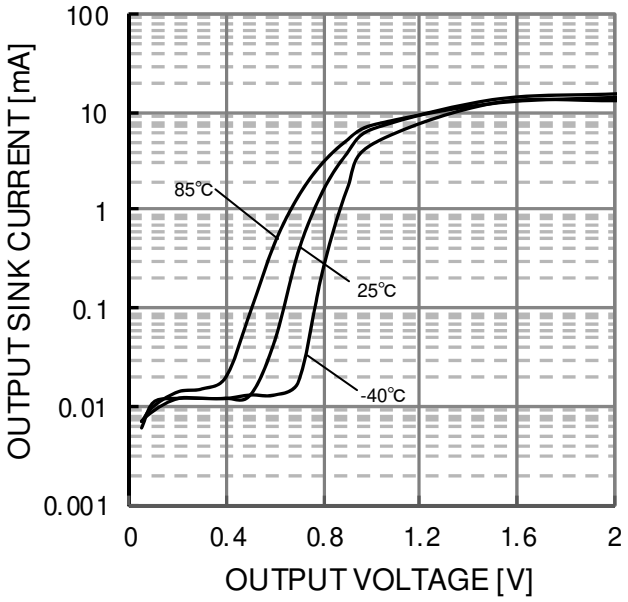

Figure 9.
Output Sink Current - Output Voltage
(VCC=5V)

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

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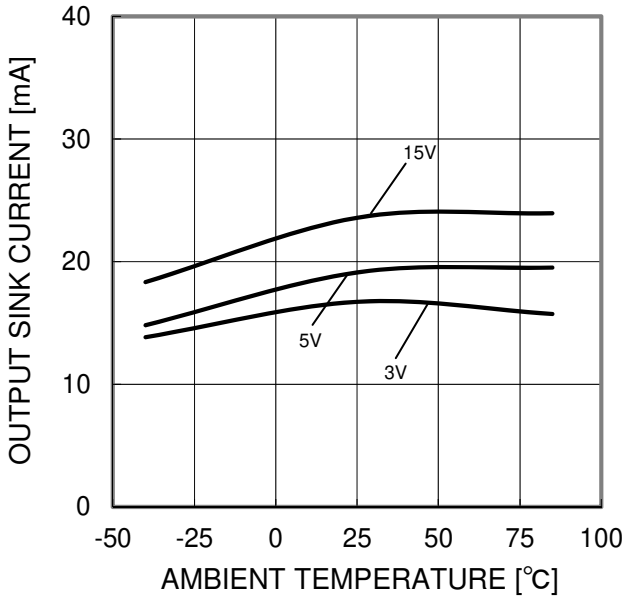

Figure 10.
Output Sink Current - Ambient Temperature
(OUT=VCC)

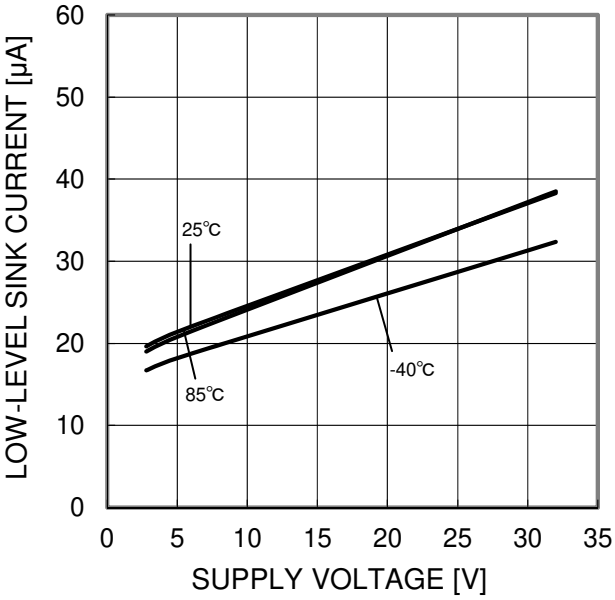

Figure 11.
Low Level Sink Current - Supply Voltage
(OUT=0.2V)

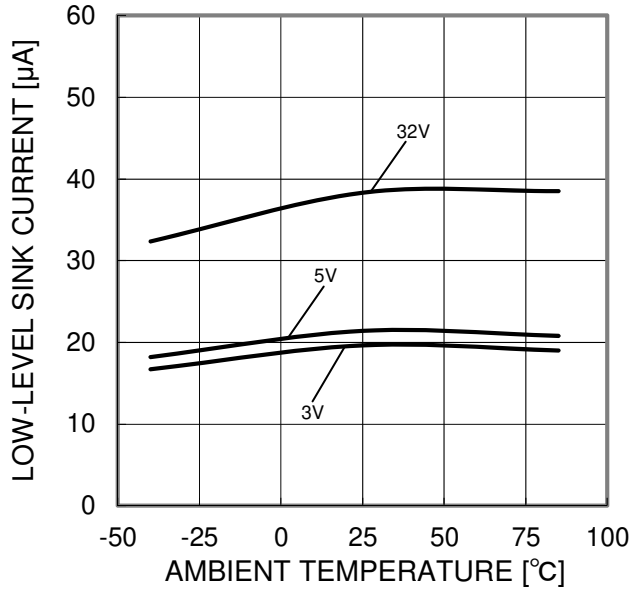

Figure 12.
Low Level Sink Current - Ambient Temperature
(OUT=0.2V)

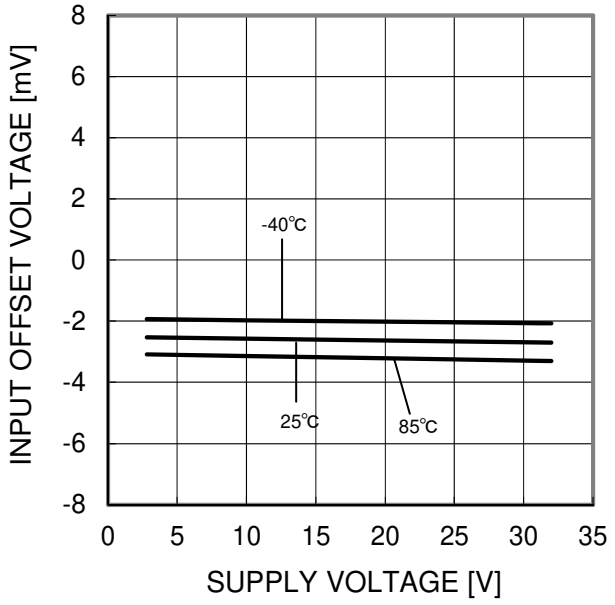

Figure 13.
Input Offset Voltage - Supply Voltage
(V_{ICM}=0V, OUT=1.4V)

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

○BA10358

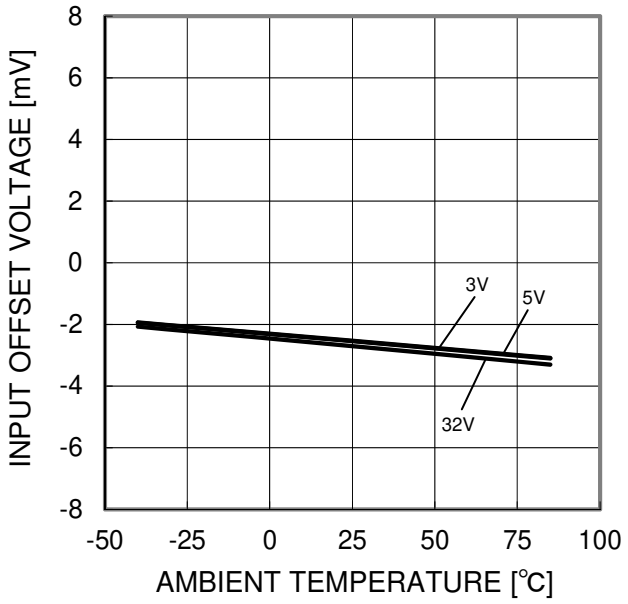

Figure 14.
Input Offset Voltage - Ambient Temperature
(V_{ICM}=0V, OUT=1.4V)

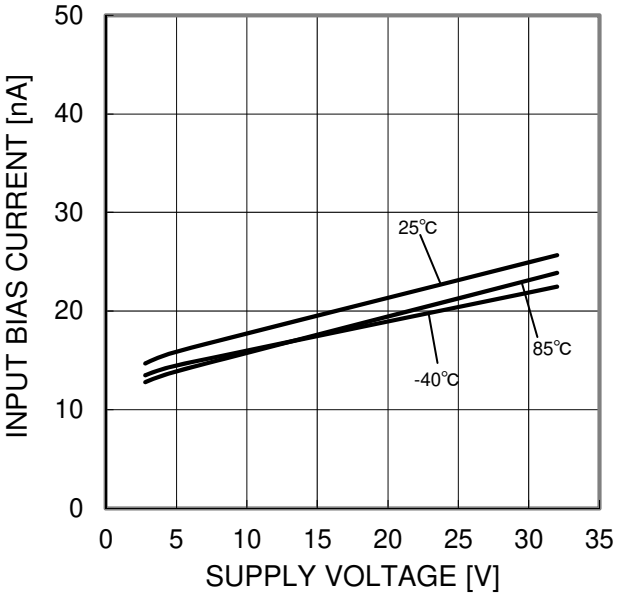

Figure 15.
Input Bias Current - Supply Voltage
(V_{ICM}=0V, OUT=1.4V)

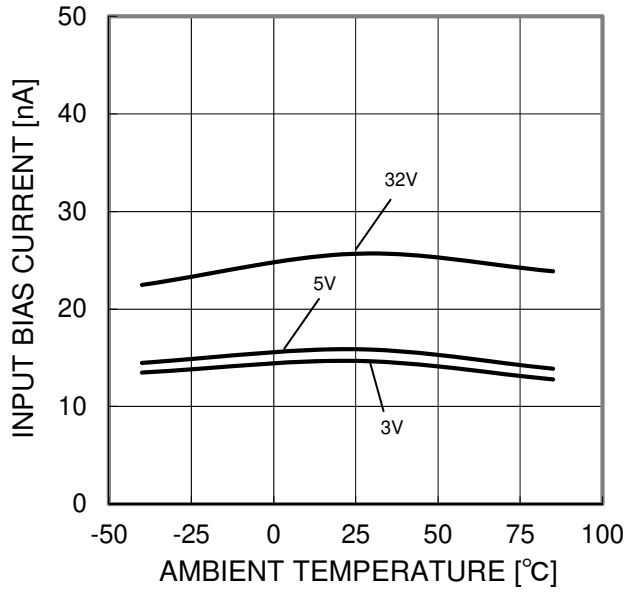

Figure 16.
Input Bias Current - Ambient Temperature
(V_{ICM}=0V, OUT=1.4V)

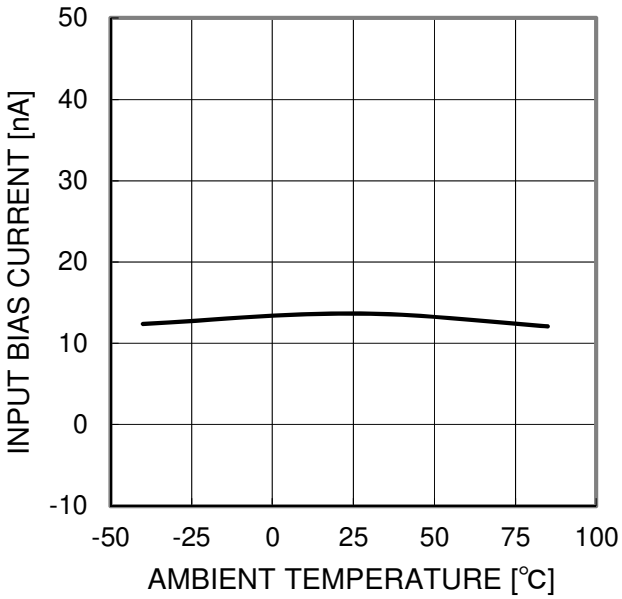

Figure 17.
Input Bias Current - Ambient Temperature
(VCC=30V, V_{ICM}=28V, OUT=1.4V)

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

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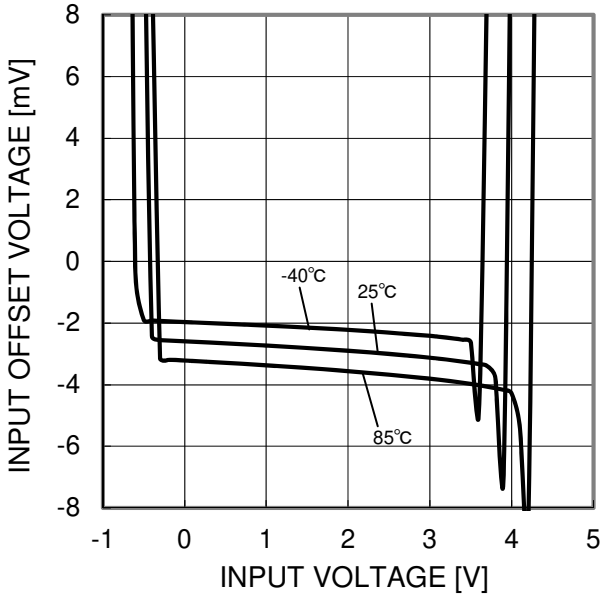

Figure 18.
Input Offset Voltage - Common Mode Input Voltage
(VCC=5V)

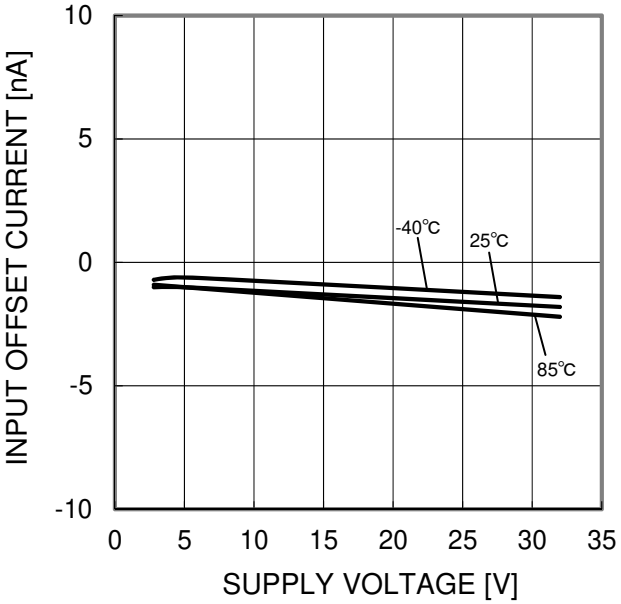

Figure 19.
Input Offset Current - Supply Voltage
(V_{ICM}=0V, OUT=1.4V)

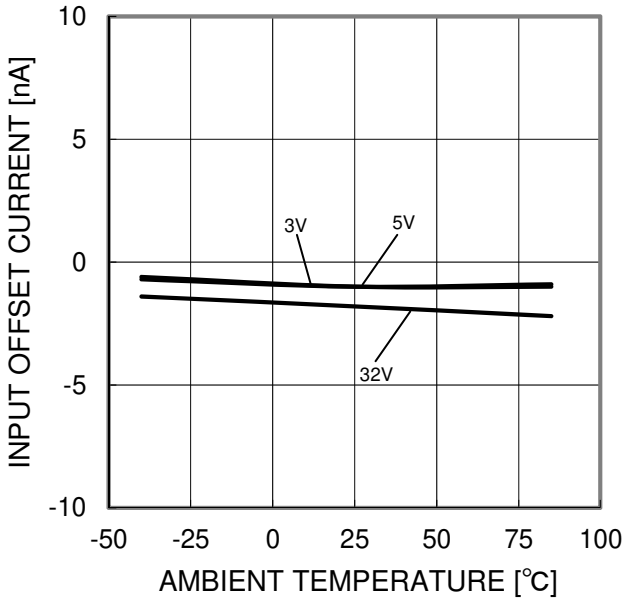

Figure 20.
Input Offset Current - Ambient Temperature
(V_{ICM}=0V, OUT=1.4V)

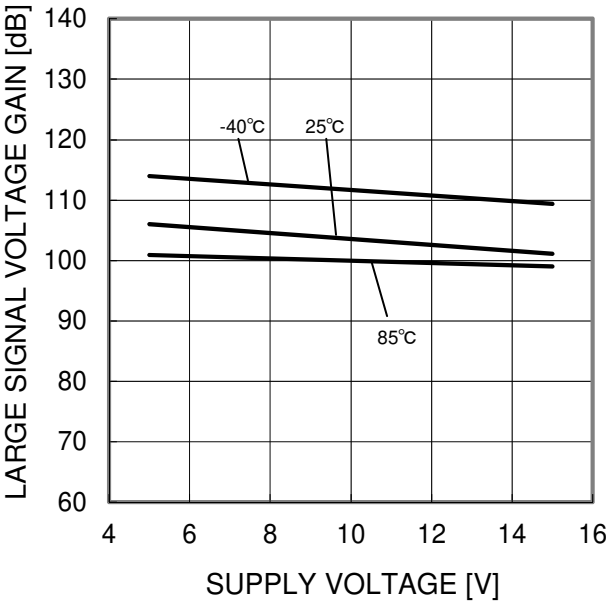

Figure 21.
Large Signal Voltage Gain - Supply Voltage
(RL=2kΩ)

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

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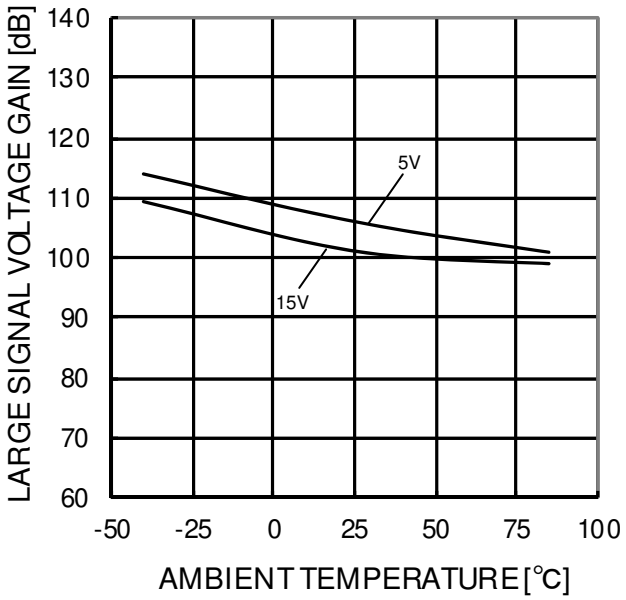

Figure 22.
Large Signal Voltage Gain - Ambient Temperature
(RL=2kΩ)

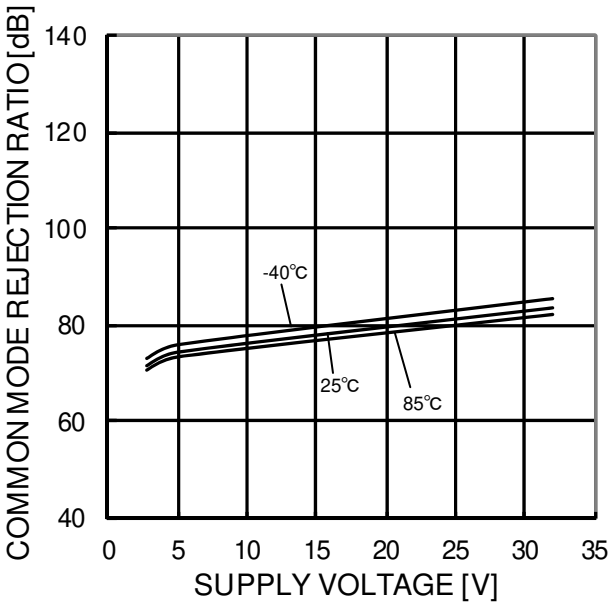

Figure 23.
Common Mode Rejection Ratio
- Supply Voltage

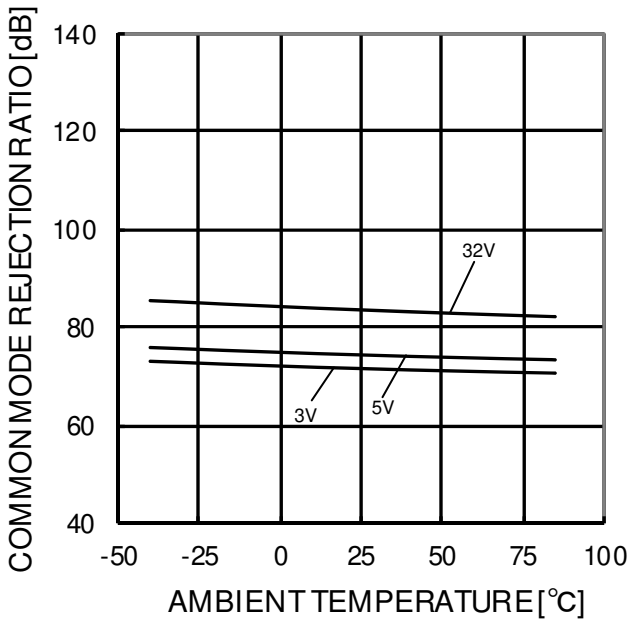

Figure 24.
Common Mode Rejection Ratio
- Ambient Temperature

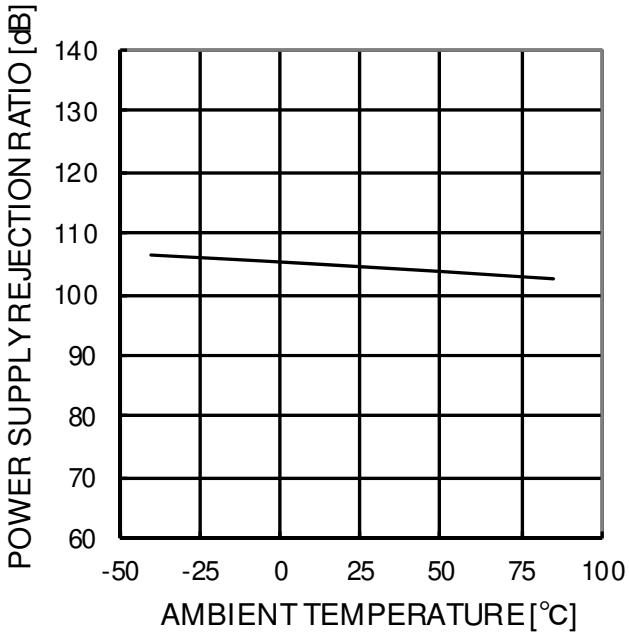

Figure 25.
Power Supply Rejection Ratio
- Ambient Temperature

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

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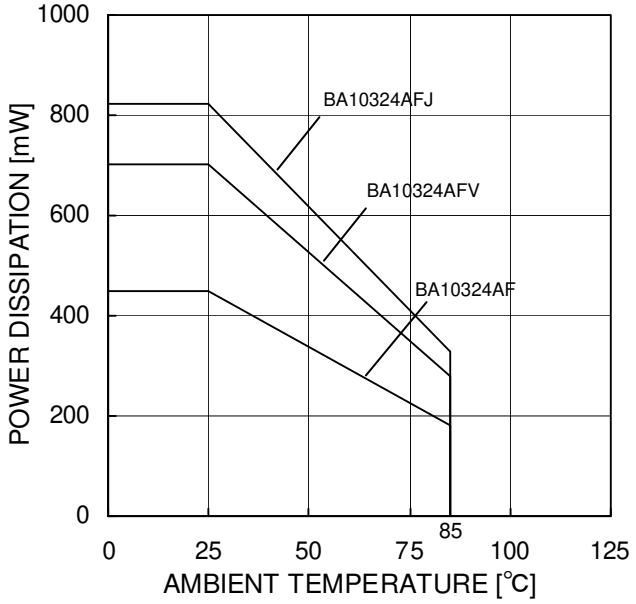

Figure 26.
Derating Curve

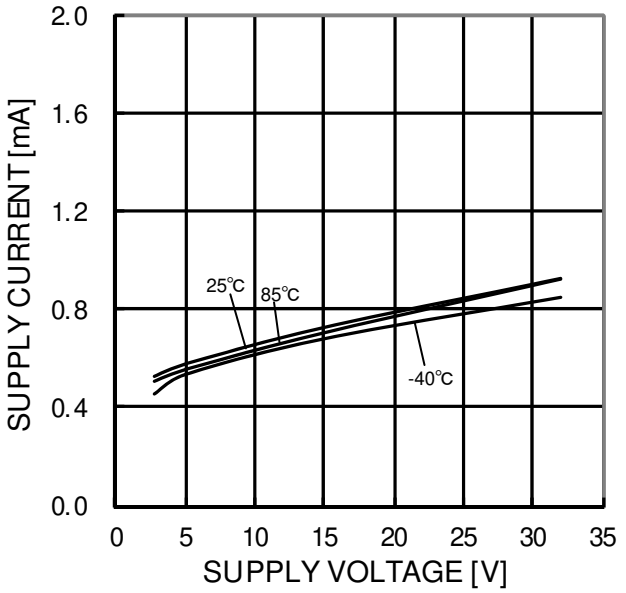

Figure 27.
Supply Current - Supply Voltage

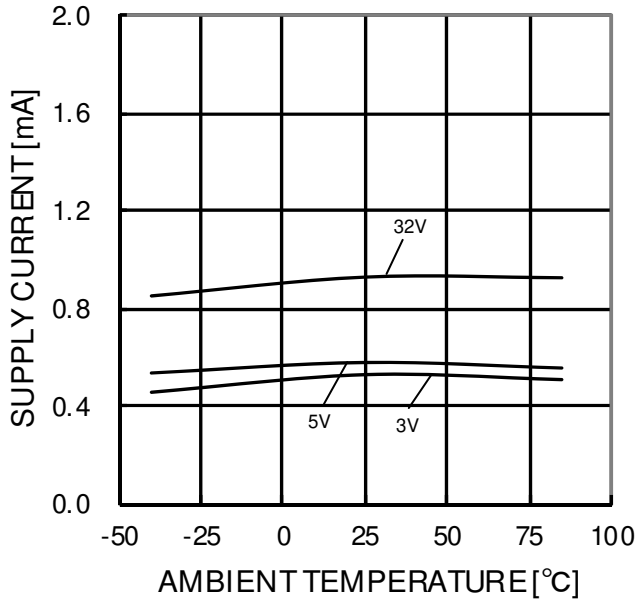

Figure 28.
Supply Current - Ambient Temperature

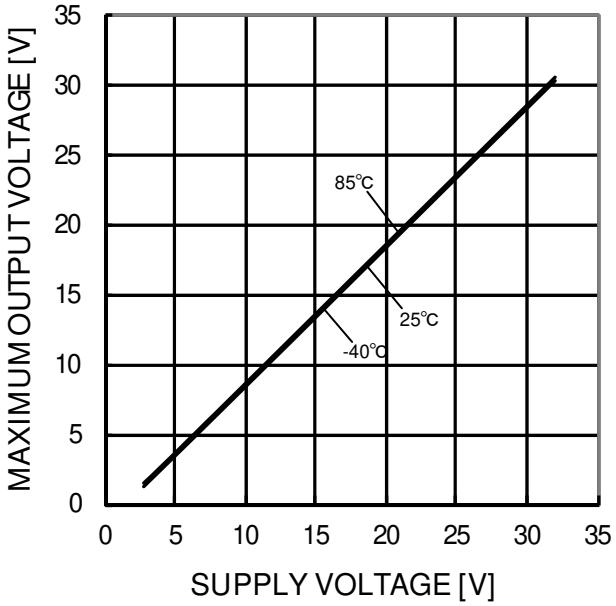

Figure 29.
Maximum Output Voltage - Supply Voltage
(RL=10kΩ)

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

○BA10324A

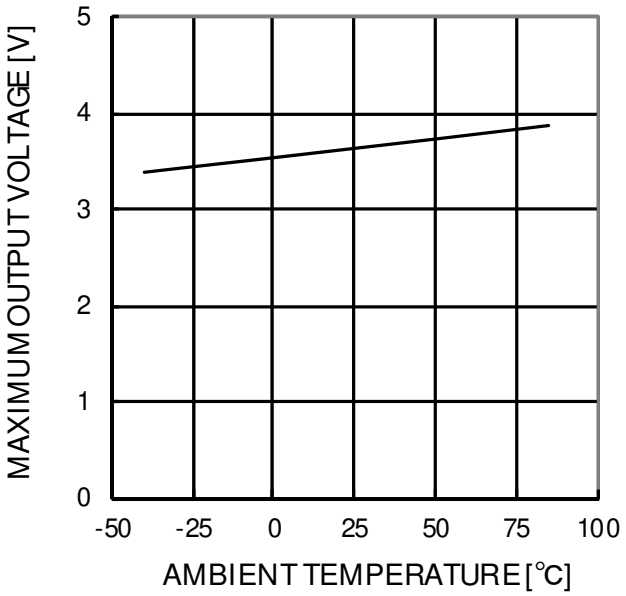

Figure 30.
Maximum Output Voltage - Ambient Temperature
(VCC=5V, RL=2kΩ)

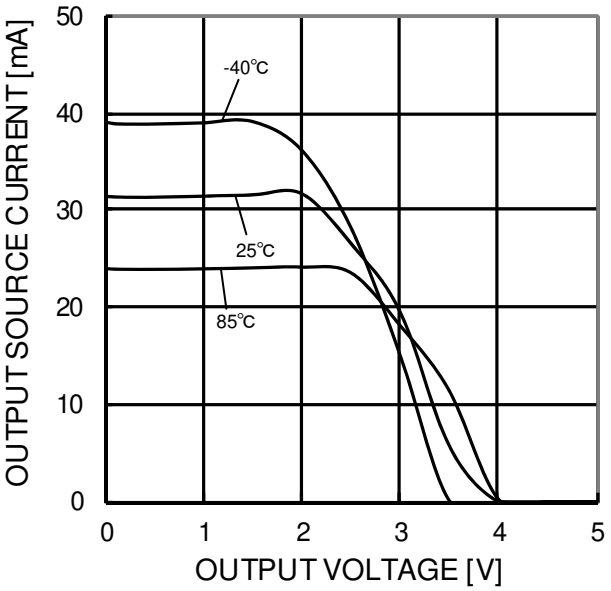

Figure 31.
Output Source Current - Output Voltage
(VCC=5V)

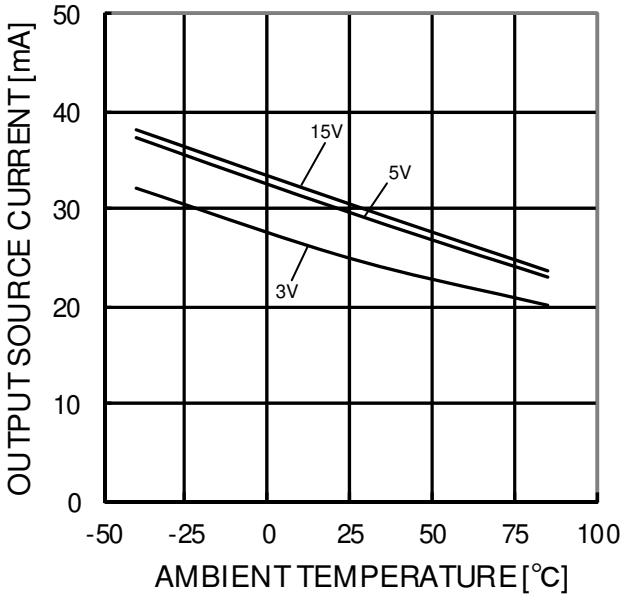

Figure 32.
Output Source Current - Ambient Temperature
(OUT=0V)

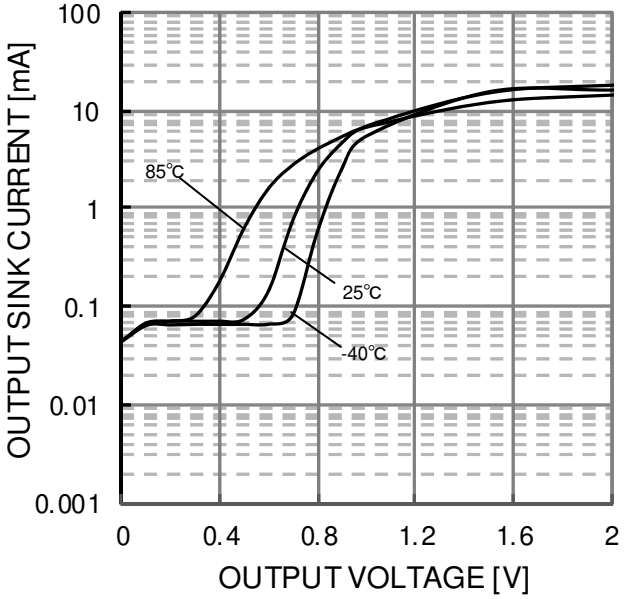

Figure 33.
Output Sink Current - Output Voltage
(VCC=5V)

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

○BA10324A

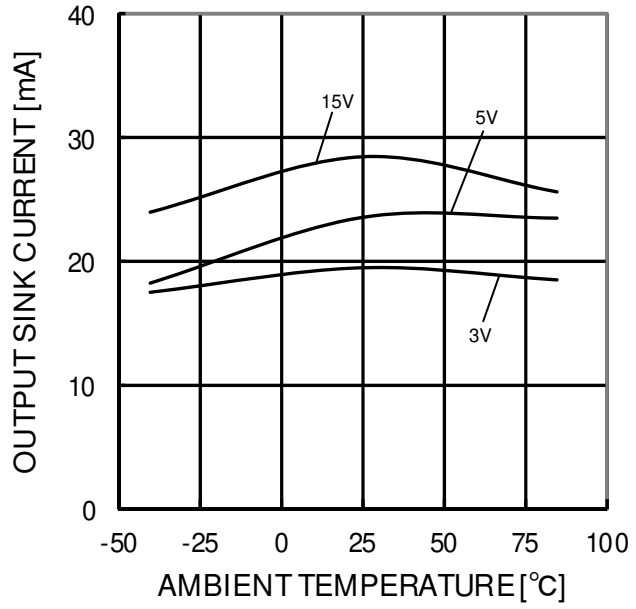

Figure 34.
Output Sink Current - Ambient Temperature
(OUT=VCC)

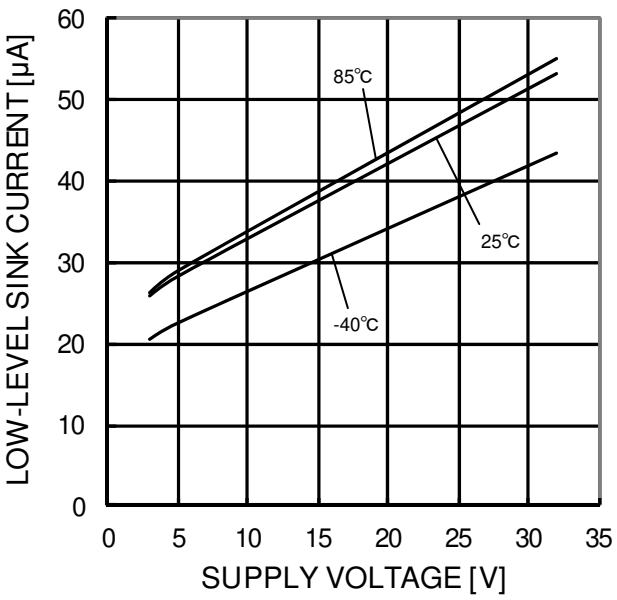

Figure 35.
Low Level Sink Current - Supply Voltage
(OUT=0.2V)

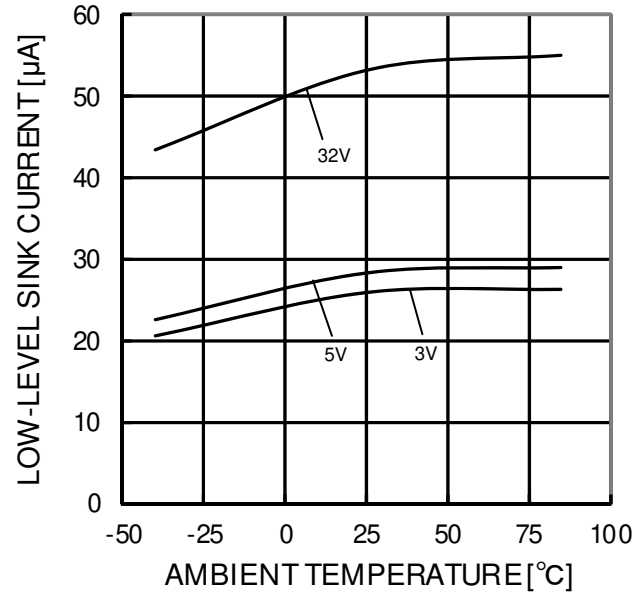

Figure 36.
Low Level Sink Current - Ambient Temperature
(OUT=0.2V)

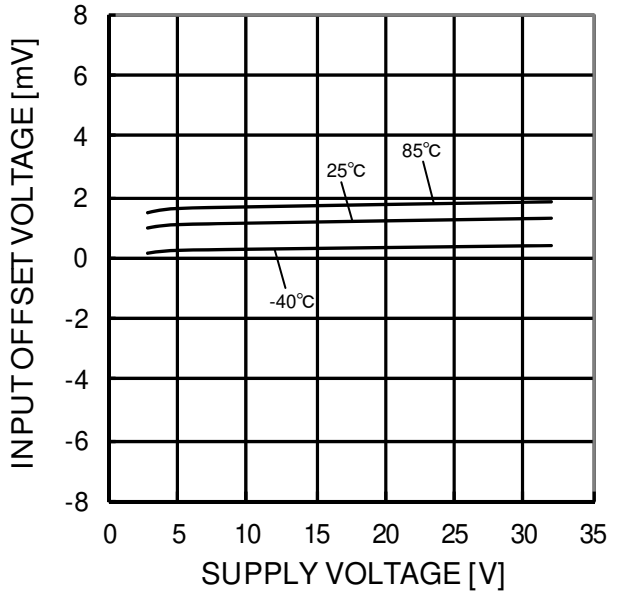

Figure 37.
Input Offset Voltage - Supply Voltage
(V_{ICM}=0V, OUT=1.4V)

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

○BA10324A

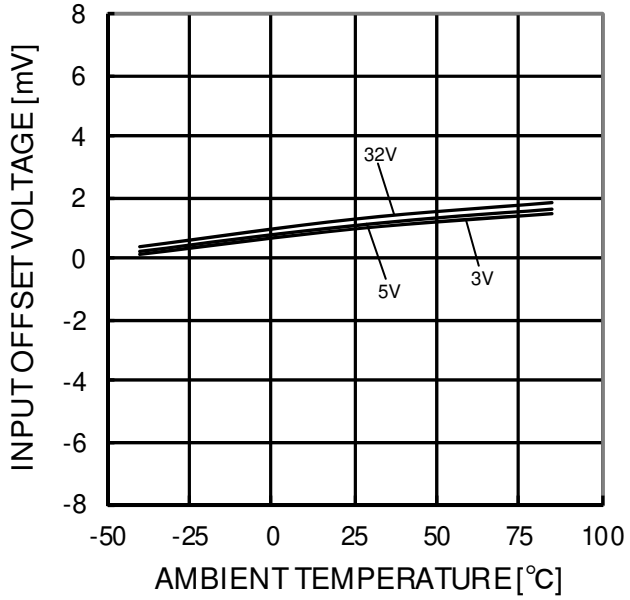

Figure 38.
Input Offset Voltage - Ambient Temperature
(V_{ICM}=0V, OUT=1.4V)

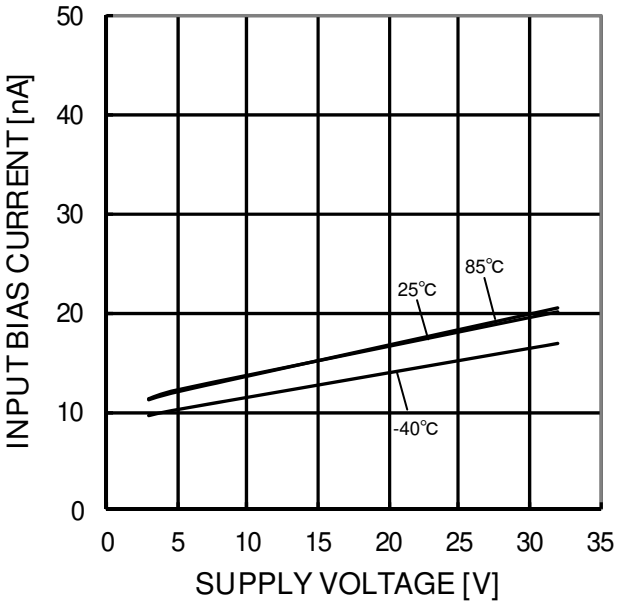

Figure 39.
Input Bias Current - Supply Voltage
(V_{ICM}=0V, OUT=1.4V)

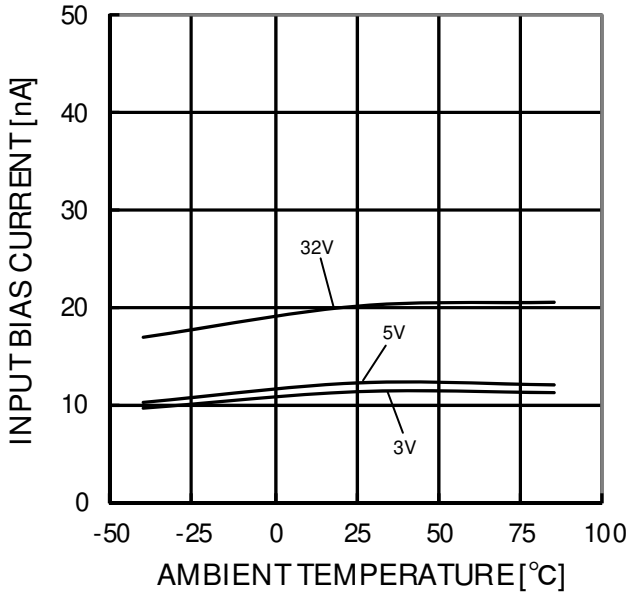

Figure 40.
Input Bias Current - Ambient Temperature
(V_{ICM}=0V, OUT=1.4V)

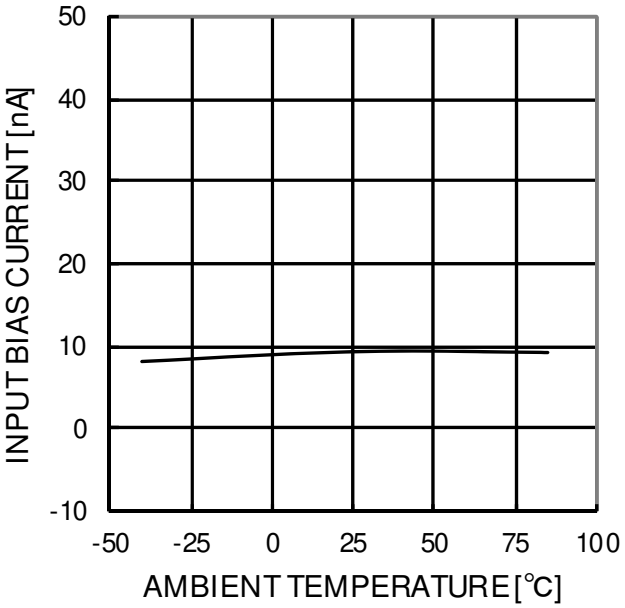

Figure 41.
Input Bias Current - Ambient Temperature
(VCC=30V, V_{ICM}=28V, OUT=1.4V)

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

○BA10324A

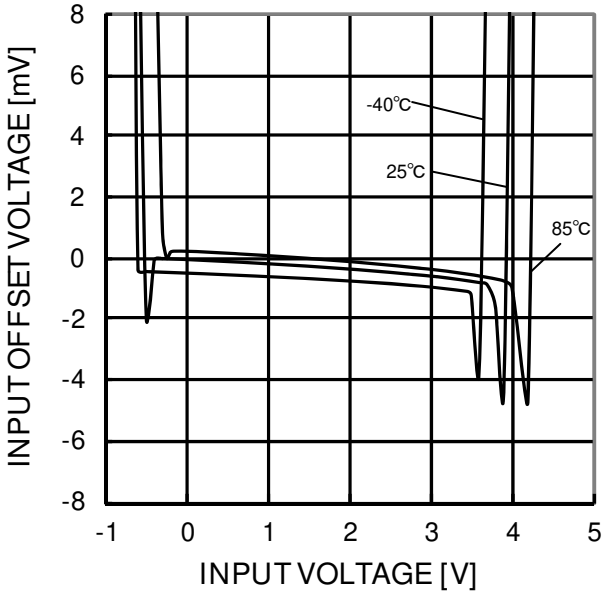

Figure 42.
Input Offset Voltage
- Common Mode Input Voltage
(VCC=5V)

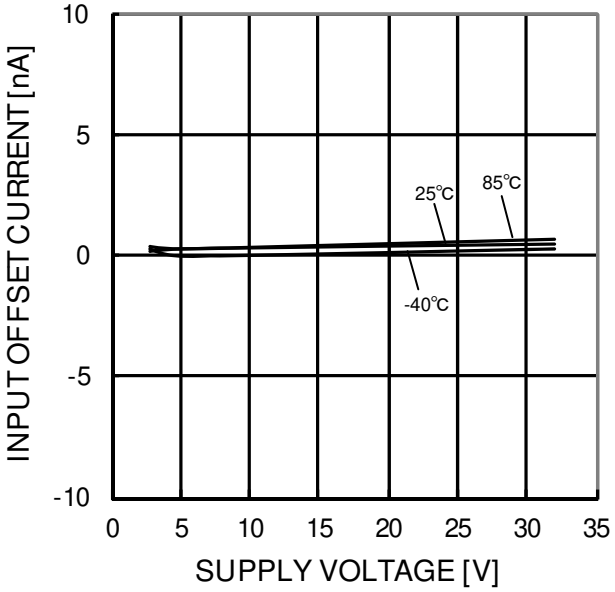

Figure 43.
Input Offset Current - Supply Voltage
(V_{ICM}=0V, OUT=1.4V)

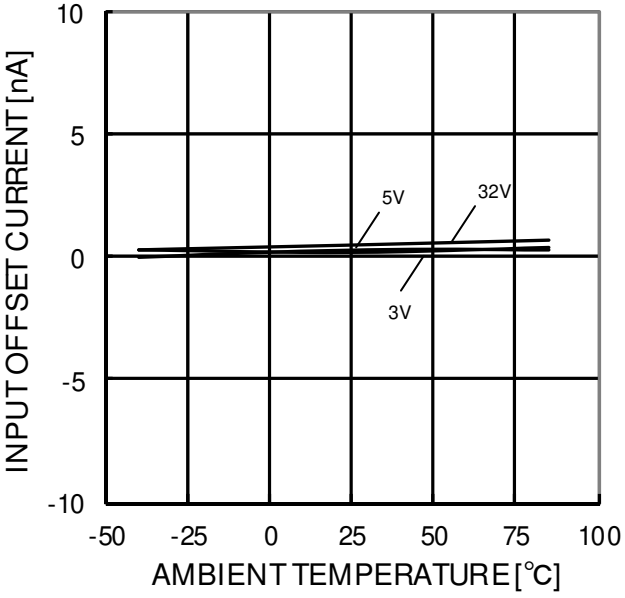

Figure 44.
Input Offset Current - Ambient Temperature
(V_{ICM}=0V, OUT=1.4V)

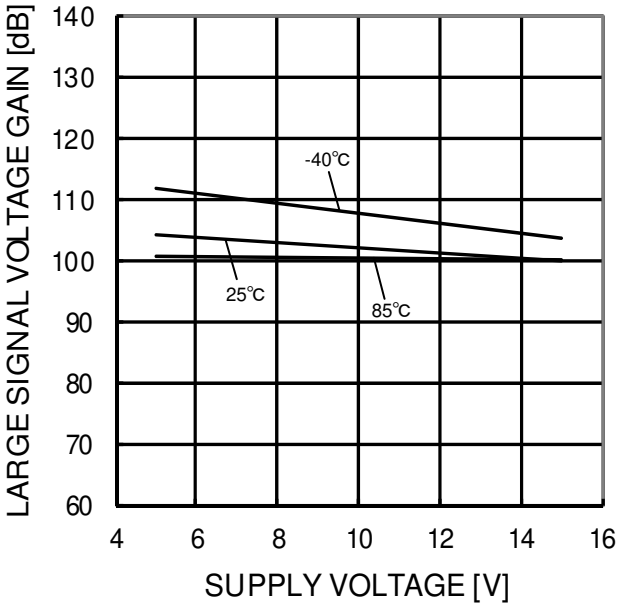

Figure 45.
Large Signal Voltage Gain - Supply Voltage
(RL=2kΩ)

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

○BA10324A

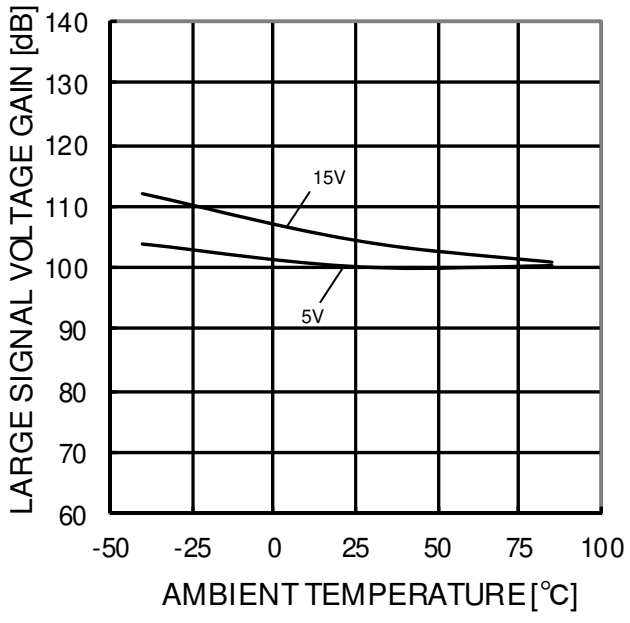

Figure 46.
Large Signal Voltage Gain
- Ambient Temperature
(RL=2kΩ)

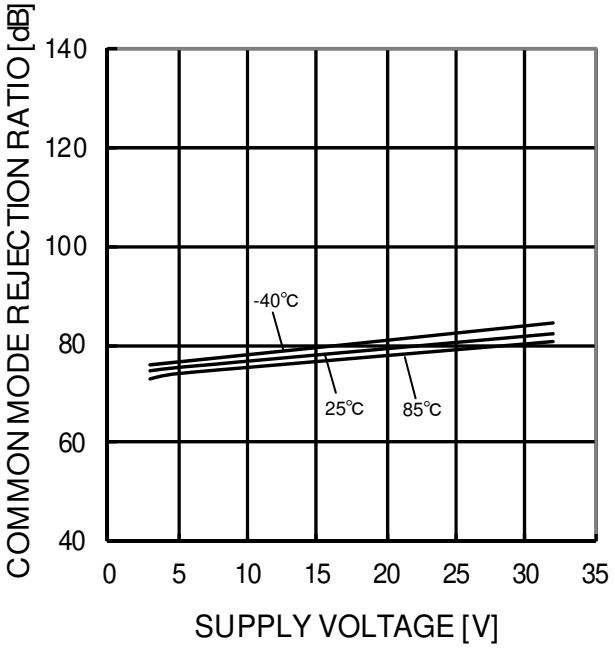

Figure 47.
Common Mode Rejection Ratio
- Supply Voltage

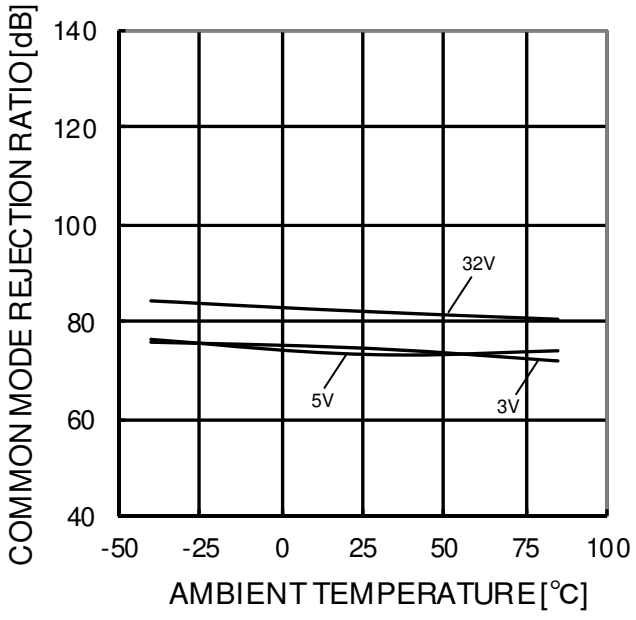

Figure 48.
Common Mode Rejection Ratio
- Ambient Temperature

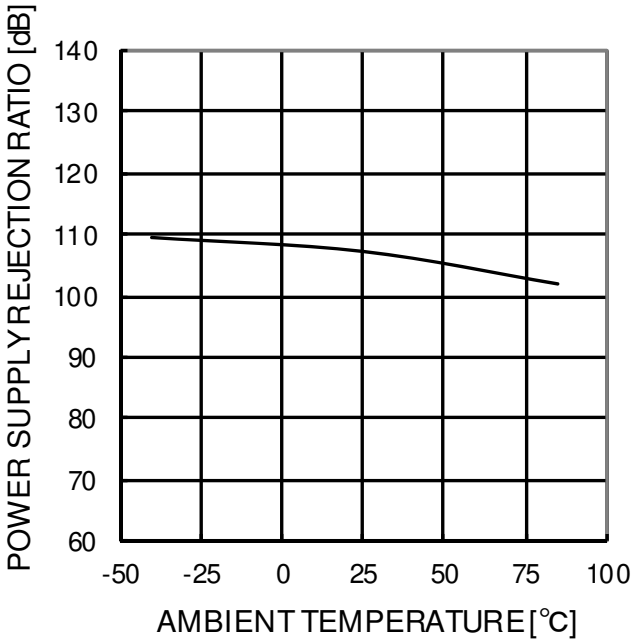

Figure 49.
Power Supply Rejection Ratio
- Ambient Temperature

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

○BA2904, BA2904S, BA2904W

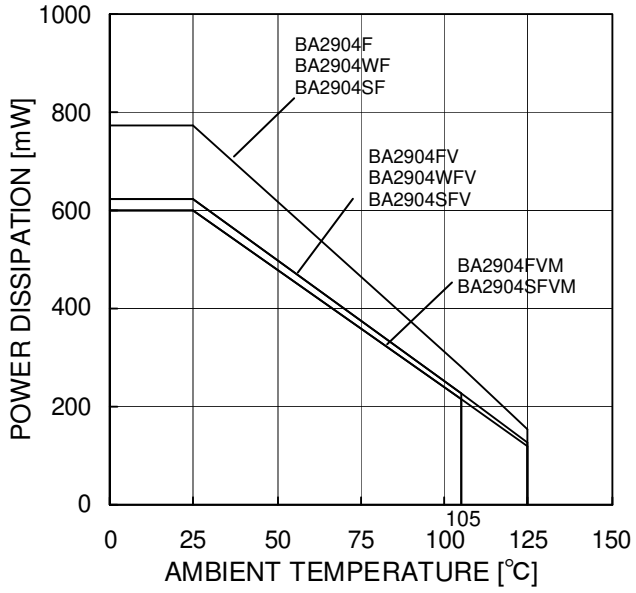

Figure 50.
Derating Curve

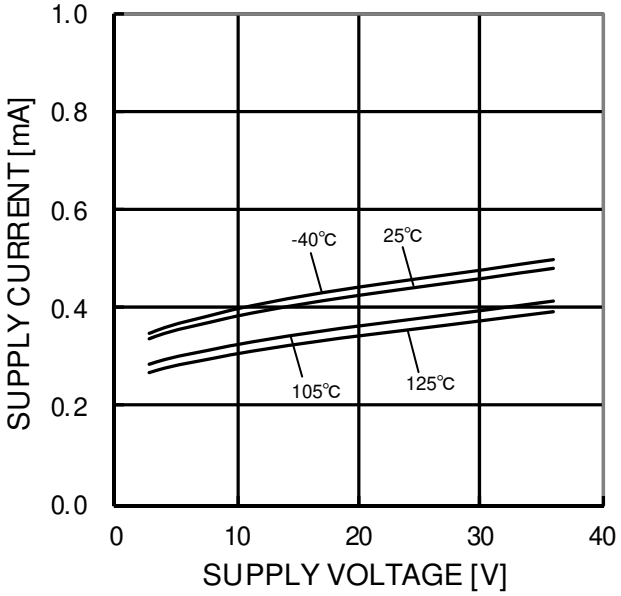

Figure 51.
Supply Current- Supply Voltage

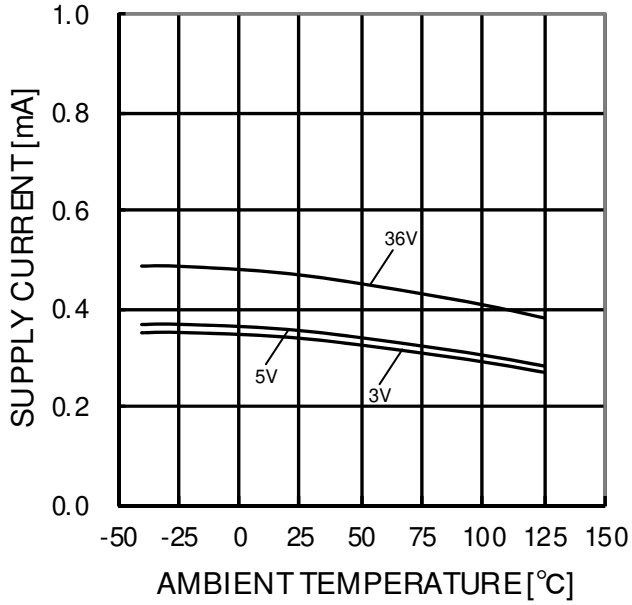

Figure 52.
Supply Current – Ambient Temperature

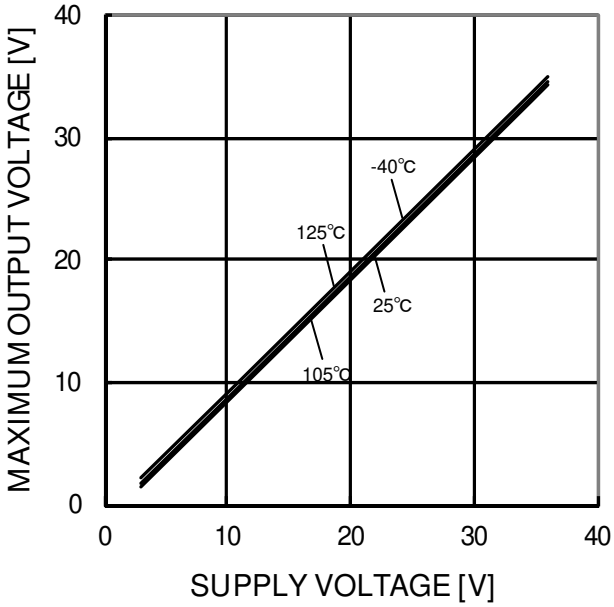

Figure 53.
Maximum Output Voltage - Supply Voltage
(RL=10kΩ)

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA2904, BA2904W : -40°C to +125°C BA2904S : -40°C to +105°C