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Operational Amplifiers

High Speed with High Voltage Operational Amplifiers

BA3472xxx BA3472RFVM BA3474xxx BA3474RFV

General Description

BA3472xxx/BA3472RFVM/BA3474xxx/BA3474RFV are high speed operational amplifiers of dual circuits and quad circuits. An operational range is wide with +3V~+36V (single power supply), and gain bandwidth product 4MHz and a high slew rate of in wideband and 10V/μs are good points.

Features

- Operable with a single power supply
- Wide operating supply voltage
- Internal phase compensation
- High open loop voltage gain
- Operable low input voltage around GND level
- Wide output voltage range

Application

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

Packages

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
TSSOP-B8	3.00mm x 6.40mm x 1.20mm
MSOP8	2.90mm x 4.00mm x 0.90mm
SOP14	8.70mm x 6.20mm x 1.71mm
SSOP-B14	5.00mm x 6.40mm x 1.35mm
TSSOP-B14J	5.00mm x 6.40mm x 1.20mm

Key Specifications

- Wide Operating Supply Voltage:
  - Single power supply: +3.0V to +36.0V
  - Dual power supply: ±1.5V to ±18.0V
- Operating Temperature Range:
  - BA3474F: -40°C to +75°C
  - BA3472xxx BA3474xxx: -40°C to +85°C
  - BA3472RFVM BA3474RFV: -40°C to +105°C
- Slew Rate: 10V/μs(Typ)
- Unity Gain Frequency: 4MHz(Typ)

Simplified Schematic

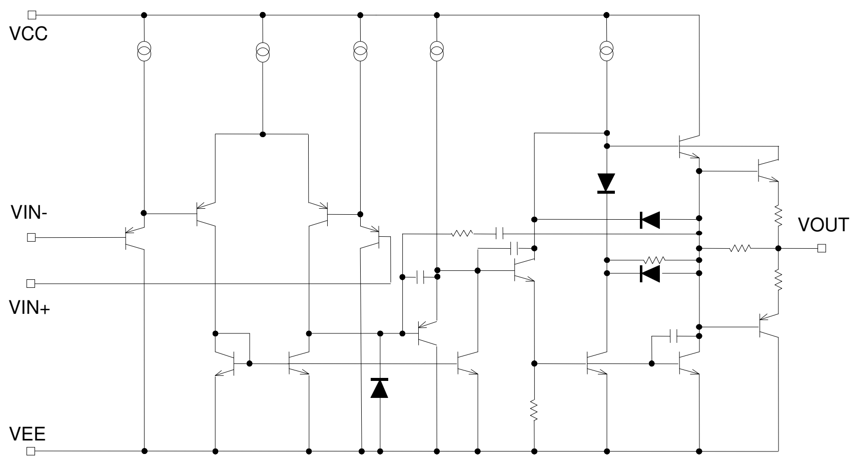

Figure 1. Simplified schematic (one channel only)

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

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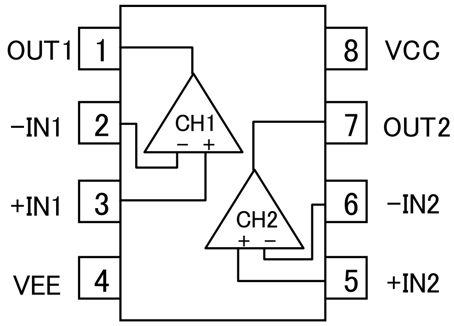
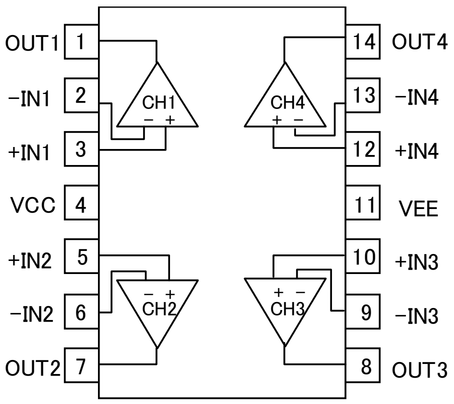
Pin Configuration

BA3472F	:SOP8
BA3472FJ	:SOP-J8
BA3472FV	:SSOP-B8
BA3472FVT	:TSSOP-B8
BA3472FVM, BA3472RFVM	:MSOP8



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

BA3474F	:SOP14
BA3474FV, BA3474RFV	:SSOP-B14
BA3474FVJ	:TSSOP-B14J



Pin No.	Symbol
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	SOP-J8	TSSOP-B8	MSOP8	SOP14	SSOP-B14	TSSOP-B14J
BA3472F	BA3472FV	BA3472FJ	BA3472FVT	BA3472FVM BA3472RFVM	BA3474F	BA3474FV BA3474RFV	BA3474FVJ

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Ordering Information

B A 3 4 7 x x x x x - x x

Part Number
BA3472xxx
BA3472Rxxx
BA3474xxx
BA3474Rxx

Package
F : SOP8
SOP14
FV : SSOP-B8
SSOP-B14
FJ : SOP-J8
FVT : TSSOP-B8
FVJ : TSSOP-B14J
FVM : MSOP8

Packaging and forming specification
E2: Embossed tape and reel
(SOP8/SOP14/SSOP-B8/SSOP-B14
SOP-J8/TSSOP-B8/TSSOP-B14J)
TR: Embossed tape and reel
(MSOP8)

Line-up

Topr	Supply Current (Typ)	Slew Rate (Typ)	Package		Orderable Part Number
-40°C to +75°C	8.0mA	10V/µs	SOP14	Reel of 2500	BA3474F-E2
-40°C to +85°C	4.0mA		SOP8	Reel of 2500	BA3472F-E2
			SSOP-B8	Reel of 2500	BA3472FV-E2
			SOP-J8	Reel of 2500	BA3472FJ-E2
			TSSOP-B8	Reel of 2500	BA3472FVT-E2
			MSOP8	Reel of 3000	BA3472FVM-TR
	8.0mA		SSOP-B14	Reel of 2500	BA3474FV-E2
			TSSOP-B14J	Reel of 2500	BA3474FVJ-E2
-40°C to +105°C	4.0mA		MSOP8	Reel of 3000	BA3472RFVM-TR
	8.0mA		SSOP-B14	Reel of 2500	BA3474RFV-E2

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Absolute Maximum Ratings (Ta=25℃)

Parameter	Symbol		Ratings				Unit
			BA3472	BA3474	BA3472R	BA3474R	
Supply Voltage	VCC-VEE		+36				V
Power Dissipation	Pd	SOP8	780[*1*13]	-	-	-	mW
		SSOP-B8	690[*2*13]	-	-	-	
		MSOP8	590[*3*13]	-	590[*3*13]	-	
			-	-	625[*4*14]	-	
			-	-	713[*5*15]	-	
			-	-	937[*6*16]	-	
		SOP-J8	675[*7*13]	-	-	-	
		TSSOP-B8	625[*4*13]	-	-	-	
		SOP14	-	610[*8*13]	-	-	
		SSOP-B14	-	870[*9*13]	-	870[*9*13]	
			-	-	-	1187[*10*15]	
			-	-	-	1689[*11*16]	
		TSSOP-B14	-	850[*12*13]	-	-	
Differential Input Voltage[*17]	Vid		+36				V
Input Common-mode Voltage Range	Vicm		(VEE - 0.3) to VEE + 36				V
Input Current[*18]	I_I		-10				mA
Operable with Low Voltage	Vopr		+3.0V to +36.0V (±1.5V to ±18.0V)				V
Operating Temperature Range	Topr		-40 to +85(SOP14:to +75)		-40 to +105		℃
Storage Temperature Range	Tstg		-55 to +150				℃
Maximum Junction Temperature	Tjmax		+150				℃

*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 5.0mW/℃
*5 To use at temperature above Ta＝25℃ reduce 5.7mW/℃
*6 To use at temperature above Ta＝25℃ reduce 7.5mW/℃
*7 To use at temperature above Ta＝25℃ reduce 5.4mW/℃
*8 To use at temperature above Ta＝25℃ reduce 4.9mW/℃
*9 To use at temperature above Ta＝25℃ reduce 7.0mW/℃
*10 To use at temperature above Ta＝25℃ reduce 9.5mW/℃
*11 To use at temperature above Ta＝25℃ reduce 13.5mW/℃
*12 To use at temperature above Ta＝25℃ reduce 6.8mW/℃
*13 Mounted on a FR4 glass epoxy PCB(70mm×70mm×1.6mm).
*14 Mounted on a FR4 glass epoxy 2 layers PCB 70mm×70mm×1.6mm (occupied copper area：15mm×15mm).
*15 Mounted on a FR4 glass epoxy 2 layers PCB 70mm×70mm×1.6mm (occupied copper area：70mm×70mm).
*16 Mounted on a FR4 glass epoxy 4 layers PCB 70mm×70mm×1.6mm (occupied copper area：70mm×70mm).
*17 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.
*18 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.

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Electrical Characteristics

○BA3472 (Unless otherwise specified VCC=+15V, VEE=-15V , Ta=25℃)

Parameter	Symbol	Limits			Unit	Condition
		Min	Typ	Max		
Input Offset Voltage [*19]	Vio	-	1	10	mV	Vicm=0V, VOUT=0V
		-	1	10		VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2
Input Offset Current [*19]	Iio	-	6	75	nA	Vicm=0V, VOUT=0V
Input Bias Current [*19]	Ib	-	100	500	nA	Vicm=0V, VOUT=0V
Supply Current	ICC	-	4	5.5	mA	RL=∞
Maximum Output Voltage(High)	VOH	3.7	4	-	V	VCC=5V, RL=2kΩ
		13.7	14	-		RL=10kΩ
		13.5	-	-		RL=2kΩ
Maximum Output Voltage(Low)	VOL	-	0.1	0.3	V	VCC=5V, RL=2kΩ
		-	-14.7	-14.3		RL=10kΩ
		-	-	-13.5		RL=2kΩ
Large Signal Voltage Gain	Av	80	100	-	dB	RL≧2kΩ, VOUT=±10 V
Input Common-mode Voltage Range	Vicm	0	-	VCC-2.0	V	VCC=5V, VEE=0V VOUT=VCC/2
Common-mode Rejection Ratio	CMRR	60	97	-	dB	Vicm=0V, VOUT=0V
Power Supply Rejection Ratio	PSRR	60	97	-	dB	Vicm=0V, VOUT=0V
Output Source Current [*20]	Isource	10	30	-	mA	VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit
Output Sink Current [*20]	Isink	20	30	-	mA	VCC=5V, VIN+=0V VIN-=1V, VOUT=5V Only 1ch is short circuit
Unity Gain Frequency	f_T	-	4	-	MHz	-
Gain Bandwidth	GBW	-	4	-	MHz	f=100kHz open loop
Slew Rate	SR	-	10	-	V/µs	Av=1, Vin=-10 to +10V RL=2kΩ
Channel Separation	CS	-	120	-	dB	f=1kHz, input referred

*19 Absolute value

*20 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.

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○BA3472R (Unless otherwise specified VCC=+15V, VEE=-15V, Ta=25℃)

Parameter	Symbol	Limits			Unit	Condition
		Min	Typ	Max		
Input Offset Voltage [21]	Vio	-	1	10	mV	Vicm=0V, VOUT=0V
		-	1	10		VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2
Input Offset Current [*21]	Iio	-	6	75	nA	Vicm=0V, VOUT=0V
Input Bias Current [*21]	Ib	-	100	500	nA	Vicm=0V, VOUT=0V
Supply Current	ICC	-	4	5.5	mA	RL=∞
Maximum Output Voltage(High)	VOH	3.7	4	-	V	VCC=5V, RL=2kΩ
		13.7	14	-		RL=10kΩ
		13.5	-	-		RL=2kΩ
Maximum Output Voltage(Low)	VOL	-	0.1	0.3	V	VCC=5V, RL=2kΩ
		-	-14.7	-14.3		RL=10kΩ
		-	-	-13.5		RL=2kΩ
Large Signal Voltage Gain	Av	80	100	-	dB	RL≧2kΩ, VOUT=±10 V
Input Common-mode Voltage Range	Vicm	0	-	VCC-2.0	V	VCC=5V, VEE=0V VOUT=VCC/2
Common-mode Rejection Ratio	CMRR	60	97	-	dB	Vicm=0V, VOUT=0V
Power Supply Rejection Ratio	PSRR	60	97	-	dB	Vicm=0V, VOUT=0V
Output Source Current [*22]	Isource	10	30	-	mA	VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit
Output Sink Current [*22]	Isink	20	30	-	mA	VCC=5V, VIN+=0V VIN-=1V, VOUT=5V Only 1ch is short circuit
Unity Gain Frequency	f_T	-	4	-	MHz	-
Gain Bandwidth	GBW	-	4	-	MHz	f=100kHz open loop
Slew Rate	SR	-	10	-	V/μs	Av=1, Vin=-10 to +10V, RL=2kΩ
Channel Separation	CS	-	120	-	dB	f=1kHz, input referred

*21 Absolute value
*22 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.

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○BA3474 (Unless otherwise specified VCC=+15V, VEE=-15V, Ta=25℃)

Parameter	Symbol	Limits			Unit	Condition
		Min	Typ	Max		
Input Offset Voltage *23	Vio	-	1	10	mV	Vicm=0V, VOUT=0V
		-	1	10		VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2
Input Offset Current *23	Iio	-	6	75	nA	Vicm=0V, VOUT=0V
Input Bias Current *23	Ib	-	100	500	nA	Vicm=0V, VOUT=0V
Supply Current	ICC	-	8	11	mA	RL=∞
Maximum Output Voltage(High)	VOH	3.7	4	-	V	VCC=5V, RL=2kΩ
		13.7	14	-		RL=10kΩ
		13.5	-	-		RL=2kΩ
Maximum Output Voltage(Low)	VOL	-	0.1	0.3	V	VCC=5V, RL=2kΩ
		-	-14.7	-14.3		RL=10kΩ
		-	-	-13.5		RL=2kΩ
Large Signal Voltage Gain	Av	80	100	-	dB	RL≧2kΩ, VOUT=±10 V
Input Common-mode Voltage Range	Vicm	0	-	VCC-2.0	V	VCC=5V, VEE=0V, VOUT=VCC/2
Common-mode Rejection Ratio	CMRR	60	97	-	dB	Vicm=0V, VOUT=0V
Power Supply Rejection Ratio	PSRR	60	97	-	dB	Vicm=0V, VOUT=0V
Output Source Current *24	Isource	10	30	-	mA	VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit
Output Sink Current *24	Isink	20	30	-	mA	VCC=5V, VIN+=0V VIN-=1V, VOUT=5V Only 1ch is short circuit
Unity Gain Frequency	f_T	-	4	-	MHz	-
Gain Bandwidth	GBW	-	4	-	MHz	f=100kHz open loop
Slew Rate	SR	-	10	-	V/μs	Av=1, Vin=-10 to +10V, RL=2kΩ
Channel Separation	CS	-	120	-	dB	f=1kHz, input referred

*23 Absolute value
*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.

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○BA3474R (Unless otherwise specified VCC=+15V, VEE=-15V, Ta=25℃)

Parameter	Symbol	Limits			Unit	Condition
		Min	Typ	Max		
Input Offset Voltage *25	Vio	-	1	10	mV	Vicm=0V, VOUT=0V
		-	1	10		VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2
Input Offset Current *25	Iio	-	6	75	nA	Vicm=0V, VOUT=0V
Input Bias Current *25	Ib	-	100	500	nA	Vicm=0V, VOUT=0V
Supply Current	ICC	-	8	11	mA	RL=∞
Maximum Output Voltage(High)	VOH	3.7	4	-	V	VCC=5V, RL=2kΩ
		13.7	14	-		RL=10kΩ
		13.5	-	-		RL=2kΩ
Maximum Output Voltage(Low)	VOL	-	0.1	0.3	V	VCC=5V, RL=2kΩ
		-	-14.7	-14.3		RL=10kΩ
		-	-	-13.5		RL=2kΩ
Large Signal Voltage Gain	Av	80	100	-	dB	RL≧2kΩ, VOUT=±10 V
Input Common-mode Voltage Range	Vicm	0	-	VCC-2.0	V	VCC=5V, VEE=0V, VOUT=VCC/2
Common-mode Rejection Ratio	CMRR	60	97	-	dB	Vicm=0V, VOUT=0V
Power Supply Rejection Ratio	PSRR	60	97	-	dB	Vicm=0V, VOUT=0V
Output Source Current *26	Isource	10	30	-	mA	VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit
Output Sink Current *26	Isink	20	30	-	mA	VCC=5V, VIN+=0V VIN-=1V, VOUT=5V Only 1ch is short circuit
Unity Gain Frequency	f_T	-	4	-	MHz	-
Gain Bandwidth	GBW	-	4	-	MHz	f=100kHz open loop
Slew Rate	SR	-	10	-	V/µs	Av=1, Vin=-10 to +10V, RL=2kΩ
Channel Separation	CS	-	120	-	dB	f=1kHz, input referred

*25 Absolute value
*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.

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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 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 non-inverting terminal and inverting terminal. It can be translated into the input voltage difference required for setting the output voltage at 0 V.

2.2 Input Offset Current (Iio)

Indicates the difference of input bias current between the non-inverting and inverting terminals.

2.3 Input Bias Current (Ib)

Indicates the current that flows into or out of the input terminal. It is defined by the average of input bias current at non-inverting terminal and input bias current at inverting terminal.

2.4 Circuit Current (ICC)

Indicates the current of the IC itself that flows under specified conditions and during no-load steady state.

2.5 Maximum Output Voltage(High) / Maximum Output Voltage(Low) (VOH/VOL)

Indicates the voltage range that can be output by the IC 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.

2.6 Large Signal Voltage Gain (Av)

The amplifying rate (gain) of the output voltage against the voltage difference between non-inverting and inverting terminals, it is (normally) the amplifying rate (gain) with respect to DC voltage.

AV = (output voltage fluctuation) / (input offset fluctuation)

2.7 Input Common-mode Voltage Range (Vicm)

Indicates the input voltage range under which the IC operates normally.

2.8 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)

2.9 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)

2.10 Output Source Current/ Output Sink Current (Isource/Isink)

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.

2.11 Unity Gain Frequency (f_T)

Indicates a frequency where the voltage gain of operational amplifier is 1.

2.12 Gain Bandwidth (GBW)

Indicates to multiply by the frequency and the gain where the voltage gain decreases 6dB/octave.

2.13 Slew Rate (SR)

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

2.14 Channel Separation (CS)

Indicates the fluctuation of input offset voltage or that of output voltage with reference to the change of output voltage of driven channel.

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Typical Performance Curves

○BA3472, BA3472R

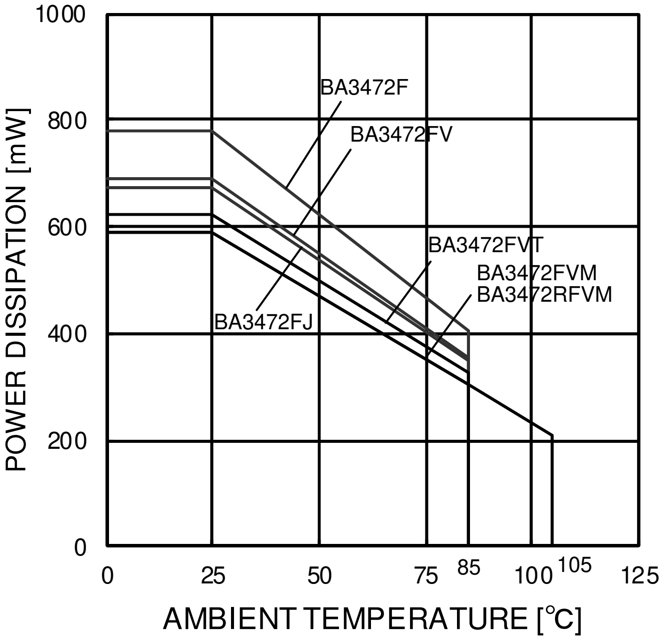

Figure 2.
Derating Curve

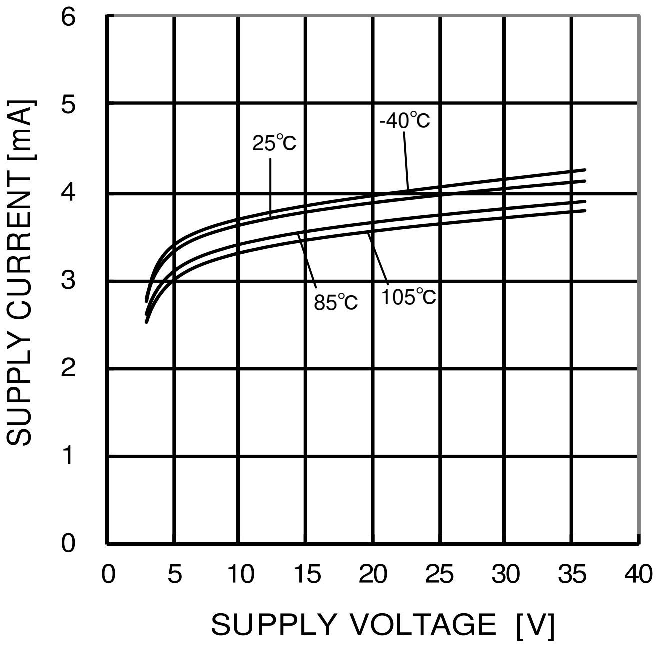

Figure 3.
Supply Current - Supply Voltage

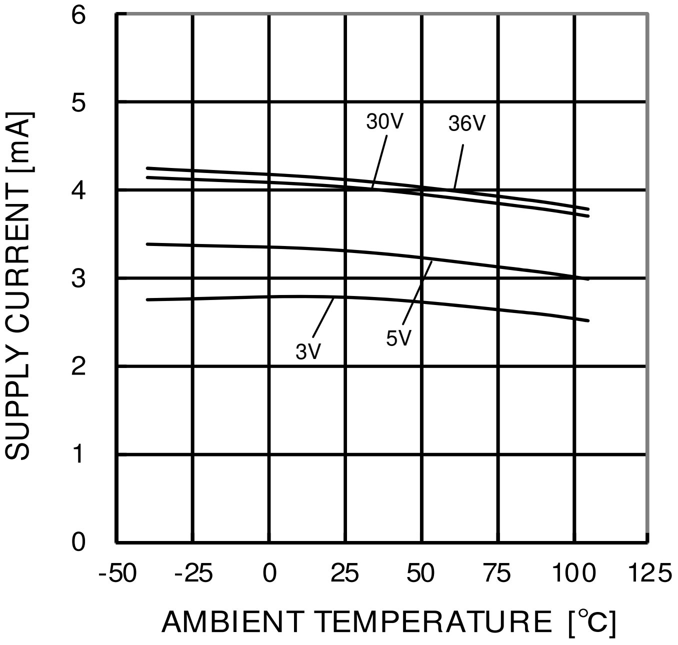

Figure 4.
Supply Current - Ambient Temperature

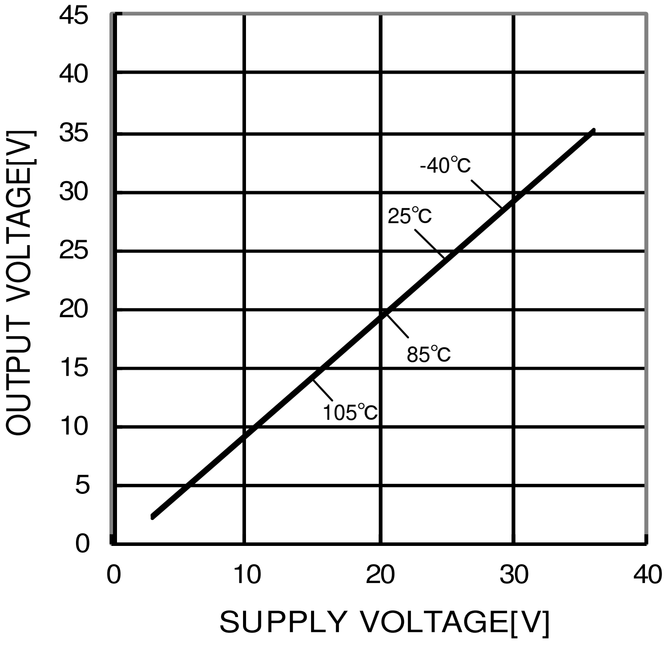

Figure 5.
High level Output Voltage - Supply Voltage
(RL=10kΩ)

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3472 : -40℃~＋85℃ BA3472R : -40℃~＋105℃

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○BA3472, BA3472R

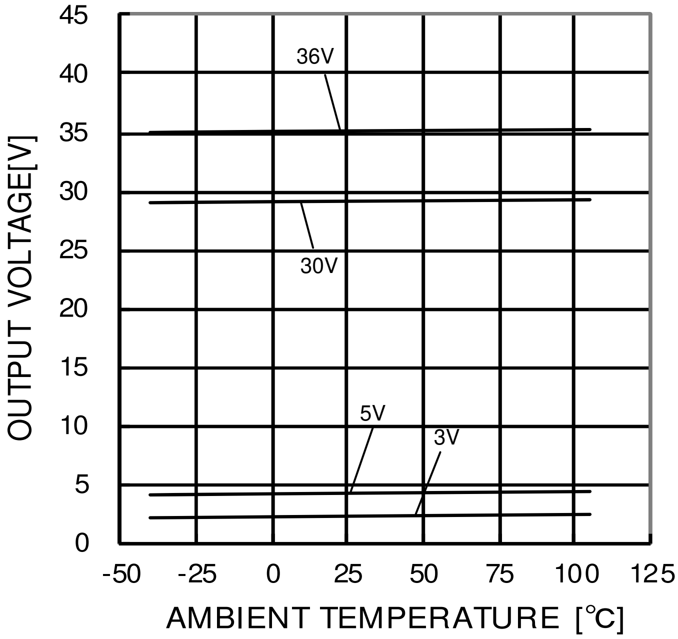

Figure 6.
High level Output Voltage
- Ambient Temperature
(RL=10kΩ)

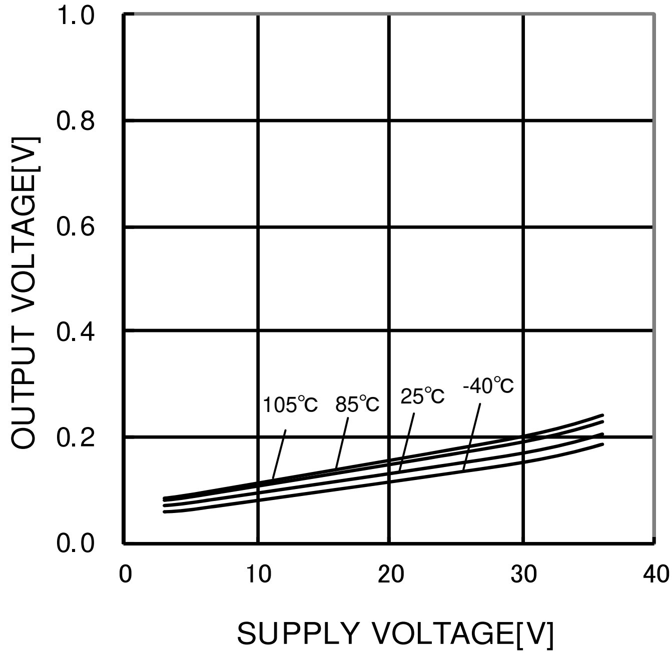

Figure 7.
Low level Output Voltage
- Supply Voltage
(RL=10kΩ)

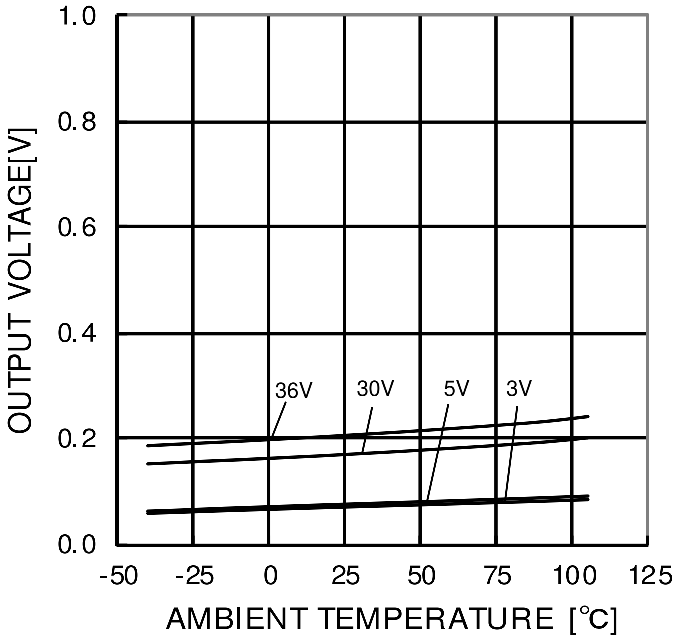

Figure 8.
Low level Output Voltage
- Ambient Temperature
(RL=10kΩ)

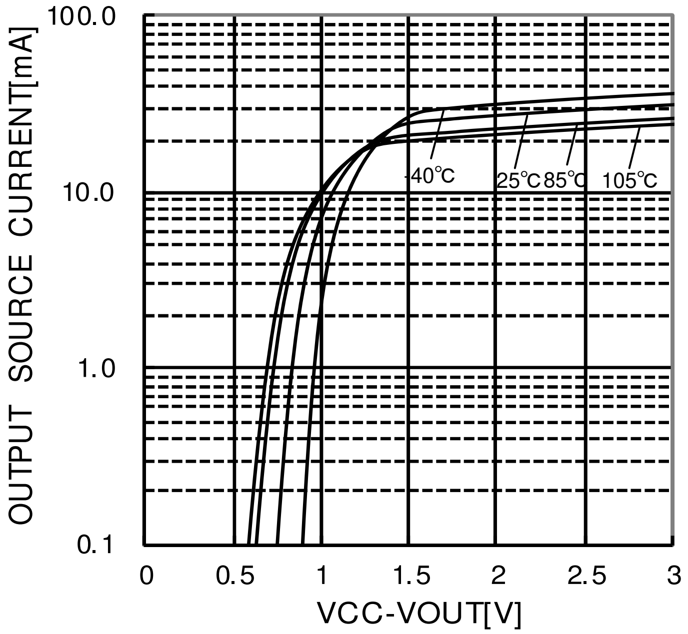

Figure 9.
Output Source Current - (VCC-VOUT)
(VCC/VEE=5V/0V)

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3472 : -40℃~＋85℃ BA3472R : -40℃~＋105℃

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○BA3472, BA3472R

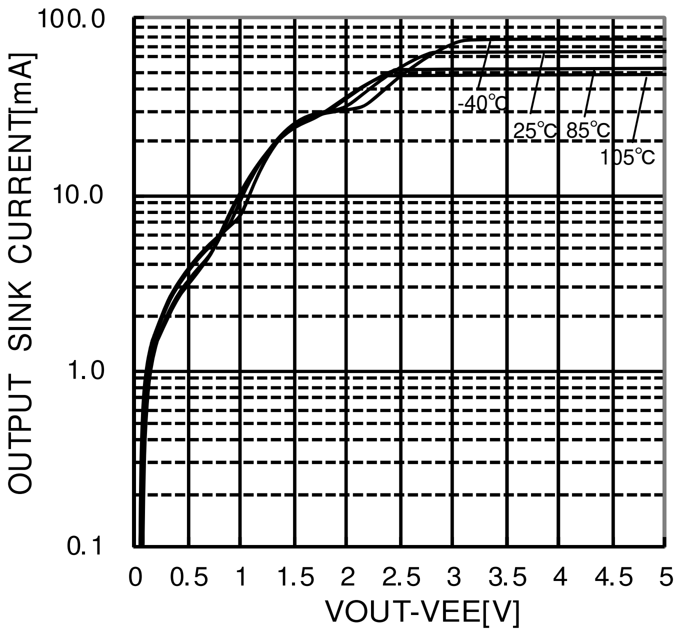

Figure 10.
Output Sink Current - (VOUT-VEE)
(VCC/VEE=5V/0V)

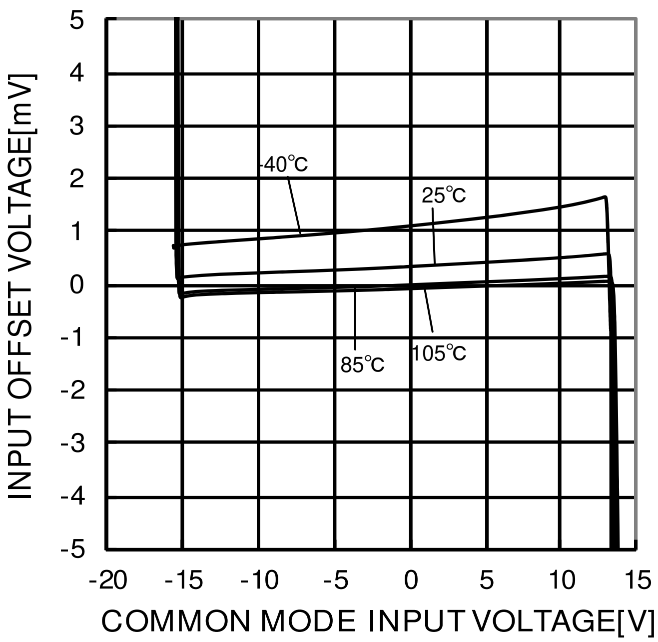

Figure 11.
Input Common-mode Voltage Range
(VCC/VEE=15V/-15V)

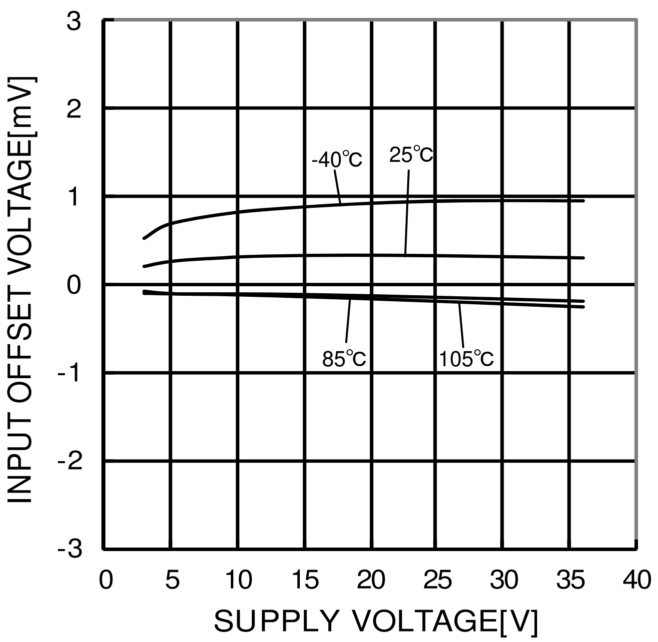

Figure 12.
Input Offset Voltage - Supply voltage

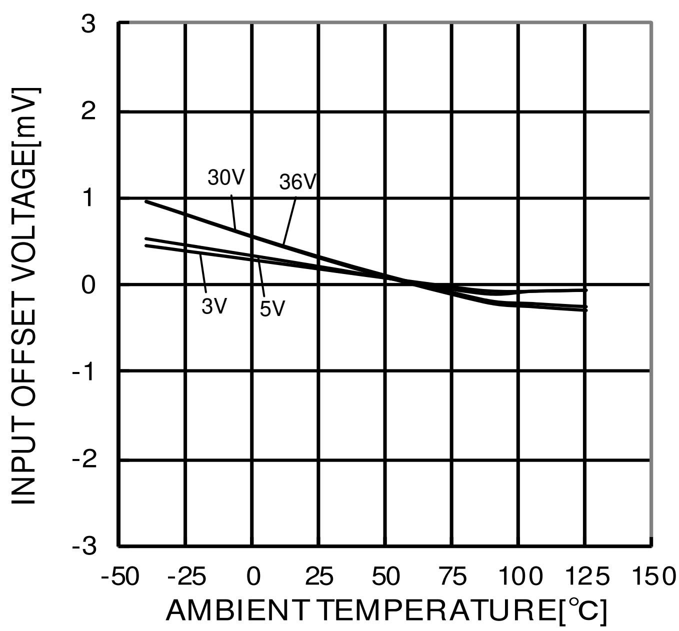

Figure 13.
Input Offset Voltage - Ambient Temperature

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3472：-40℃~＋85℃ BA3472R：-40℃~＋105℃

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○BA3472, BA3472R

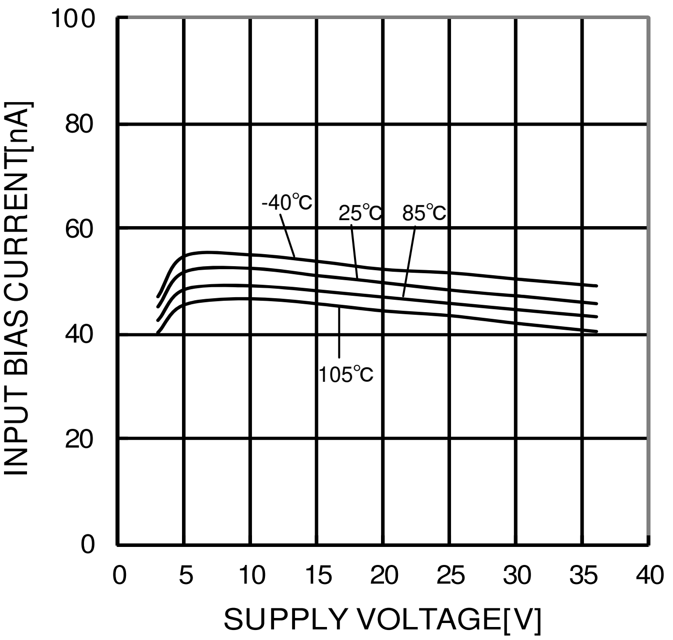

Figure 14.
Input Bias Current - Supply voltage

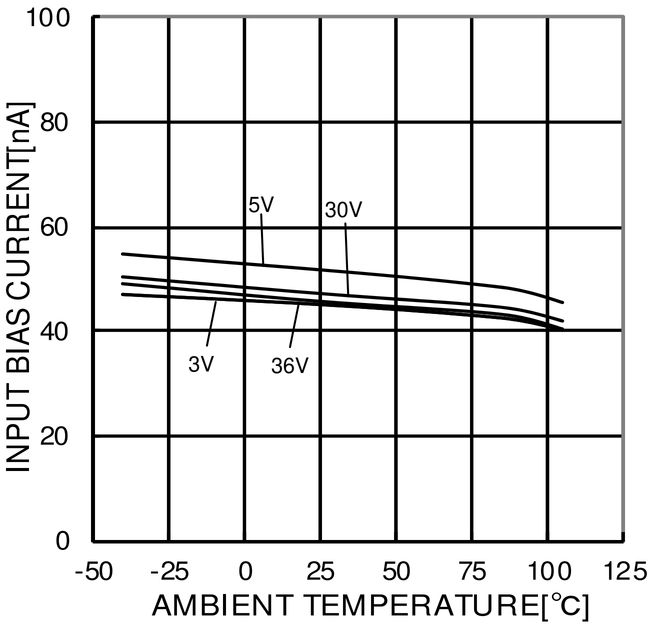

Figure 15.
Input Bias Current - Ambient Temperature

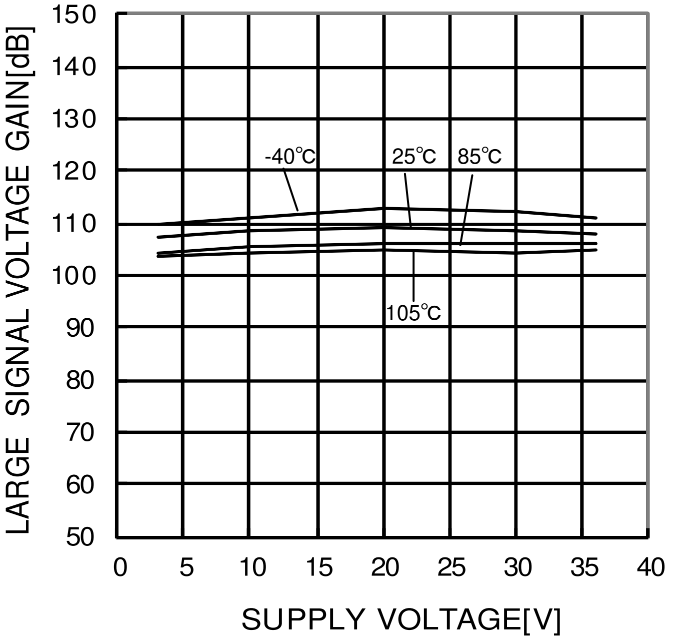

Figure 16.
Large Signal Voltage Gain
- Supply Voltage

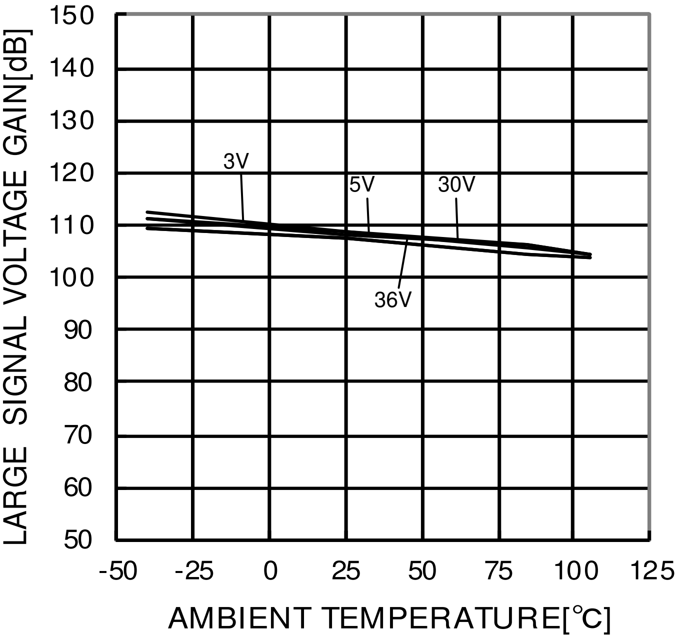

Figure 17.
Large Signal Voltage Gain
- Ambient Temperature

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3472：-40℃~＋85℃ BA3472R：-40℃~＋105℃

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○BA3472, BA3472R

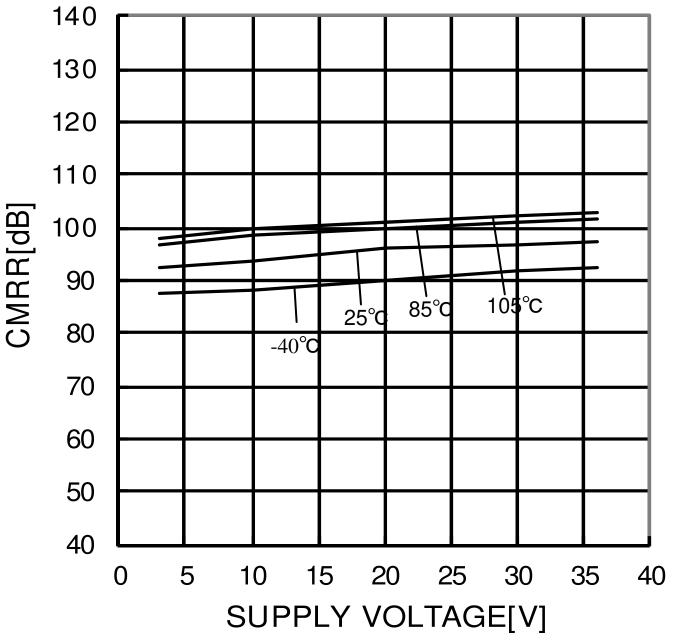

Figure 18.
Common Mode Rejection Ratio
- Supply Voltage

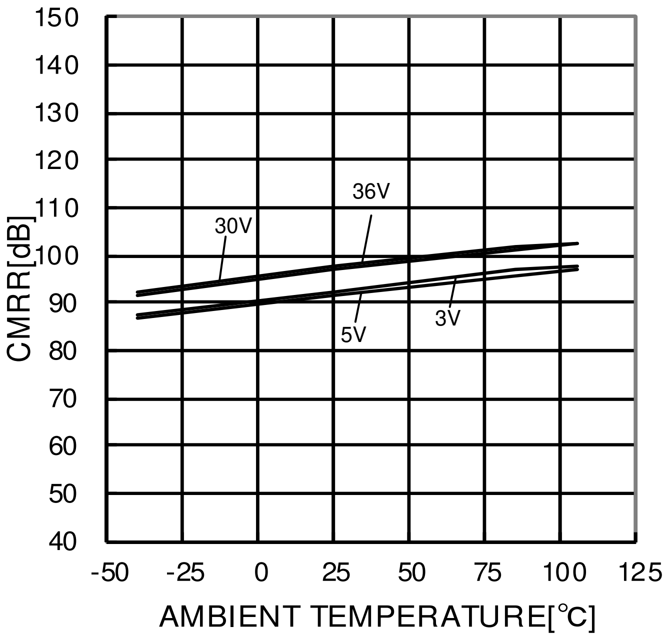

Figure 19.
Common Mode Rejection Ratio
- Ambient Temperature

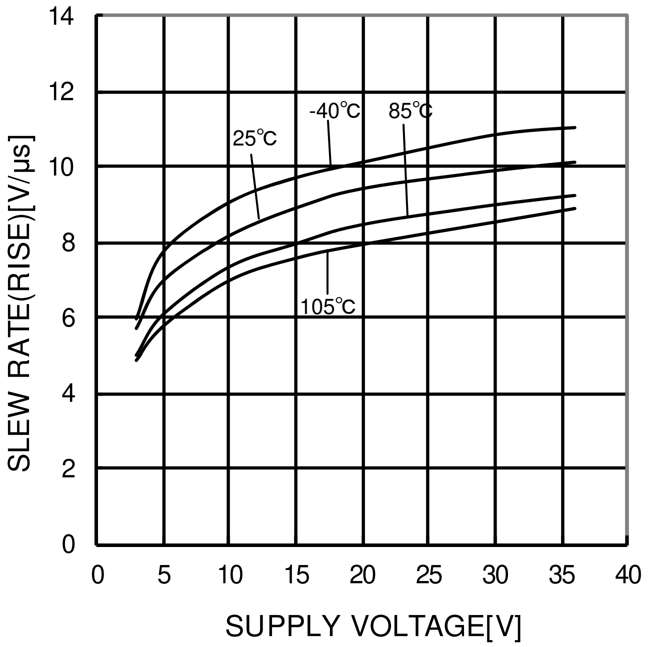

Figure 20.
Slew Rate L-H - Supply Voltage
(RL=10kΩ)

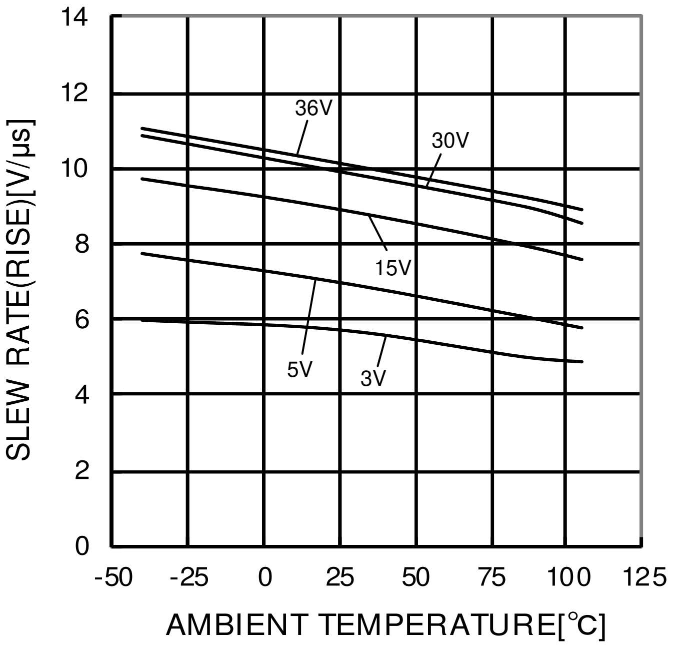

Figure 21.
Slew Rate L-H - Ambient Temperature
(RL=10kΩ)

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3472 : -40℃~＋85℃ BA3472R : -40℃~＋105℃

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○BA3472, BA3472R

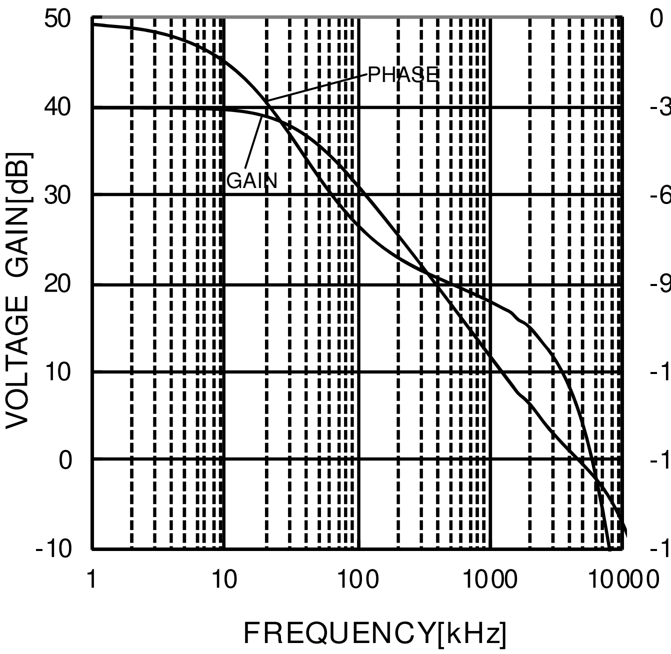

Figure 22.
Voltage Gain・Phase - Frequency
(VCC=7.5V/-7.5V, Av=40dB,
RL=2kΩ, CL=100pF, Ta=25℃)

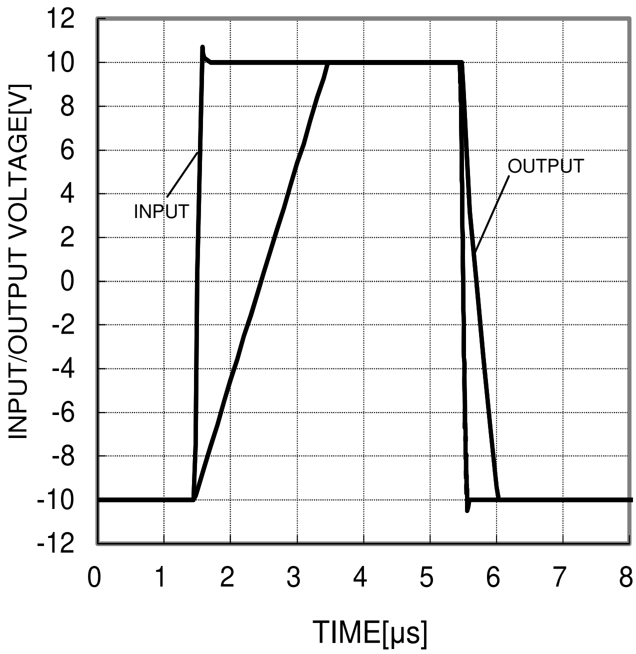

Figure 23.
Input / Output Voltage - Time
(VCC/VEE=15V/-15V, Av=0dB,
RL=2kΩ, CL=100pF, Ta=25℃)

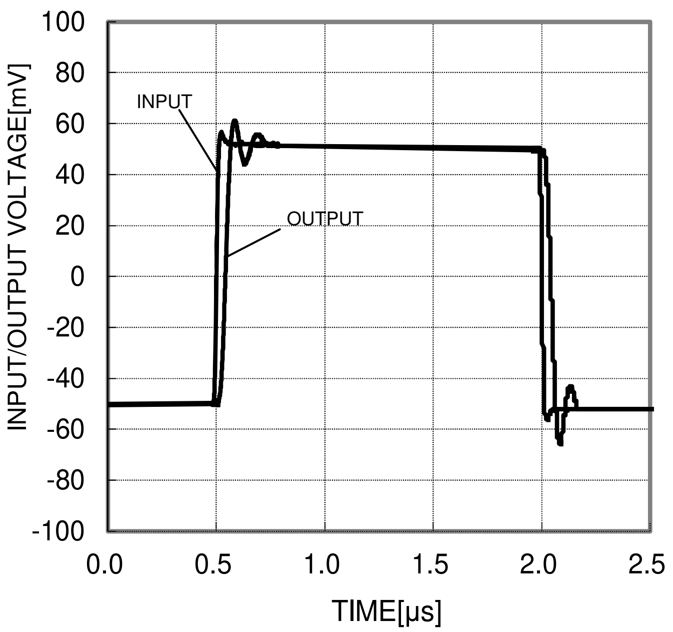

Figure 24.
Input / Output Voltage - Time
(VCC/VEE=15V/-15V, Av=0dB,
RL=2kΩ, CL=100pF, Ta=25℃)

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3472：-40℃~＋85℃ BA3472R：-40℃~＋105℃

○BA3474, BA3474R

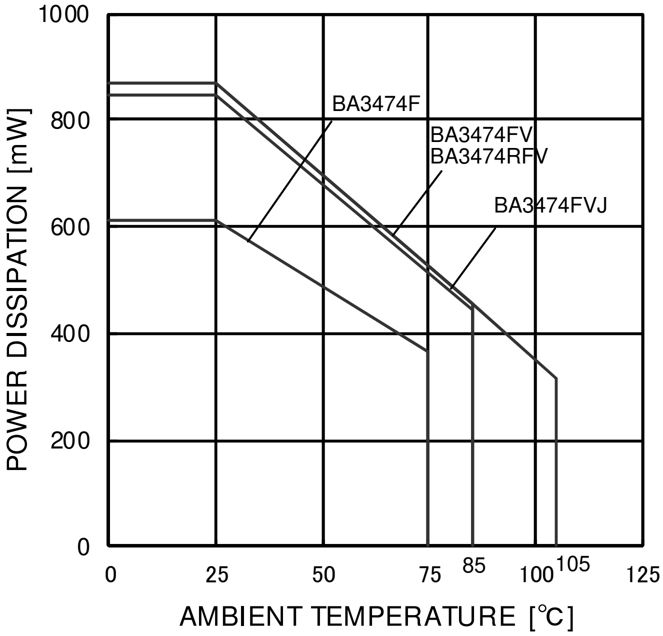

Figure 25.
Derating Curve

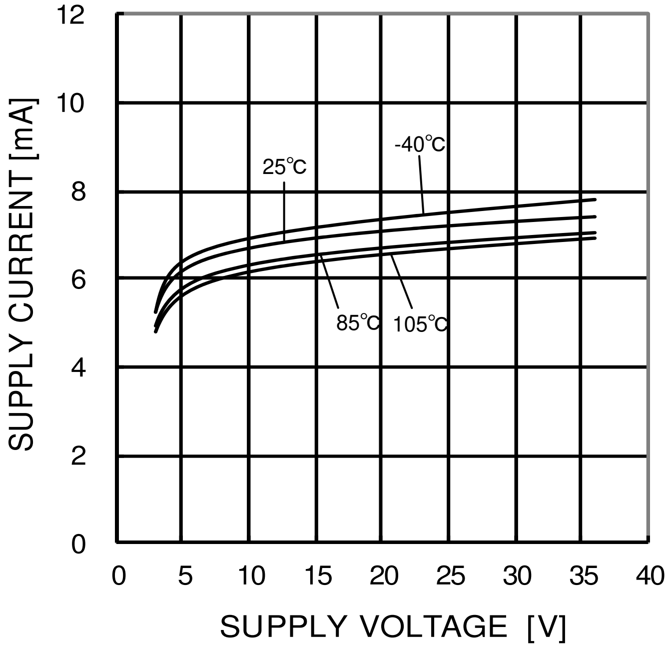

Figure 26.
Supply Current - Supply Voltage

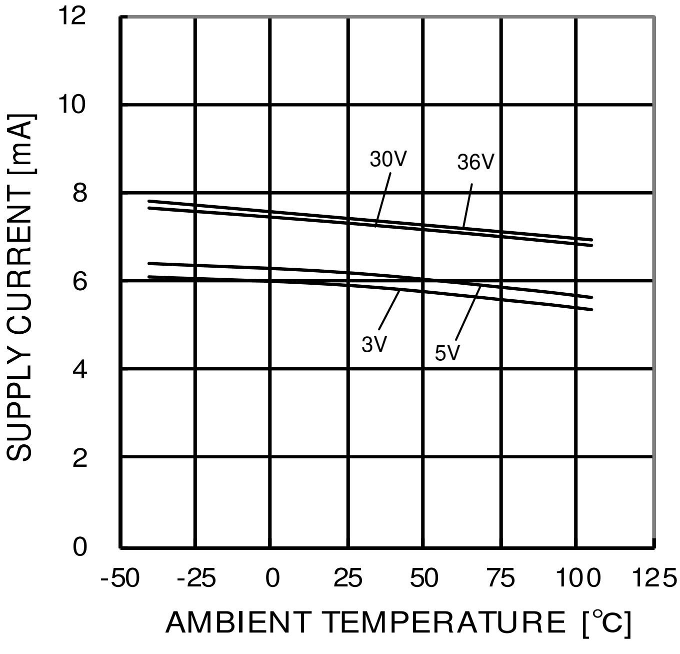

Figure 27.
Supply Current - Ambient Temperature

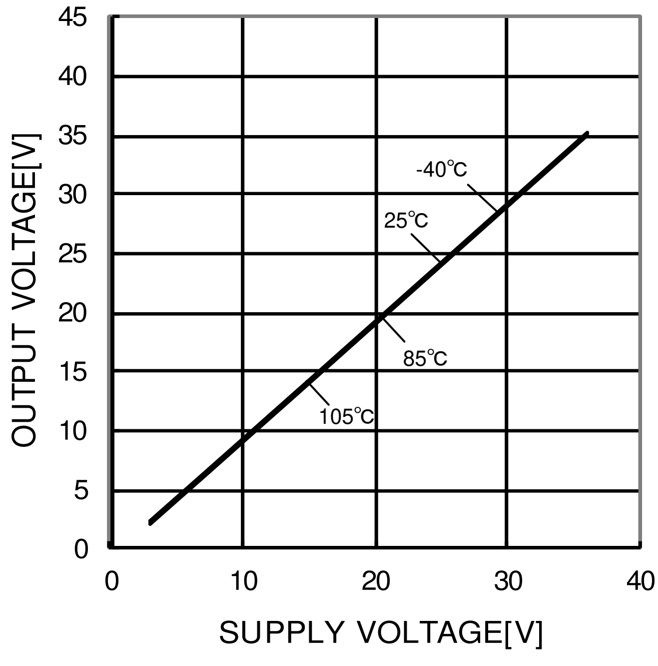

Figure 28.
High level Output Voltage
- Supply Voltage
(RL=10kΩ)

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3474F : -40℃~＋75℃ BA3474 : -40℃~＋85℃ BA3474R : -40℃~＋105℃

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○BA3474, BA3474R

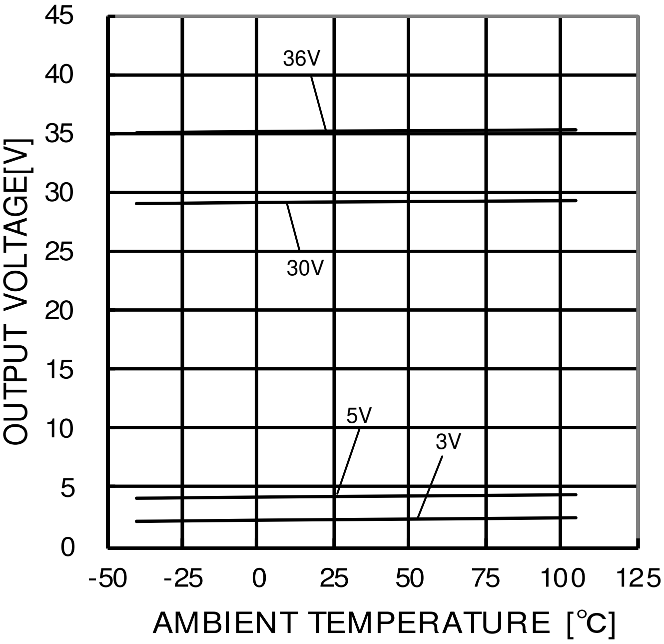

Figure 29.
High level Output Voltage
- Ambient Temperature
(RL=10kΩ)

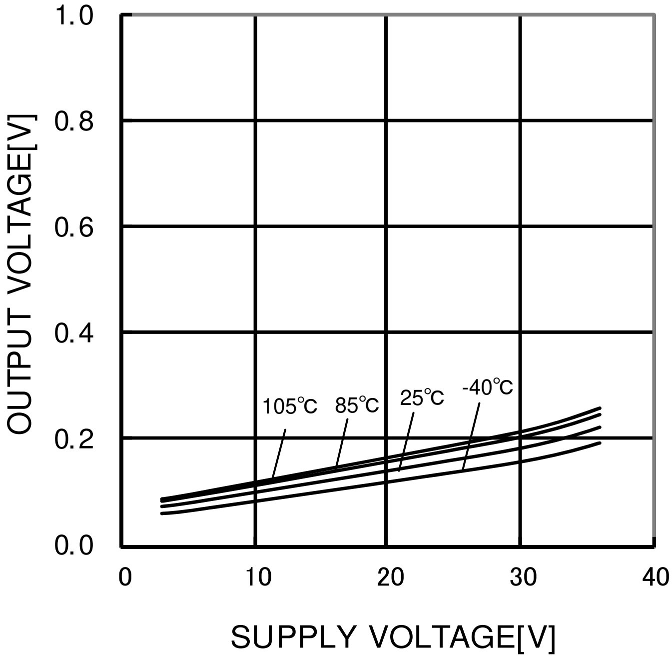

Figure 30.
Low level Output Voltage
- Supply Voltage
(RL=10kΩ)

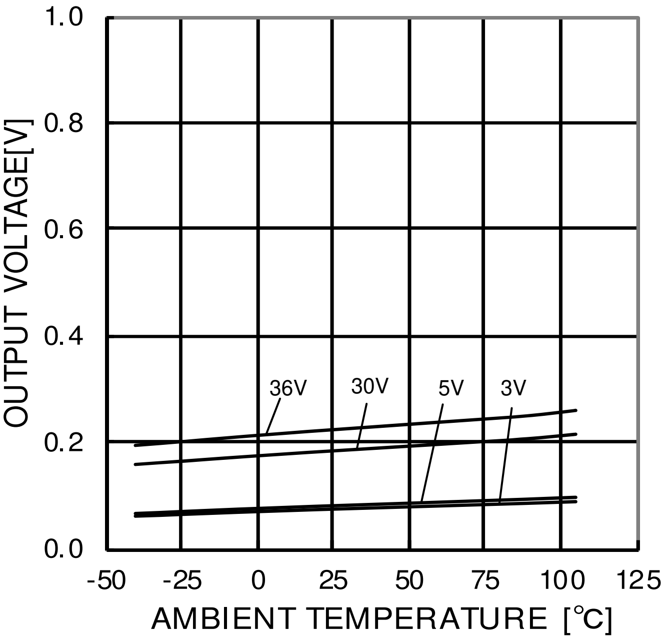

Figure 31.
Low level Output Voltage
－Ambient Temperature
(RL=10kΩ)

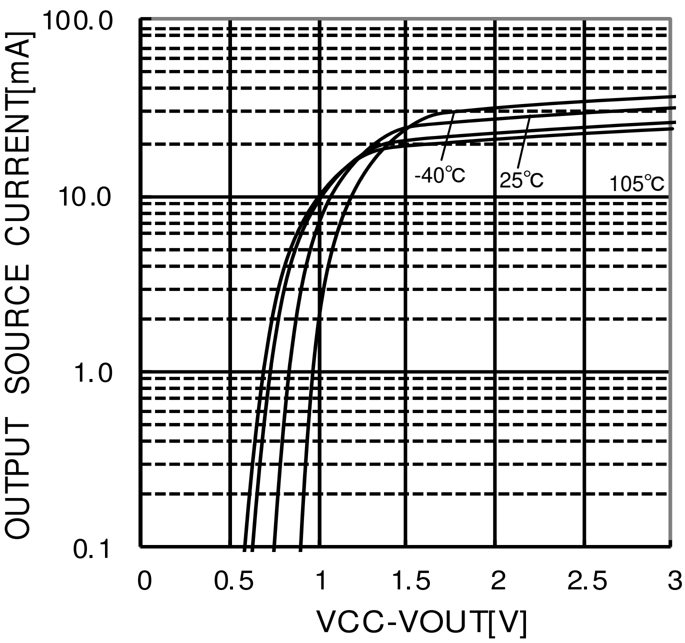

Figure 32.
Output Source Current - (VCC-VOUT)
(VCC/VEE=5V/0V)

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3474F : -40℃~＋75℃ BA3474 : -40℃~＋85℃ BA3474R : -40℃~＋105℃

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○BA3474, BA3474R

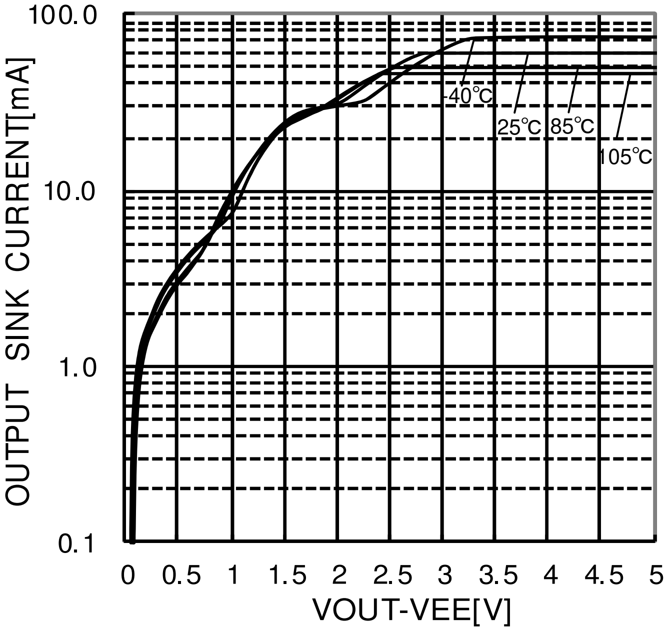

Figure 33.
Output Sink Current - (VOUT-VEE)
(VCC/VEE=5V/0V)

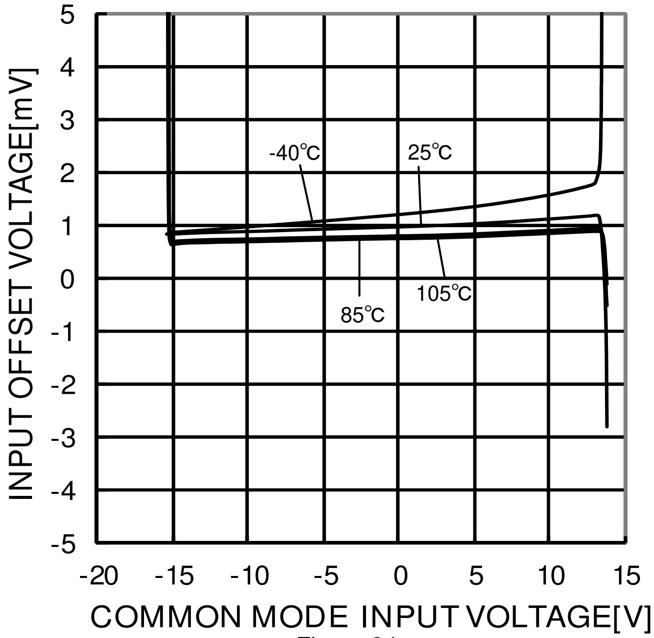

Figure 34.
Input Common-mode Voltage Range
(VCC/VEE=15V/-15V)

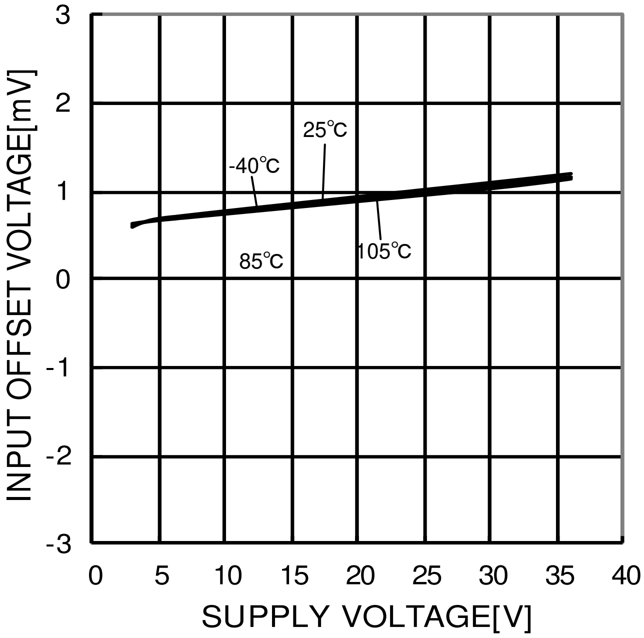

Figure 35.
Input Offset Voltage - Supply voltage

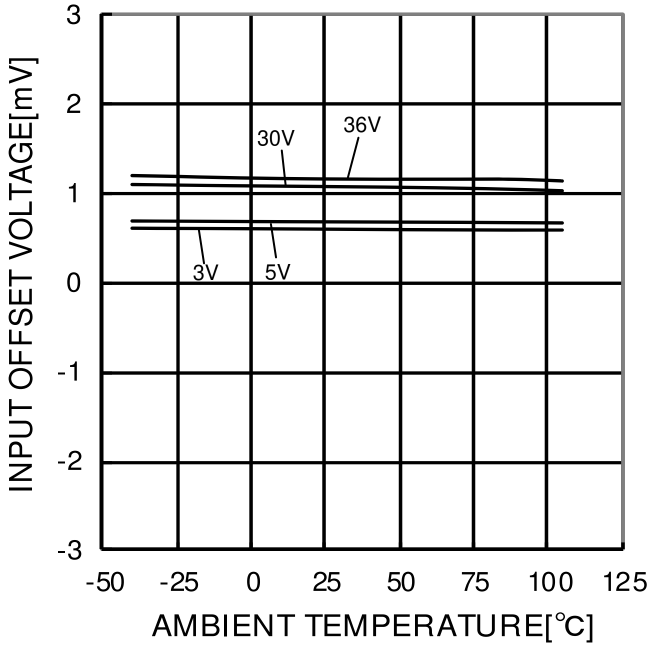

Figure 36.
Input Offset Voltage - Ambient Temperature

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3474F : -40℃~+75℃ BA3474 : -40℃~+85℃ BA3474R : -40℃~+105℃

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○BA3474, BA3474R

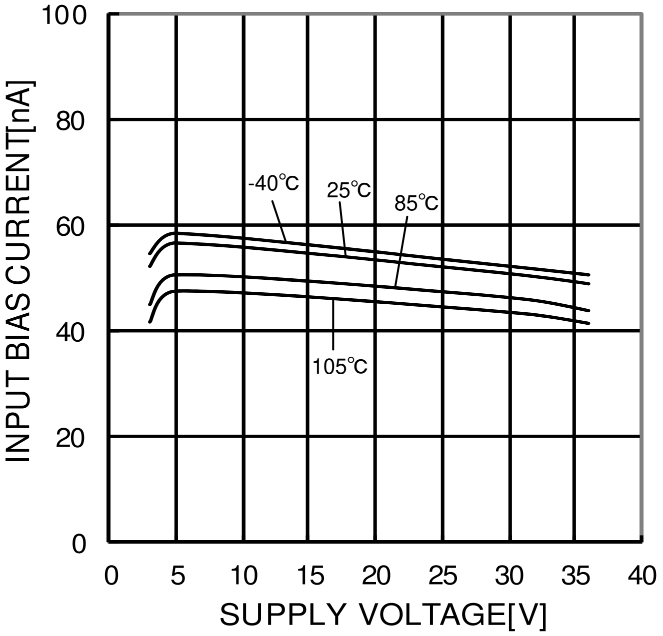

Figure 37.
Input Bias Current - Supply voltage

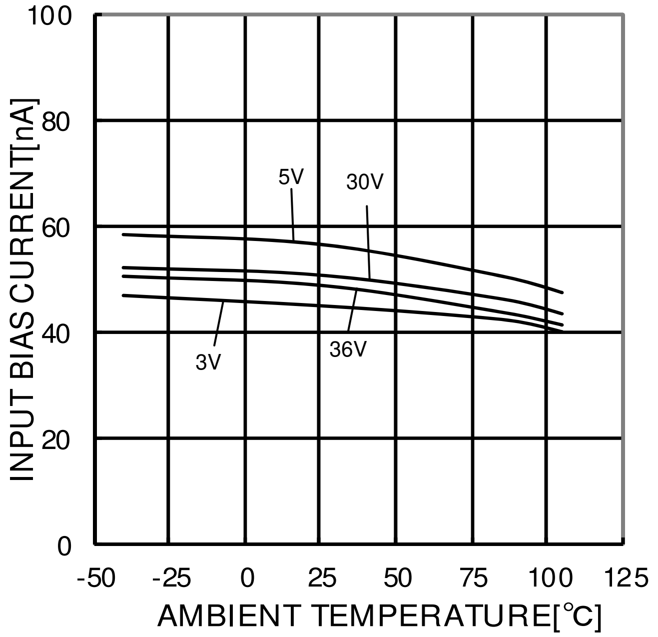

Figure 38.
Input Bias Current - Ambient Temperature

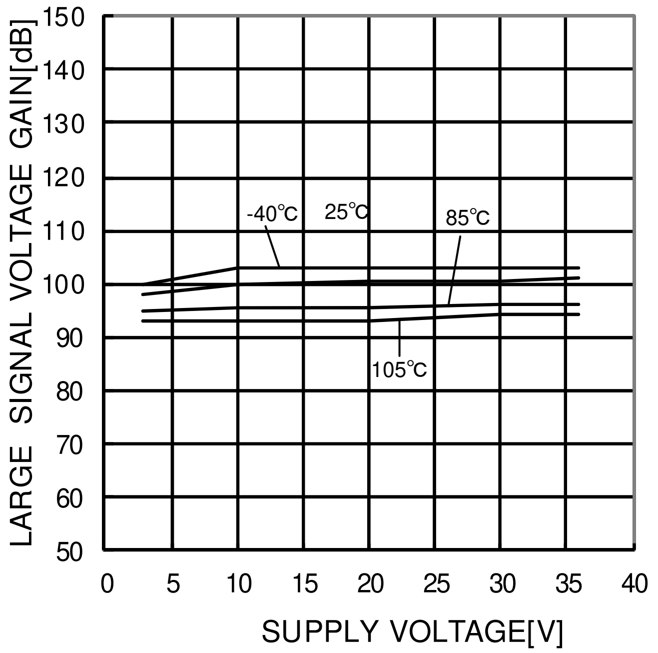

Figure 39.
Large Signal Voltage Gain
- Supply Voltage

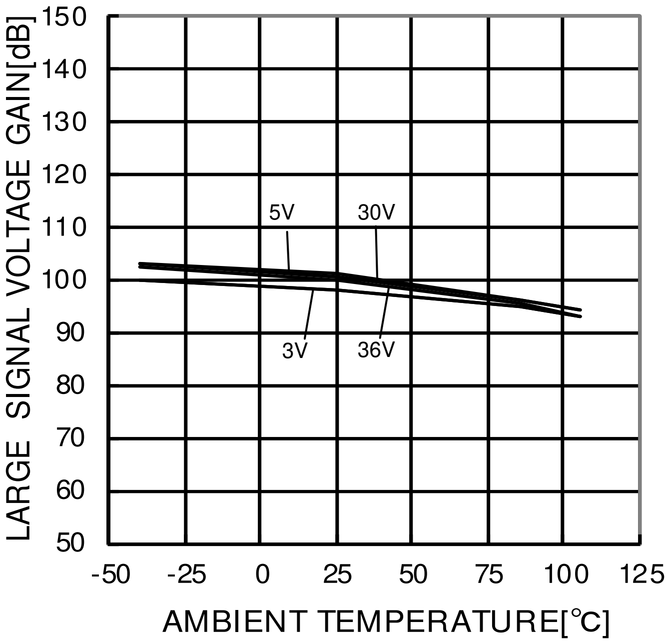

Figure 40.
Large Signal Voltage Gain
- Ambient Temperature

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3474F : -40℃~＋75℃ BA3474 : -40℃~＋85℃ BA3474R : -40℃~＋105℃

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○BA3474, BA3474R

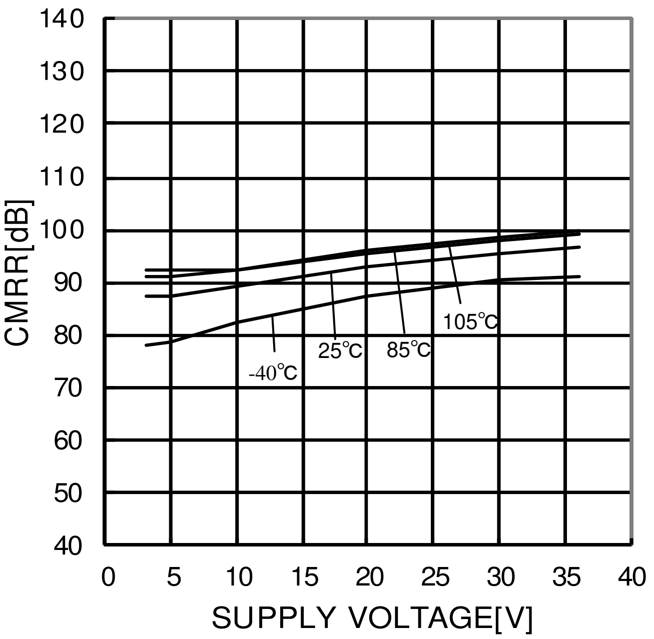

Figure 41.
Common Mode Rejection Ratio
- Supply Voltage

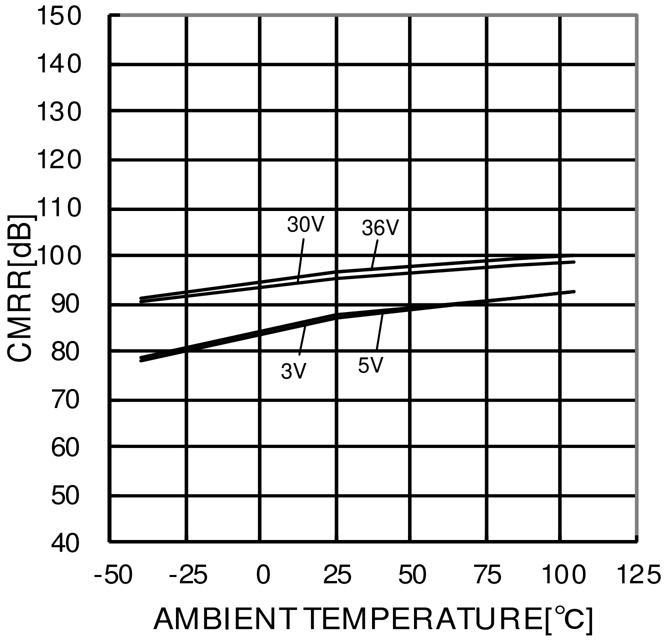

Figure 42.
Common Mode Rejection Ratio
- Ambient Temperature

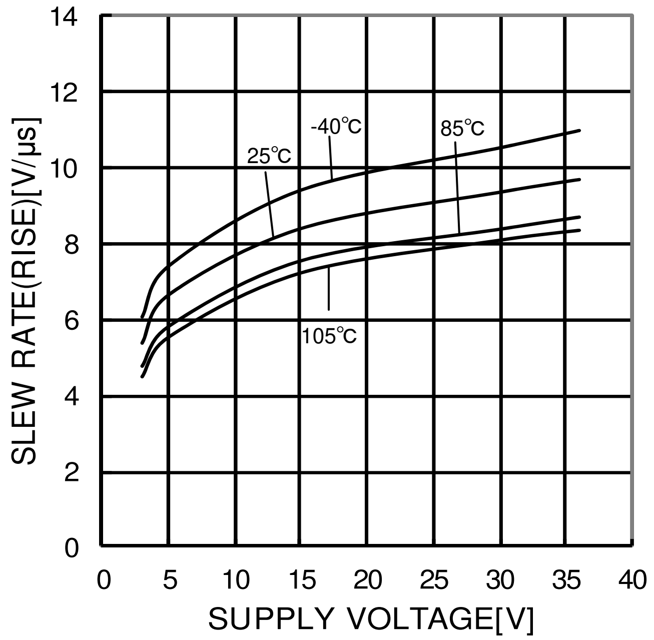

Figure 43.
Slew Rate L-H - Supply Voltage
(RL=10kΩ)

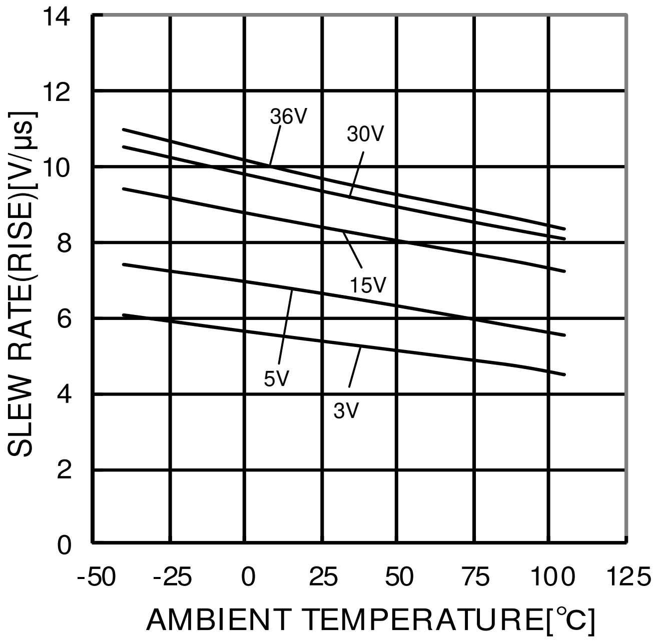

Figure 44.
Slew Rate L-H - Ambient Temperature
(RL=10kΩ)

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3474F : -40℃~＋75℃ BA3474 : -40℃~＋85℃ BA3474R : -40℃~＋105℃

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○BA3474, BA3474R

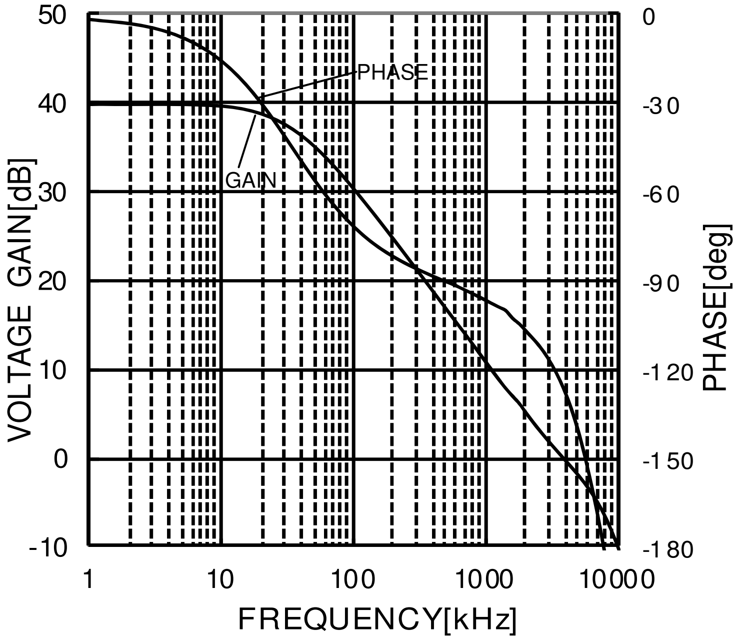

Figure 45.
Voltage Gain・Phase - Frequency
(VCC=7.5V/-7.5V, Av=40dB,
RL=2kΩ, CL=100pF, Ta=25℃)

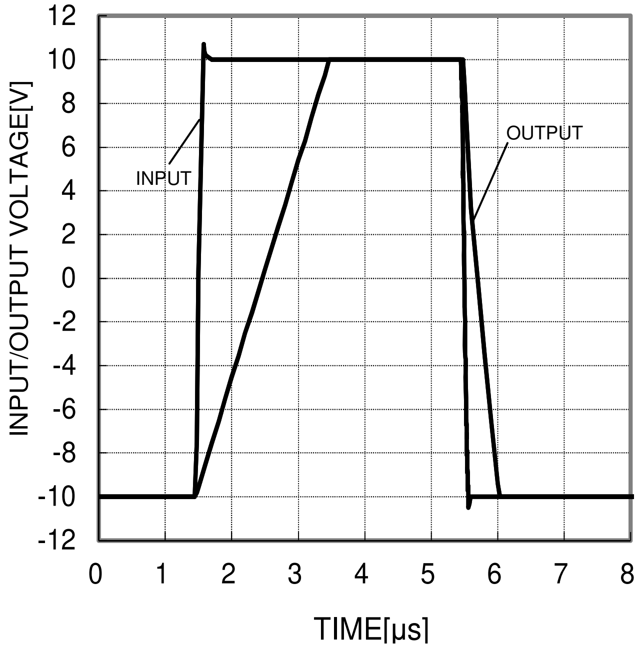

Figure 46.
Input / Output Voltage - Time
(VCC/VEE=15V/-15V, Av=0dB,
RL=2kΩ, CL=100pF, Ta=25℃)

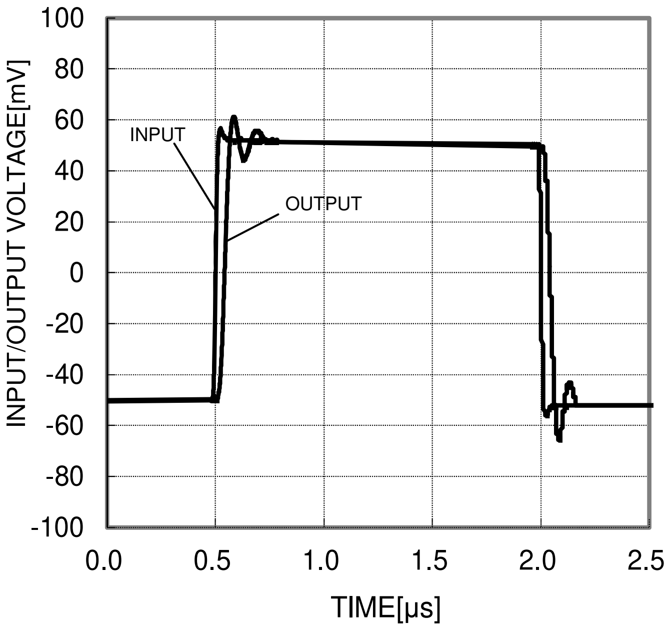

Figure 47.
Input / Output Voltage - Time
(VCC/VEE=15V/-15V, Av=0dB,
RL=2kΩ, CL=100pF, Ta=25℃)

(*) The above data is measurement value of typical sample, it is not guaranteed.
BA3474F : -40℃~＋75℃ BA3474 : -40℃~＋85℃ BA3474R : -40℃~＋105℃

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Application Information

NULL method condition for Test Circuit 1

VCC, VEE, EK, Vicm Unit : V

Parameter	VF	S1	S2	S3	VCC	VEE	EK	Vicm	Calculation
Input Offset Voltage	VF1	ON	ON	OFF	15	-15	0	0	1
Input Offset Current	VF2	OFF	OFF	OFF	15	-15	0	0	2
Input Bias Current	VF3	OFF	ON	OFF	15	-15	0	0	3
	VF4	ON	OFF						
Large Signal Voltage Gain	VF5	ON	ON	ON	15	-15	+10	0	4
	VF6				15	-15	-10	0	
Common-mode Rejection Ratio (Input Common-mode Voltage Range)	VF7	ON	ON	OFF	15	-15	0	-15	5
	VF8				15	-15	0	13	
Power Supply Rejection Ratio	VF9	ON	ON	OFF	2	-2	0	0	6
	VF10				18	-18	0	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 Ratio (CMRR)

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

6. Power Supply Rejection Ratio (PSRR)

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

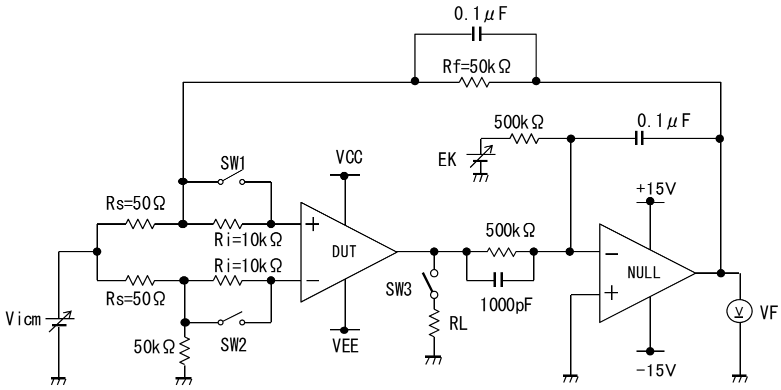

Figure 48. Test circuit 1 (one channel only)

Switch Condition for Test Circuit 2

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
Maximum Output Voltage(High)	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
Maximum Output Voltage(Low)	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	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	OFF	OFF	OFF	OFF
Gain Bandwidth Product	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
Equivalent Input Noise Voltage	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF

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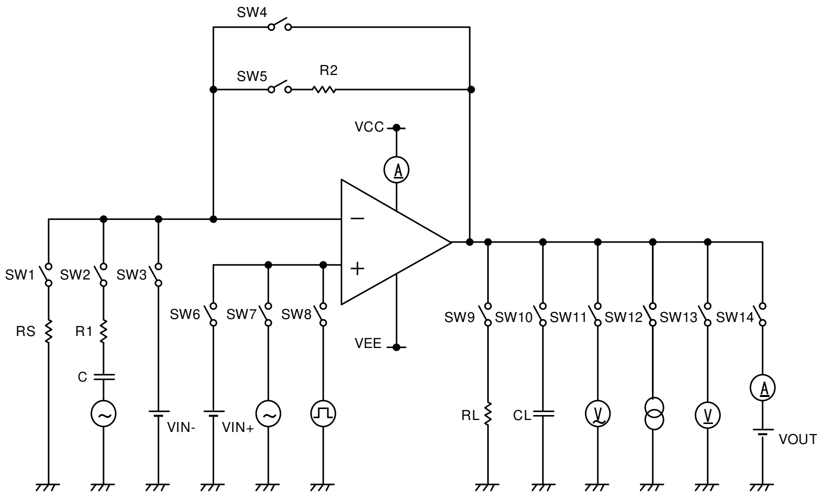


Figure 49. Test circuit 2 (one channel only)

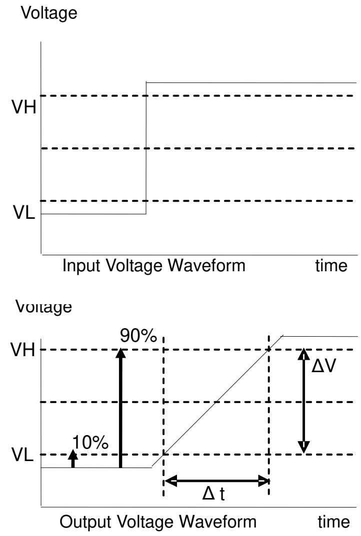
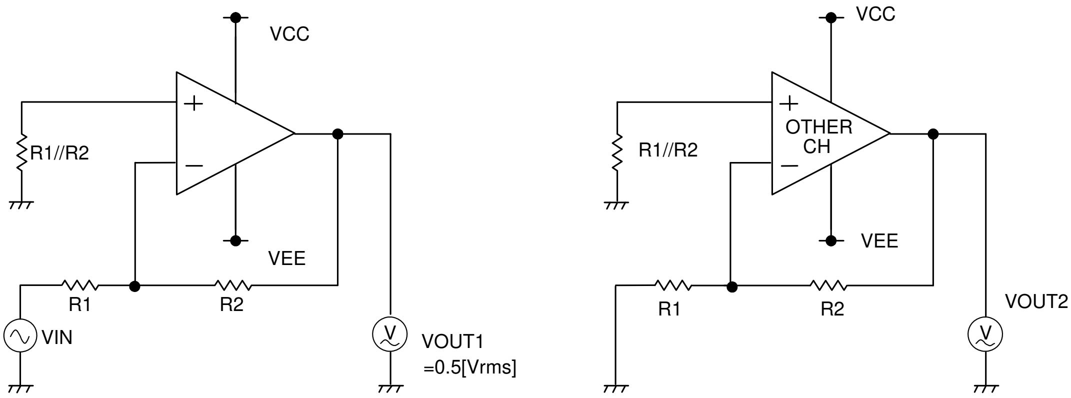


Figure 50. Slew rate input output wave



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

Figure 51. Test circuit 3 (Channel Separation)

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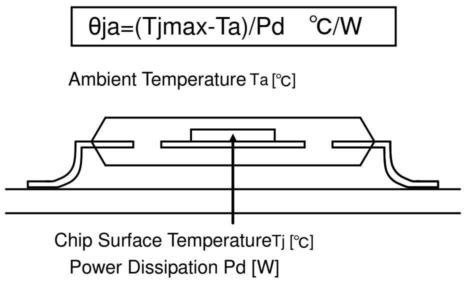
Power Dissipation

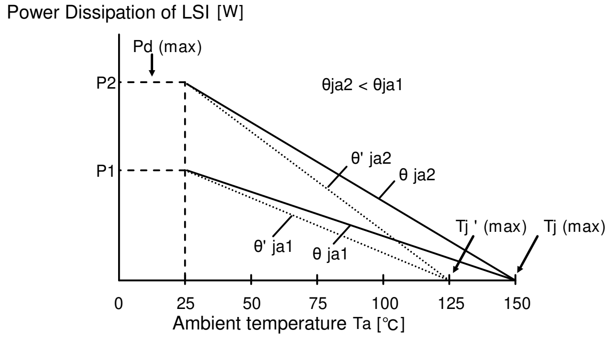
Power dissipation(total loss) indicates the power that can be consumed by IC at Ta=25℃(normal temperature). IC is heated when it consumed power, and the temperature of IC chip becomes higher than ambient temperature. The temperature that can be accepted by IC chip depends on circuit configuration, manufacturing 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 indicates this 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. Figure 52. (a) shows the model of thermal resistance of the package. Thermal resistance θja, ambient temperature Ta, maximam junction temperature Tjmax, and power dissipation Pd can be calculated by the equation below:

$\theta ja = (Tjmax - Ta) / Pd$ ℃/W

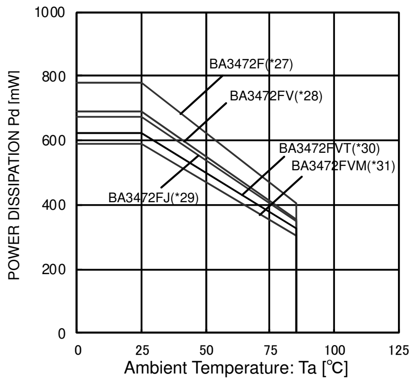
Derating curve in Figure 52. (b) indicates power that can be consumed by IC with reference to ambient temperature. Power that can be consumed by IC begins to attenuate at certain ambient temperature. This gradient iis determined by thermal resistance θja. Thermal resistance θja depends on chip size, 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. Figure 52. (c) to (f) shows a derating curve for an example of BA3472, BA3474, BA3472R, BA3474R.



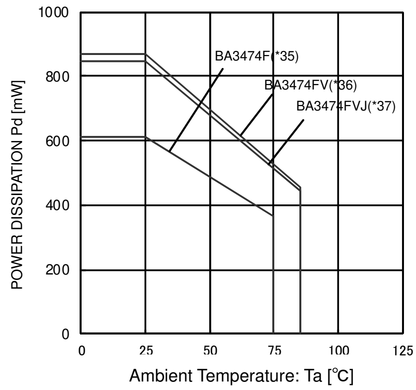
(a) Thermal Resistance



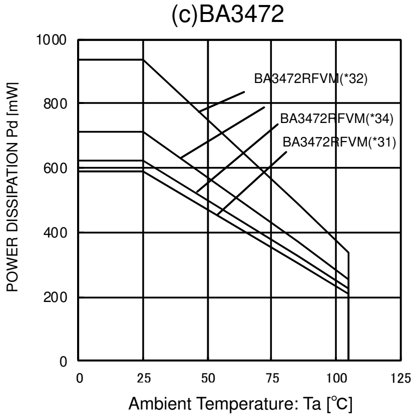
(b) Derating Curve



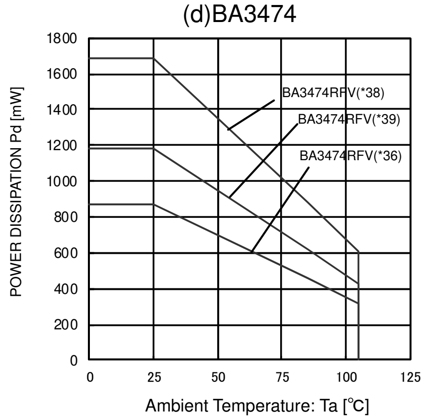
(c)BA3472



(d)BA3474



(e)BA3472R



(f)BA3474R

(*27)	(*28)	(*29)	(*30)	(*31)	(*32)	(*33)	(*34)	(*35)	(*36)	(*37)	(*38)	(*39)	Unit
6.2	5.5	5.4	5.0	4.8	7.5	5.7	5.0	4.9	7.0	6.8	13.5	9.5	mW/℃

When using the unit above Ta=25°C, subtract the value above per Celsius degree.

(*27)(*28)(*29)(*30)(*31)(*35)(*36)(*37) Mounted on a FR4 glass epoxy 1 layers PCB 70mm×70mm×1.6mm (copper foil area less than 3%).

(*34) Mounted on a FR4 glass epoxy 2 layers PCB 70mm×70mm×1.6mm (occupied copper area：15mm×15mm).

(*33) (*39) Mounted on a FR4 glass epoxy 2 layers PCB 70mm×70mm×1.6mm (occupied copper area：70mm×70mm).

(*32) (*38) Mounted on a FR4 glass epoxy 4 layers PCB 70mm×70mm×1.6mm (occupied copper area：70mm×70mm).

Figure 52. Thermal Resistance and Derating Curve

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Operational Notes

1. **Reverse Connection of Power Supply**
   Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
   Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
   When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Thermal Consideration**
   Should by any chance the power dissipation rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. The absolute maximum rating of the P_D stated in this specification is when the IC is mounted on a 70mm x 70mm x 1.6mm glass epoxy board. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the P_D rating.

6. **Recommended Operating Conditions**
   These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

7. **Inrush Current**
   When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

8. **Operation Under Strong Electromagnetic Field**
   Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

9. **Testing on Application Boards**
   When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

10. **Inter-pin Short and Mounting Errors**
    Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

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