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Operational Amplifiers Series

# High Speed with High Voltage Operational Amplifiers



**BA3472xxx, BA3472RFVM, BA3474xxx, BA3474RFV**

● **General Description**

BA3472,BA3472R,BA3474,BA3474R are dual and quad high slew rate amplifier with wide operating voltage range +3V to +36V(single supply). Especially, there characteristics are high slew rate (10V/μs) and wide gain band width (4MHz).

● **Features**

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

● **Application**

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

● **Packages**

Package	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 supply +3.0V to +36.0V
  - Dual 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
- High Slew Rate: 10V/μs(Typ.)
- Unity Gain Frequency: 4MHz(Typ.)

● **Block Diagram**

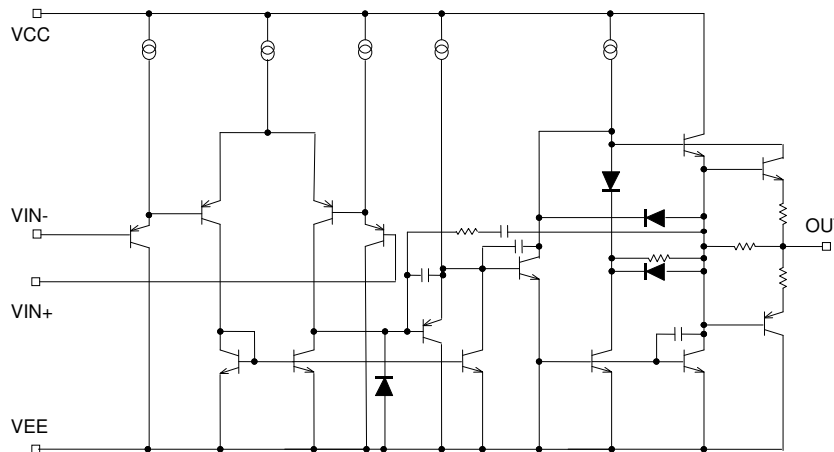
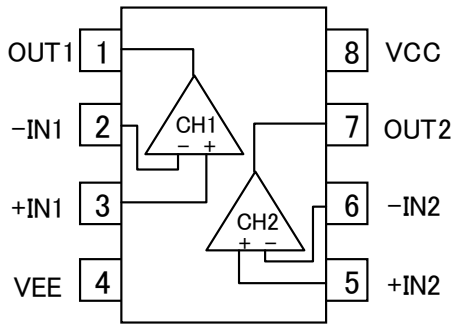


Figure 1. Simplified schematic (one channel only)

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

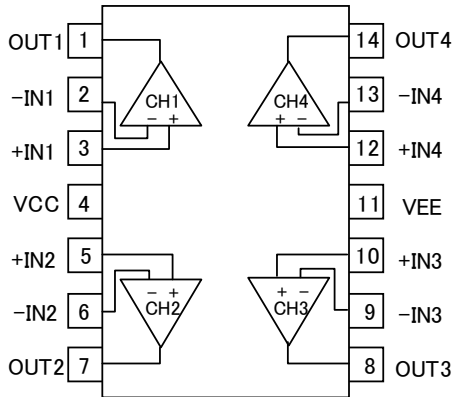
●Pin Configuration (TOP VIEW)

SOP8, SOP-J8, SSOP-B8, TSSOP-B8, MSOP8



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

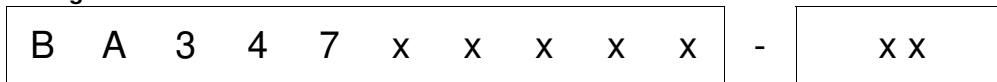
SOP14, SSOP-B14, TSSOP-B14J



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

●Ordering Information



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	
			Package	Reel of		
-40°C to +75°C	8.0mA	10V/μs	SOP14	2500	BA3474F-E2	
			SOP8	2500	BA3472F-E2	
-40°C to +85°C	4.0mA		SSOP-B8	2500	BA3472FV-E2	
			SOP-J8	2500	BA3472FJ-E2	
-40°C to +85°C	4.0mA		TSSOP-B8	2500	BA3472FVT-E2	
			MSOP8	3000	BA3472FVM-TR	
	8.0mA		SSOP-B14	2500	BA3474FV-E2	
			TSSOP-B14J	2500	BA3474FVJ-E2	
	-40°C to +105°C		4.0mA	MSOP8	3000	BA3472RFVM-TR
			8.0mA	SSOP-B14	2500	BA3474RFV-E2

## ● Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Ratings				Unit	
		BA3472	BA3474	BA3472R	BA3474R		
Supply Voltage	VCC-VEE	+36				V	
Power dissipation	Pd	SOP8	780 <sup>*1*13</sup>	-	-	-	mW
		SSOP-B8	690 <sup>*2*13</sup>	-	-	-	
		MSOP8	590 <sup>*3*13</sup>	-	590 <sup>*3*13</sup>	-	
			-	-	625 <sup>*4*14</sup>	-	
			-	-	713 <sup>*5*15</sup>	-	
		SOP-J8	675 <sup>*7*13</sup>	-	-	-	
		TSSOP-B8	625 <sup>*4*13</sup>	-	-	-	
		SOP14	-	610 <sup>*8*13</sup>	-	-	
		SSOP-B14	-	870 <sup>*9*13</sup>	-	870 <sup>*9*13</sup>	
			-	-	-	1187 <sup>*10*15</sup>	
		TSSOP-B14	-	850 <sup>*12*13</sup>	-	-	
Differential Input Voltage <sup>*17</sup>	Vid	+36				V	
Input Common-mode Voltage Range	Vicm	(VEE - 0.3) to VEE + 36				V	
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		°C	
Storage Temperature Range	Tstg	-55 to +150				°C	
Maximum Junction Temperature	Tjmax	+150				°C	

Note: Absolute maximum rating item indicates 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 To use at temperature above Ta=25°C reduce 6.2mW/°C.

\*2 To use at temperature above Ta=25°C reduce 5.5mW/°C

\*3 To use at temperature above Ta=25°C reduce 4.8mW/°C

\*4 To use at temperature above Ta=25°C reduce 5.0mW/°C

\*5 To use at temperature above Ta=25°C reduce 5.7mW/°C

\*6 To use at temperature above Ta=25°C reduce 7.5mW/°C

\*7 To use at temperature above Ta=25°C reduce 5.4mW/°C

\*8 To use at temperature above Ta=25°C reduce 4.9mW/°C

\*9 To use at temperature above Ta=25°C reduce 7.0mW/°C

\*10 To use at temperature above Ta=25°C reduce 9.5mW/°C

\*11 To use at temperature above Ta=25°C reduce 13.5mW/°C

\*12 To use at temperature above Ta=25°C reduce 6.8mW/°C

\*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.

## ● Electrical Characteristics

OBA3472 (Unless otherwise specified VCC=+15V, VEE=-15V, Ta=25°C)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Input Offset Voltage <sup>*18</sup>	Vio	-	1	10	mV	Vicm=0V, VOUT=0V
		-	1	10		VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2
Input Offset Current <sup>*18</sup>	Iio	-	6	75	nA	Vicm=0V, VOUT=0V
Input Bias Current <sup>*18</sup>	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 <sup>*19</sup>	Isource	10	30	-	mA	VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit
Output Sink Current <sup>*19</sup>	Isink	20	30	-	mA	VCC=5V, VIN+=0V VIN-=1V, VOUT=5V Only 1ch is short circuit
Unity Gain Frequency	f <sub>T</sub>	-	4	-	MHz	-
Gain Band Width	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

<sup>\*18</sup> Absolute value<sup>\*19</sup> 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.

OBA3472R (Unless otherwise specified VCC=+15V, VEE=-15V, Ta=25°C)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Input Offset Voltage <sup>*20</sup>	Vio	-	1	10	mV	Vicm=0V, VOUT=0V
		-	1	10		VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2
Input Offset Current <sup>*20</sup>	Iio	-	6	75	nA	Vicm=0V, VOUT=0V
Input Bias Current <sup>*20</sup>	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 <sup>*21</sup>	Isource	10	30	-	mA	VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit
Output Sink Current <sup>*21</sup>	Isink	20	30	-	mA	VCC=5V, VIN+=0V VIN-=1V, VOUT=5V Only 1ch is short circuit
Unity Gain Frequency	f <sub>T</sub>	-	4	-	MHz	-
Gain Band Width	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

\*20 Absolute value

\*21 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.

OBA3474 (Unless otherwise specified VCC=+15V, VEE=-15V, Ta=25°C)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Input Offset Voltage <sup>*22</sup>	Vio	-	1	10	mV	Vicm=0V, VOUT=0V
		-	1	10		VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2
Input Offset Current <sup>*22</sup>	Iio	-	6	75	nA	Vicm=0V, VOUT=0V
Input Bias Current <sup>*22</sup>	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 <sup>*23</sup>	Isource	10	30	-	mA	VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit
Output Sink Current <sup>*23</sup>	I <sub>sink</sub>	20	30	-	mA	VCC=5V, VIN+=0V VIN-=1V, VOUT=5V Only 1ch is short circuit
Unity Gain Frequency	f <sub>T</sub>	-	4	-	MHz	-
Gain Band Width	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

<sup>\*22</sup> Absolute value<sup>\*23</sup> 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.



OBA3474R (Unless otherwise specified VCC=+15V, VEE=-15V, Ta=25°C)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Input Offset Voltage <sup>*24</sup>	Vio	-	1	10	mV	Vicm=0V, VOUT=0V
		-	1	10		VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2
Input Offset Current <sup>*24</sup>	Iio	-	6	75	nA	Vicm=0V, VOUT=0V
Input Bias Current <sup>*24</sup>	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 <sup>*25</sup>	Isource	10	30	-	mA	VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit
Output Sink Current <sup>*25</sup>	I <sub>sink</sub>	20	30	-	mA	VCC=5V, VIN+=0V VIN-=1V, VOUT=5V Only 1ch is short circuit
Unity Gain Frequency	f <sub>T</sub>	-	4	-	MHz	-
Gain Band Width	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

\*24 Absolute value

\*25 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 Power dissipation (Pd)**

Indicates the power that can be consumed by a particular mounted board at ambient temperature (25°C). 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.

$$A_V = (\text{output voltage fluctuation}) / (\text{input offset fluctuation})$$

**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.

$$CMRR = (\text{Change of Input common-mode voltage}) / (\text{Input offset fluctuation})$$

**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<sub>T</sub>)**

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

**2.12 Gain Band Width (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.

● Typical Performance Curves

○ BA3472, BA3472R

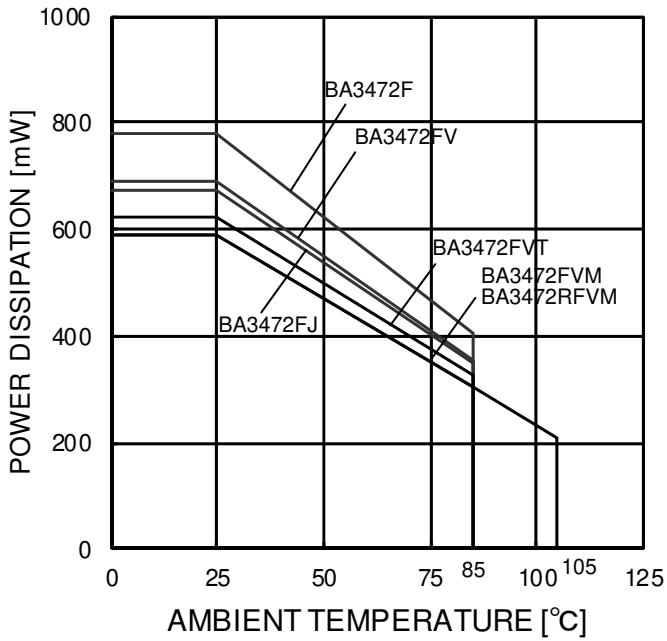


Figure 2.  
Derating Curve

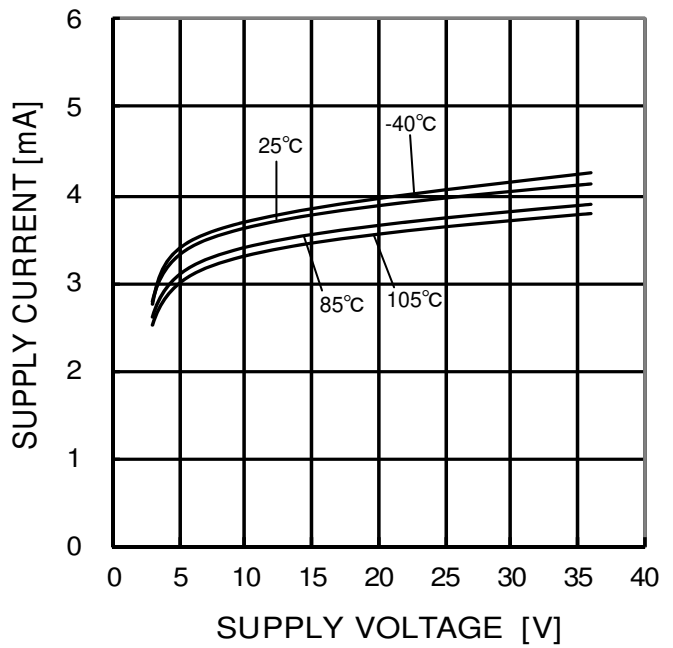


Figure 3.  
Supply Current - Supply Voltage

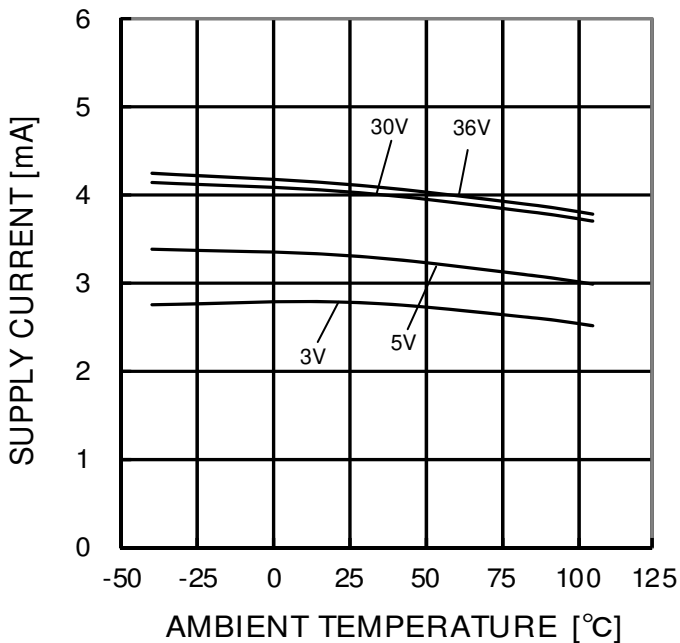


Figure 4.  
Supply Current - Ambient Temperature

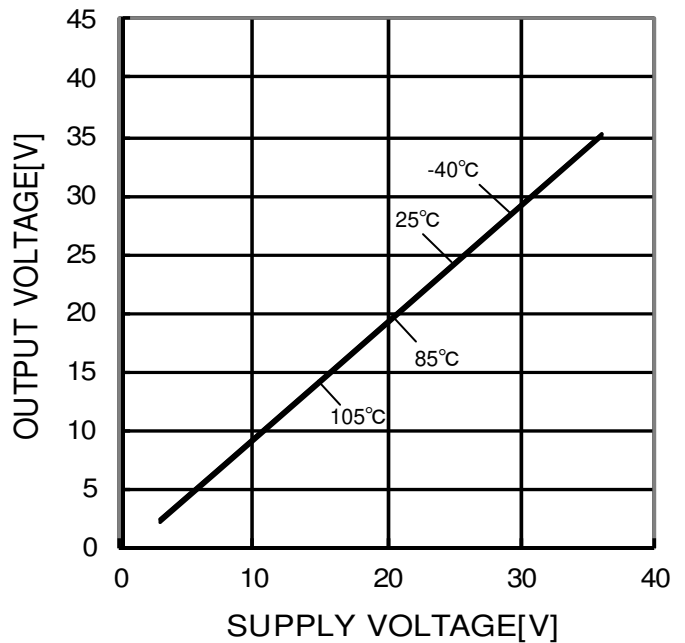


Figure 5.  
High level Output Voltage - Supply Voltage  
(RL=10kΩ)

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

OBA3472, BA3472R

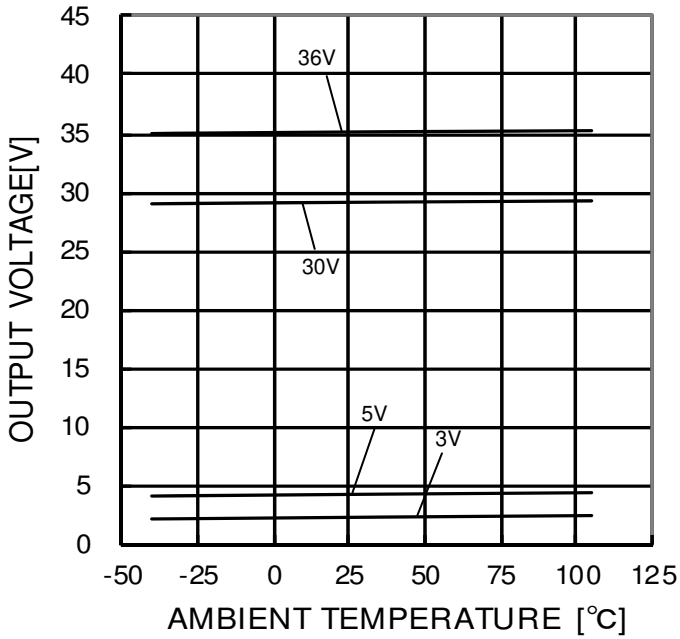


Figure 6.  
High level Output Voltage  
- Ambient Temperature  
(RL=10kΩ)

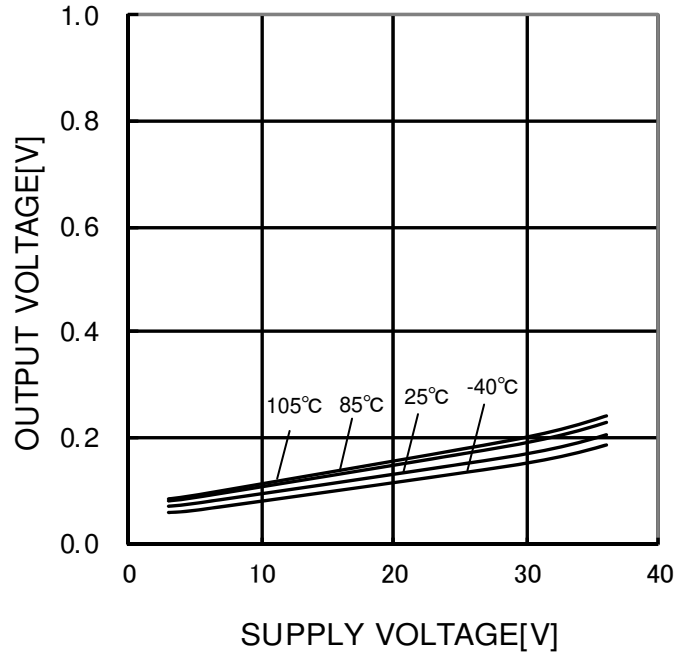


Figure 7.  
Low level Output Voltage  
- Supply Voltage  
(RL=10kΩ)

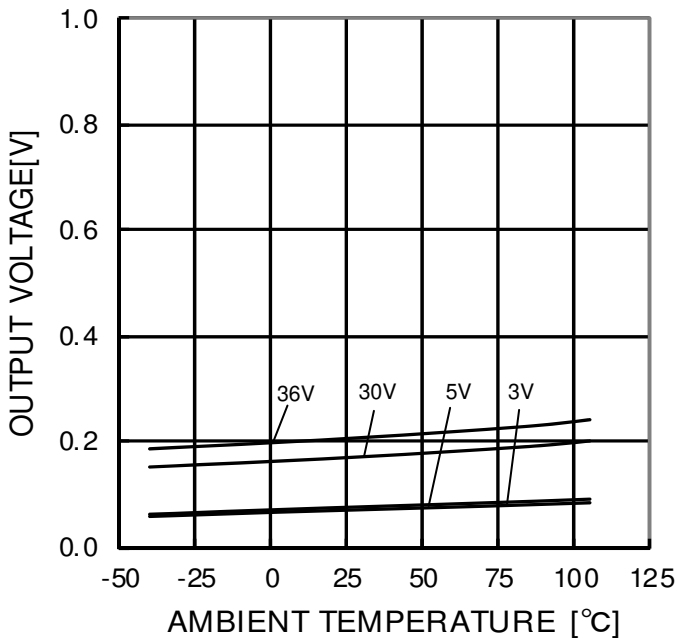


Figure 8.  
Low level Output Voltage  
- Ambient Temperature  
(RL=10kΩ)

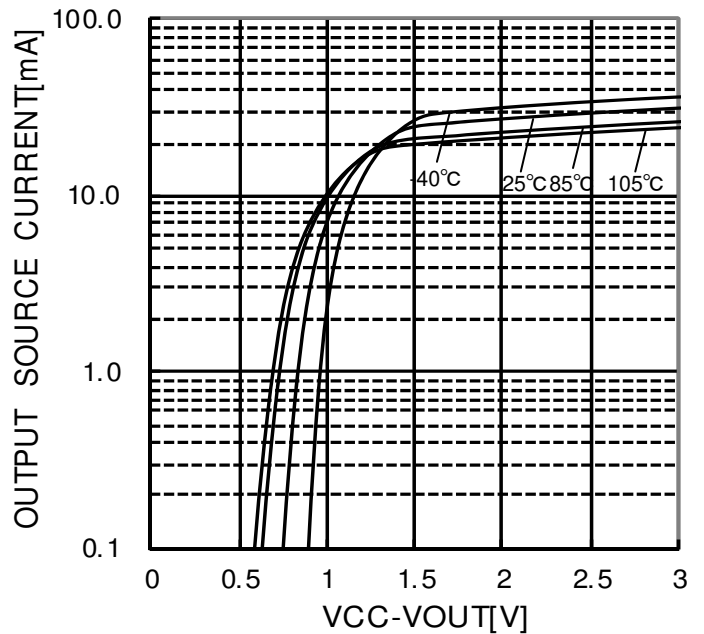


Figure 9.  
Output Source Current - (VCC-VOUT)  
(VCC/VEE=5V/0V)

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

OBA3472, BA3472R

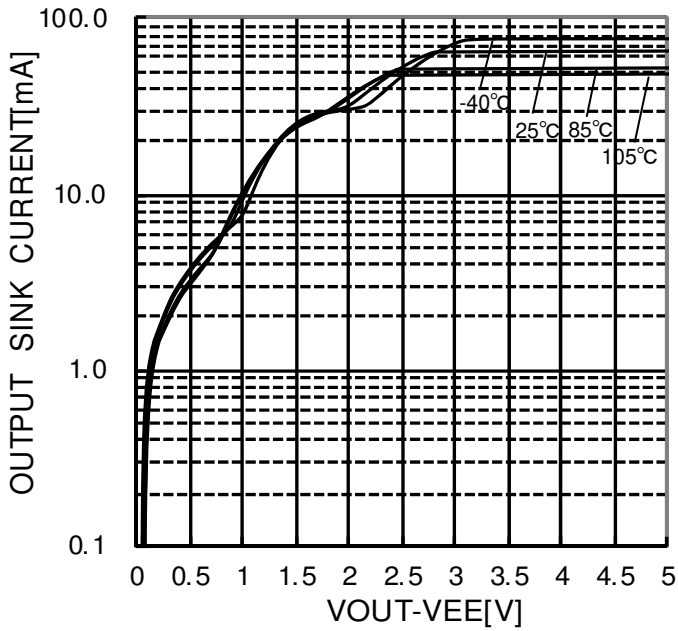


Figure 10.  
Output Sink Current - (VOUT-VEE)  
(VCC/VEE=5V/0V)

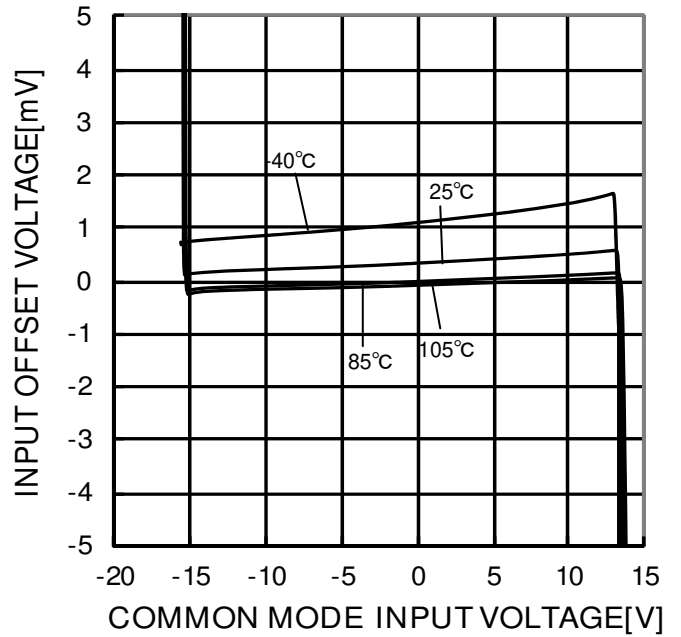


Figure 11.  
Input Offset Voltage  
- Common Mode Input Voltage  
(VCC/VEE=15V/-15V)

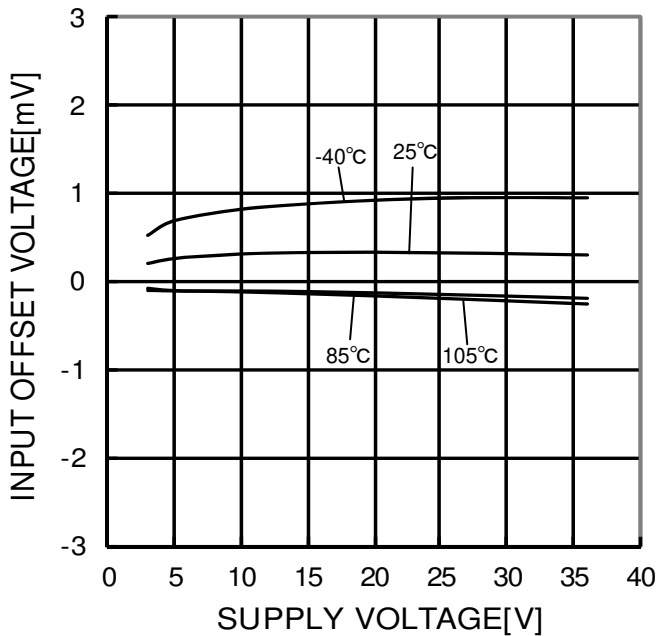


Figure 12.  
Input Offset Voltage - Supply voltage

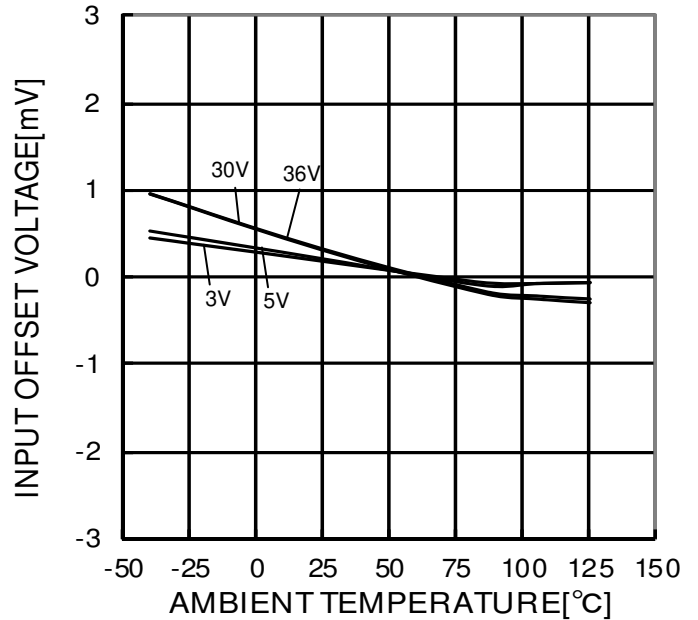


Figure 13.  
Input Offset Voltage - Ambient Temperature

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

OBA3472, BA3472R

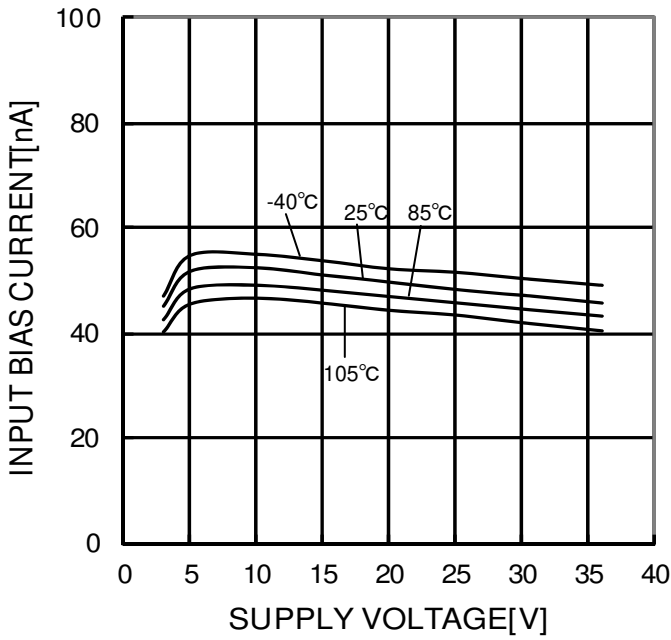


Figure 14.  
Input Bias Current - Supply voltage

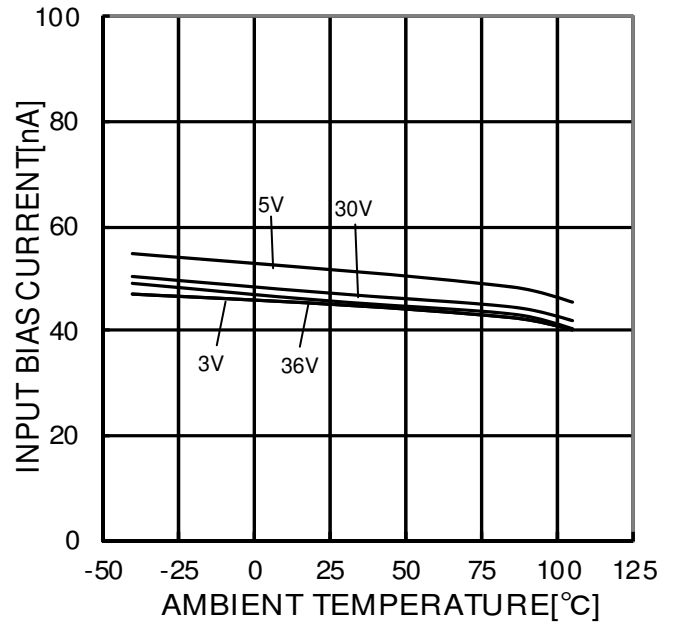


Figure 15.  
Input Bias Current - Ambient Temperature

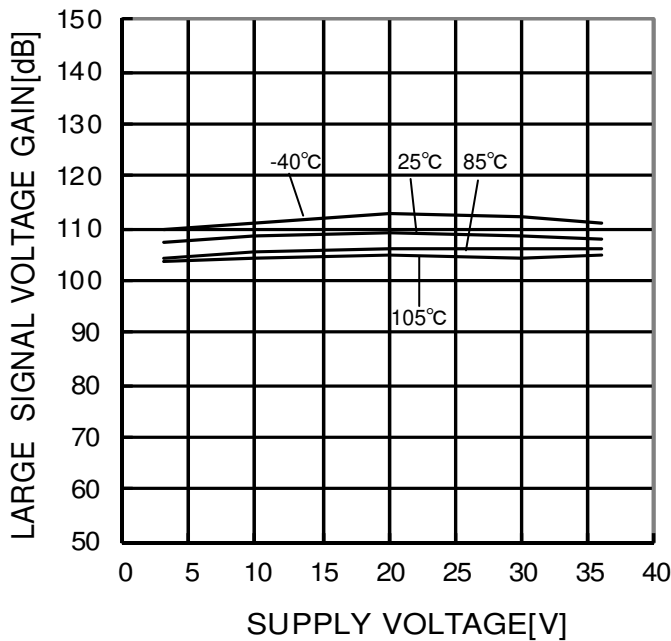


Figure 16.  
Large Signal Voltage Gain  
- Supply Voltage

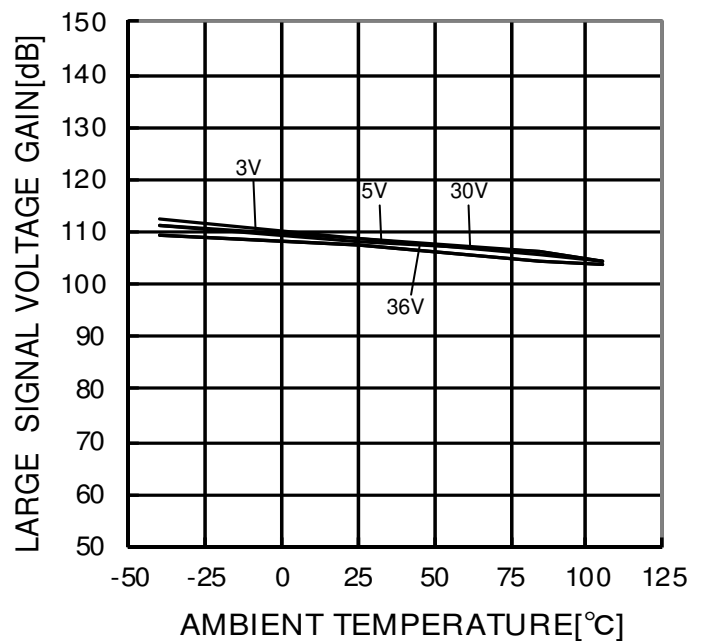


Figure 17.  
Large Signal Voltage Gain  
- Ambient Temperature

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

OBA3472, BA3472R

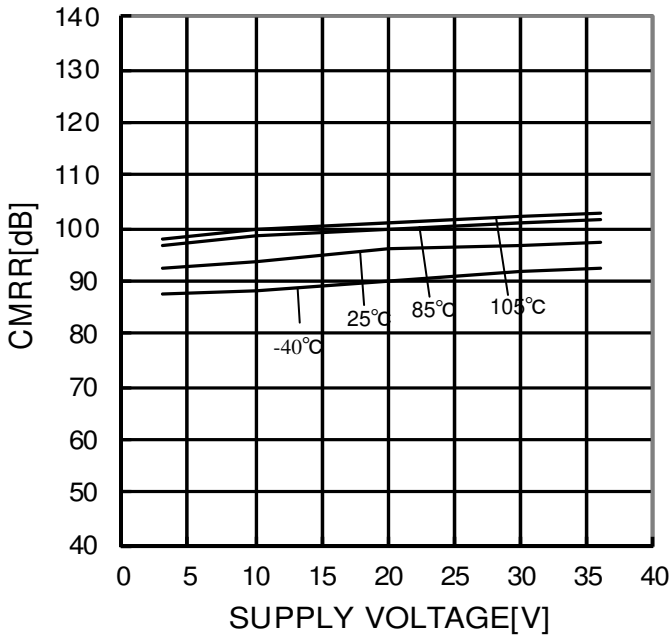


Figure 18.  
Common Mode Rejection Ratio  
- Supply Voltage

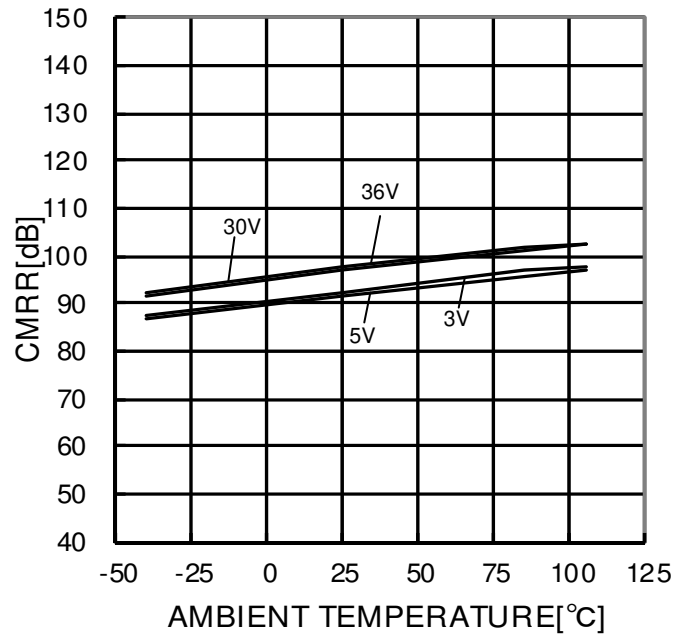


Figure 19.  
Common Mode Rejection Ratio  
- Ambient Temperature

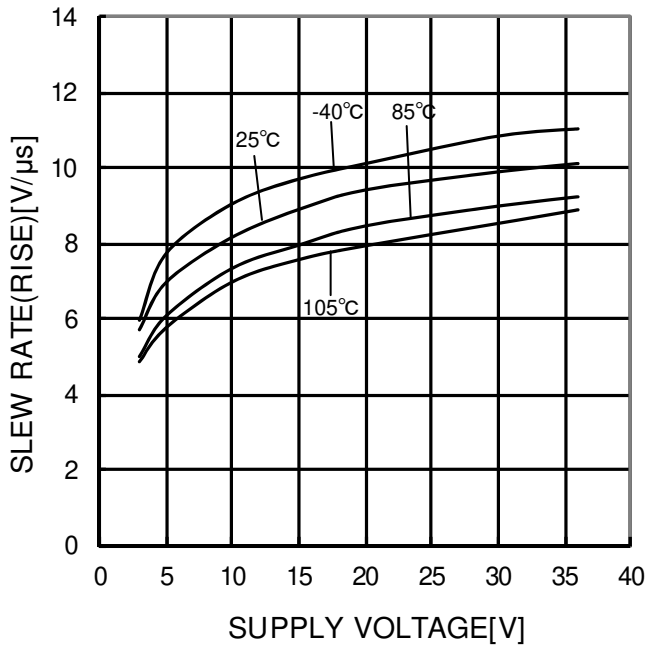


Figure 20.  
Slew Rate L-H - Supply Voltage  
(RL=10kΩ)

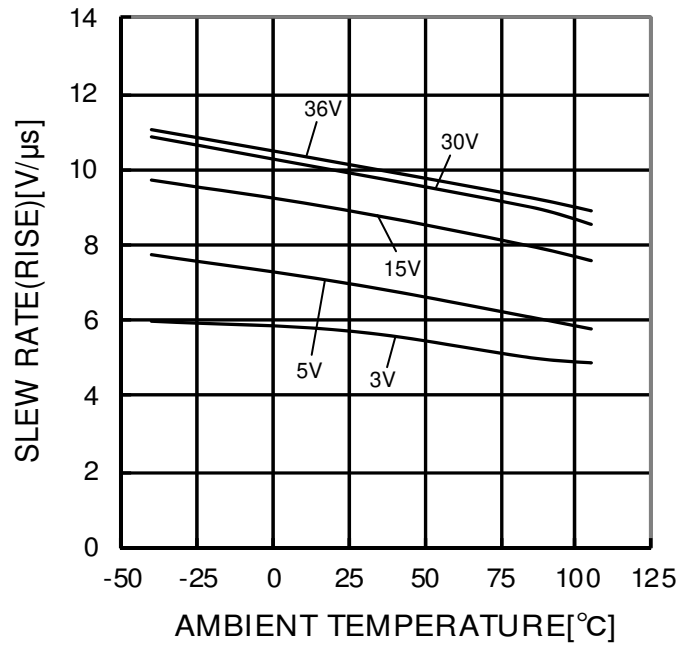


Figure 21.  
Slew Rate L-H - Ambient Temperature  
(RL=10kΩ)

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

OBA3472, BA3472R

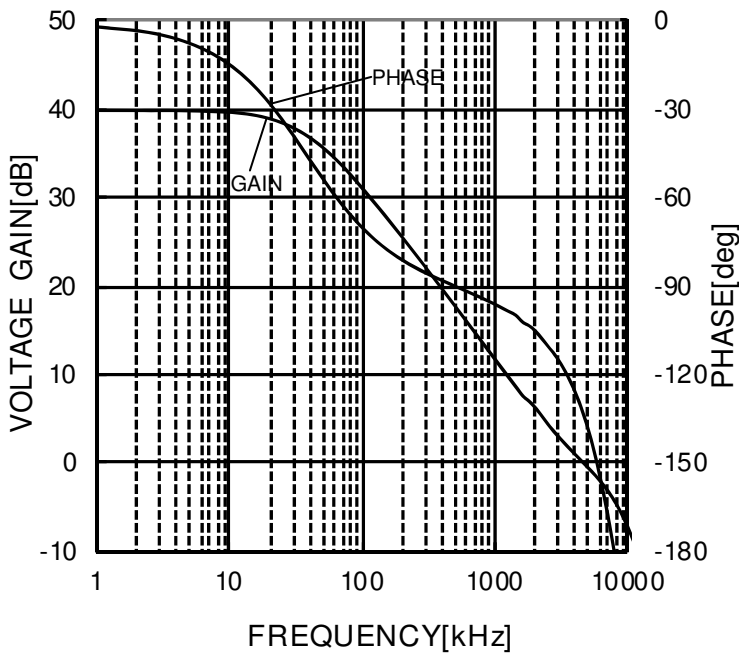


Figure 22.  
Voltage Gain · Phase - Frequency  
(VCC=7.5V/-7.5V, Av=40dB,  
RL=2kΩ, CL=100pF, Ta=25°C)

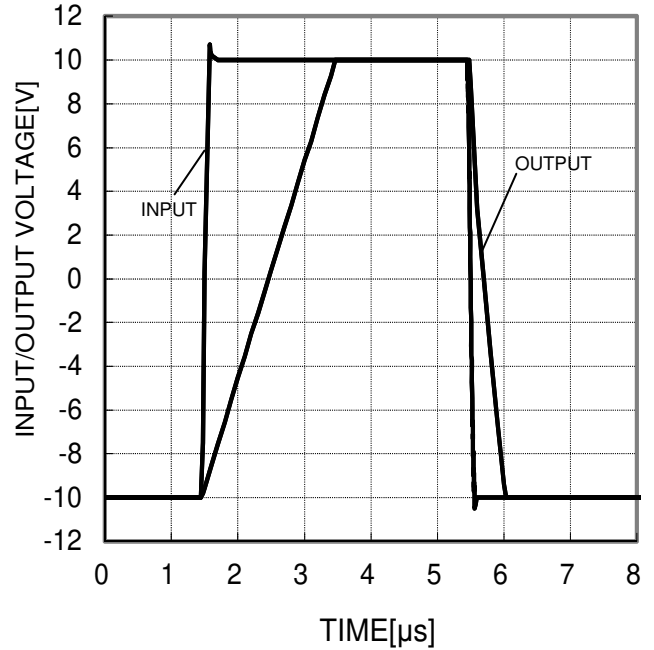


Figure 23.  
Input / Output Voltage - Time  
(VCC/VEE=15V/-15V, Av=0dB,  
RL=2kΩ, CL=100pF, Ta=25°C)

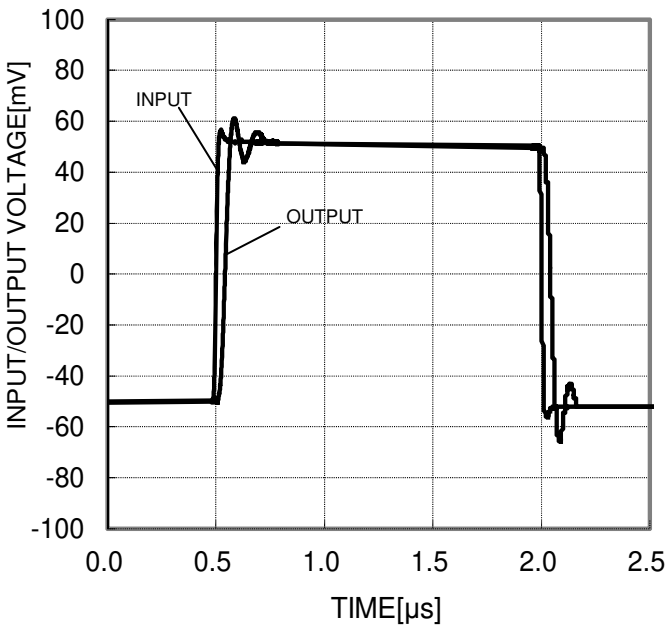


Figure 24.  
Input / Output Voltage - Time  
(VCC/VEE=15V/-15V, Av=0dB,  
RL=2kΩ, CL=100pF, Ta=25°C)

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



OBA3474, BA3474R

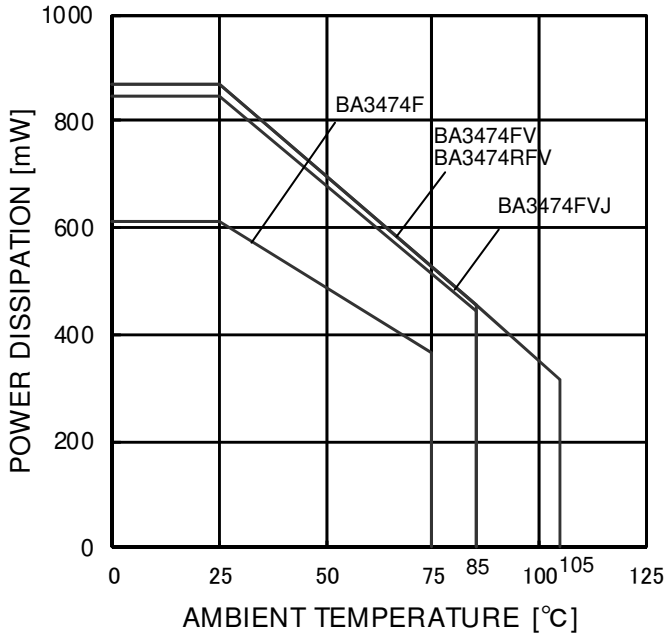


Figure 25.  
Derating Curve

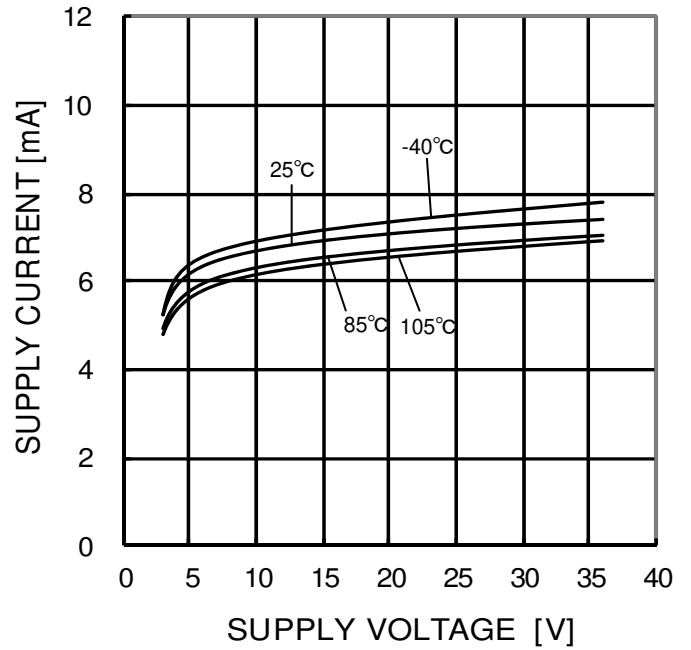


Figure 26.  
Supply Current - Supply Voltage

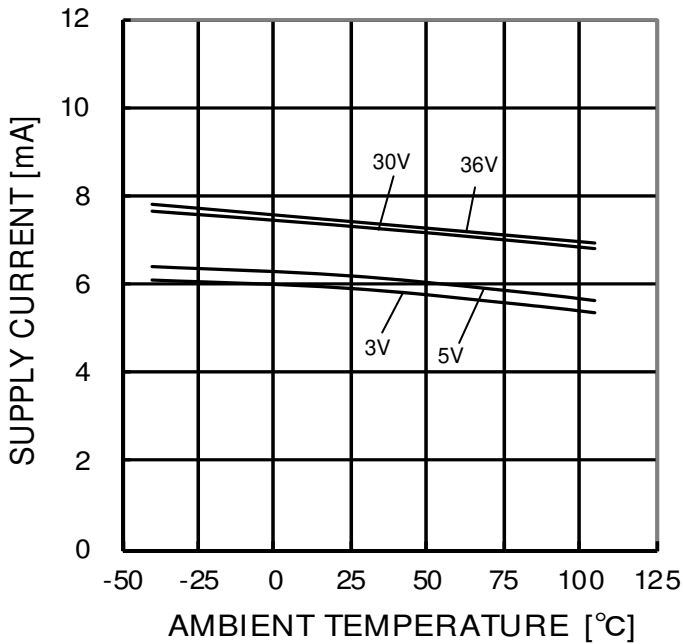


Figure 27.  
Supply Current - Ambient Temperature

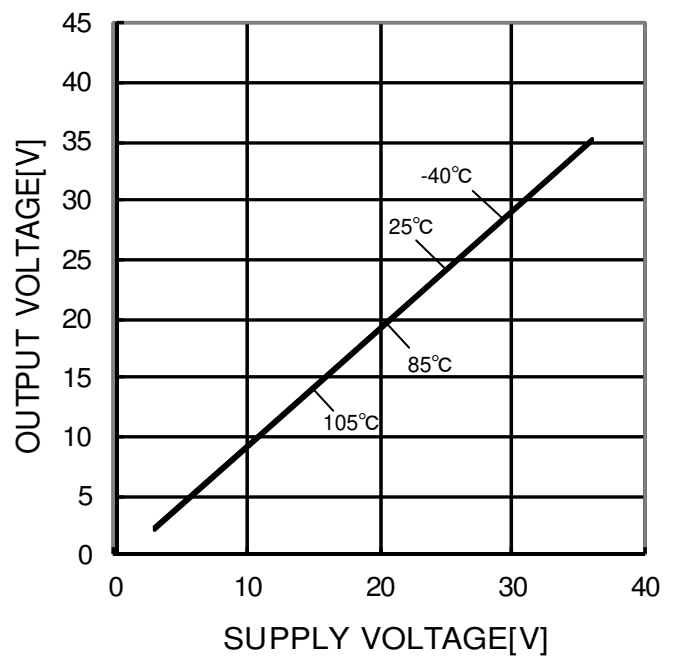


Figure 28.  
High level Output Voltage  
- Supply Voltage  
( $R_L=10k\Omega$ )

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

OBA3474, BA3474R

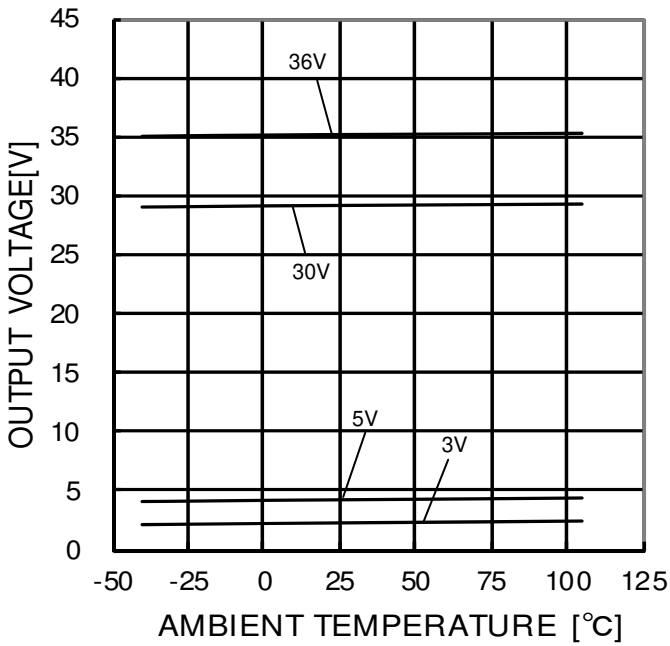


Figure 29.  
High level Output Voltage  
- Ambient Temperature  
( $R_L=10k\Omega$ )

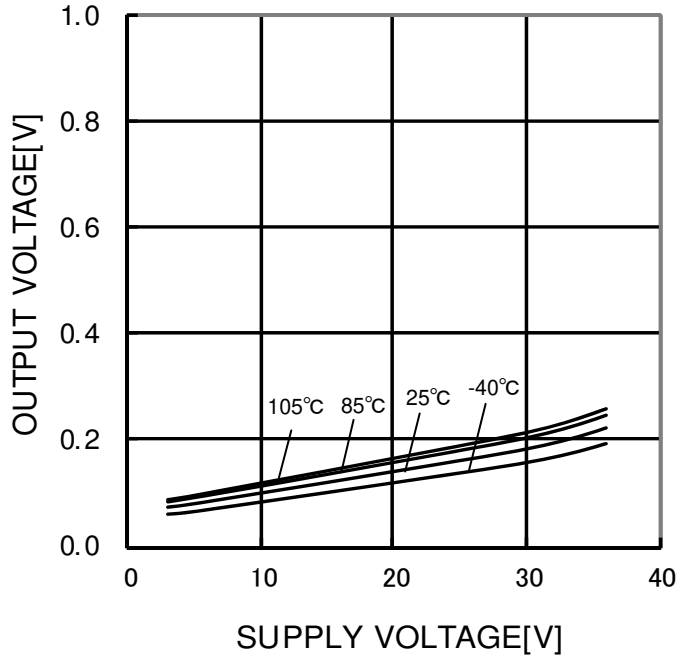


Figure 30.  
Low level Output Voltage  
- Supply Voltage  
( $R_L=10k\Omega$ )

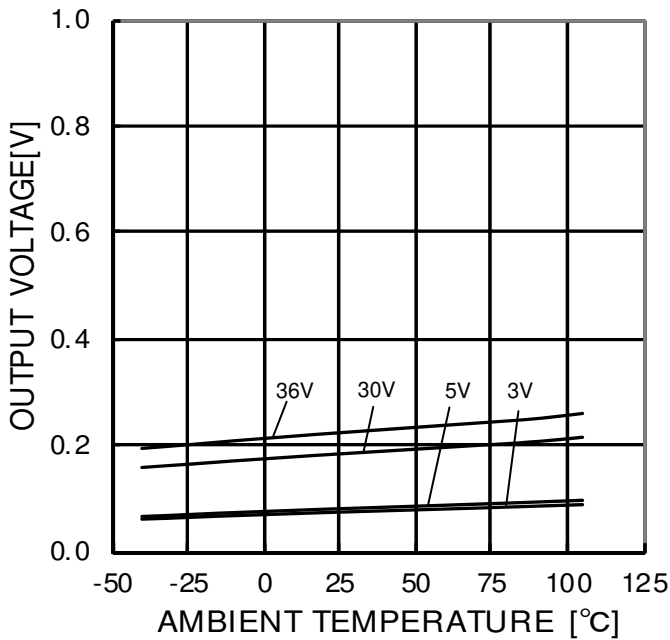


Figure 31.  
Low level Output Voltage  
- Ambient Temperature  
( $R_L=10k\Omega$ )

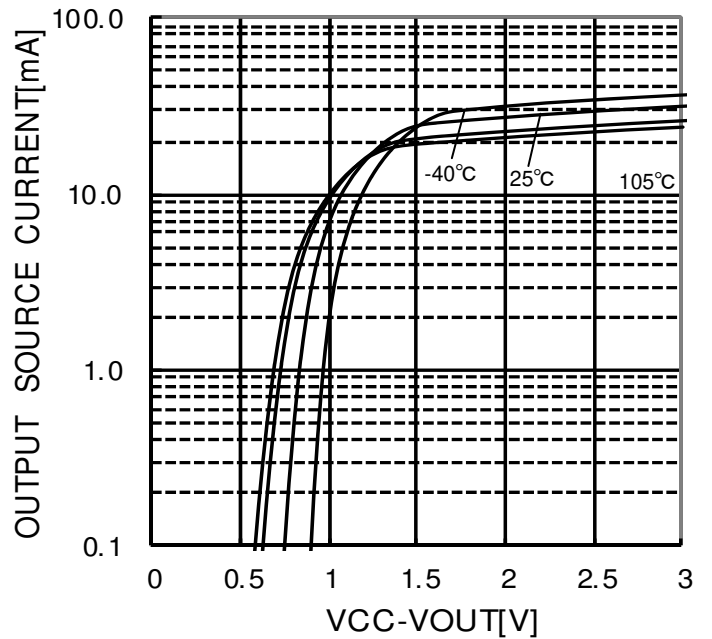


Figure 32.  
Output Source Current - ( $V_{CC}-V_{OUT}$ )  
( $V_{CC}/V_{EE}=5V/0V$ )

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

OBA3474, BA3474R

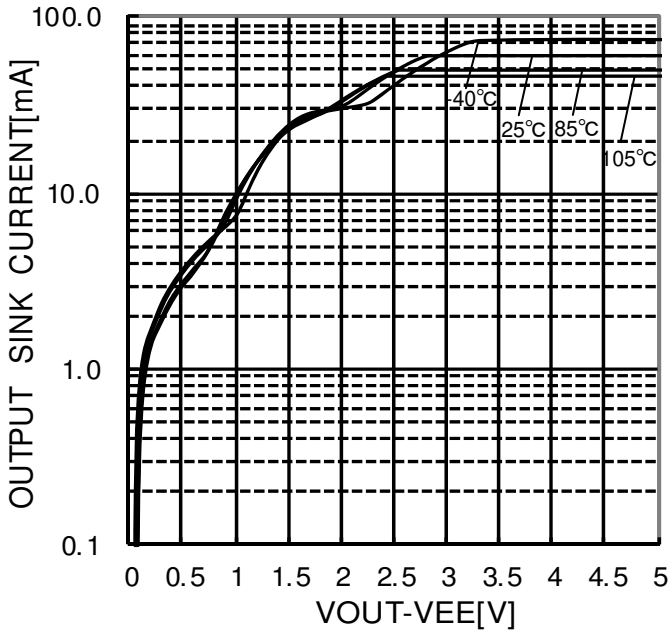


Figure 33.  
Output Sink Current - (VOUT-VEE)  
(VCC/VEE=5V/0V)

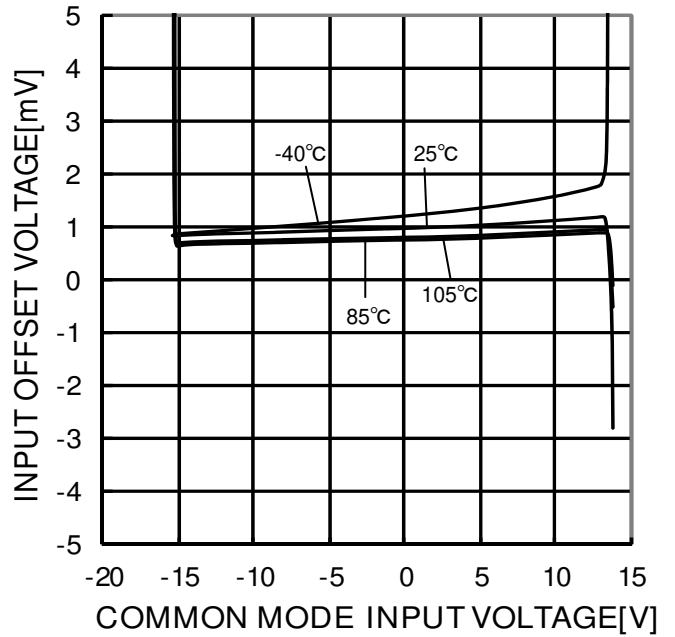


Figure 34.  
Input Offset Voltage  
- Common Model Input Voltage  
(VCC/VEE=15V/-15V)

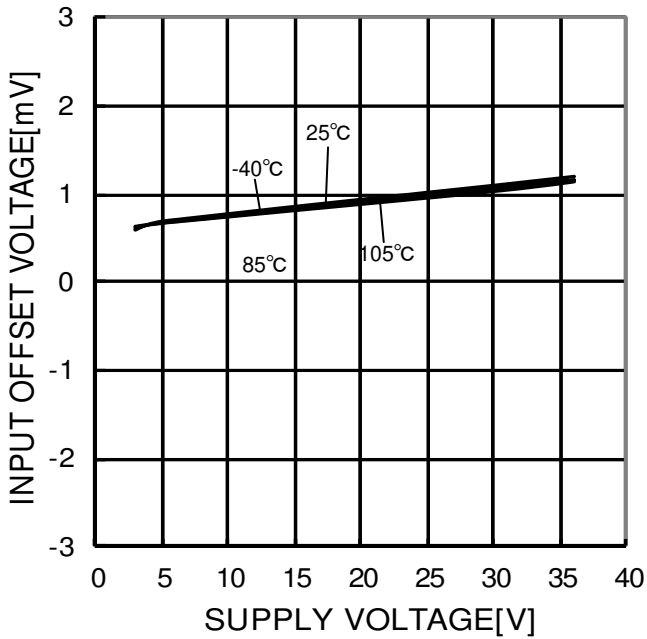


Figure 35.  
Input Offset Voltage - Supply voltage

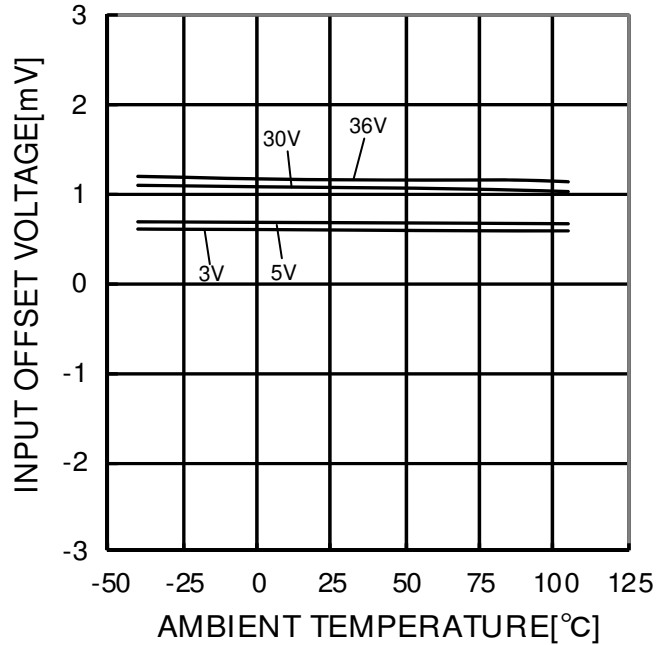


Figure 36.  
Input Offset Voltage - Ambient Temperature

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

OBA3474, BA3474R

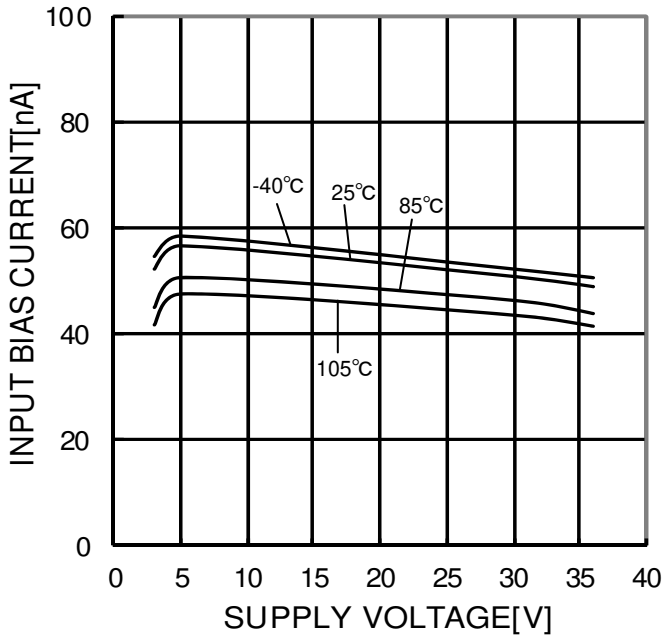


Figure 37.  
Input Bias Current - Supply voltage

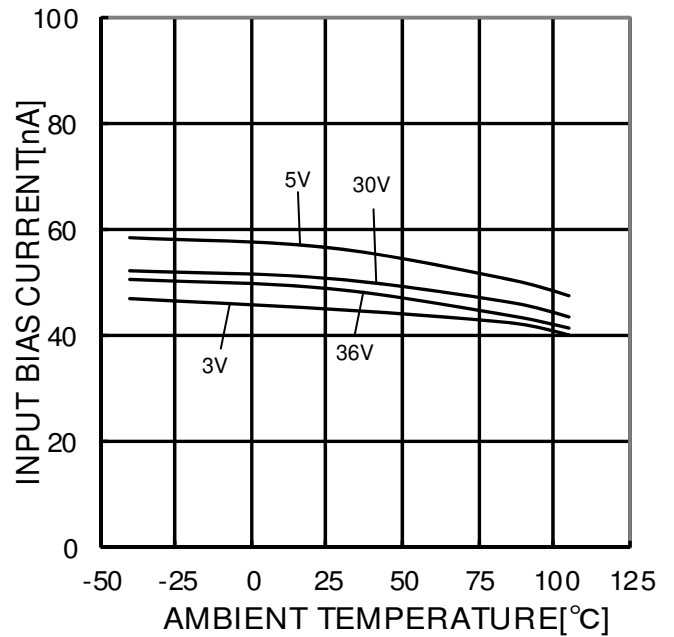


Figure 38.  
Input Bias Current - Ambient Temperature

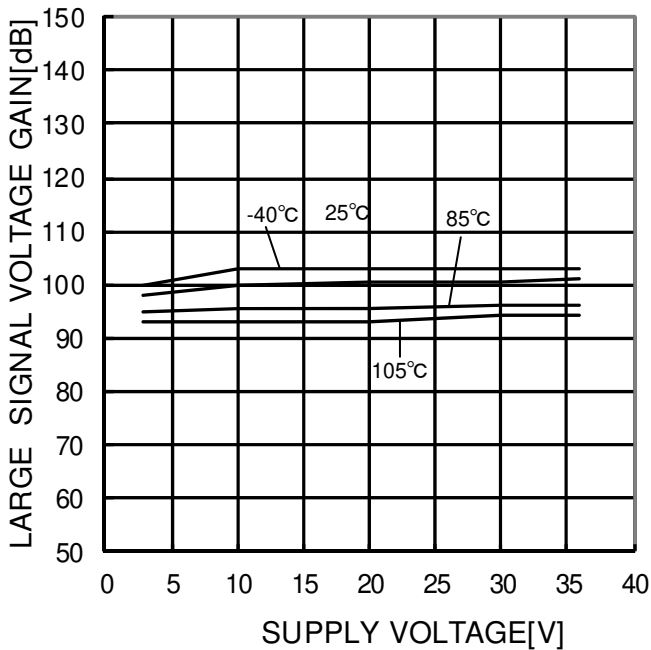


Figure 39.  
Large Signal Voltage Gain  
- Supply Voltage

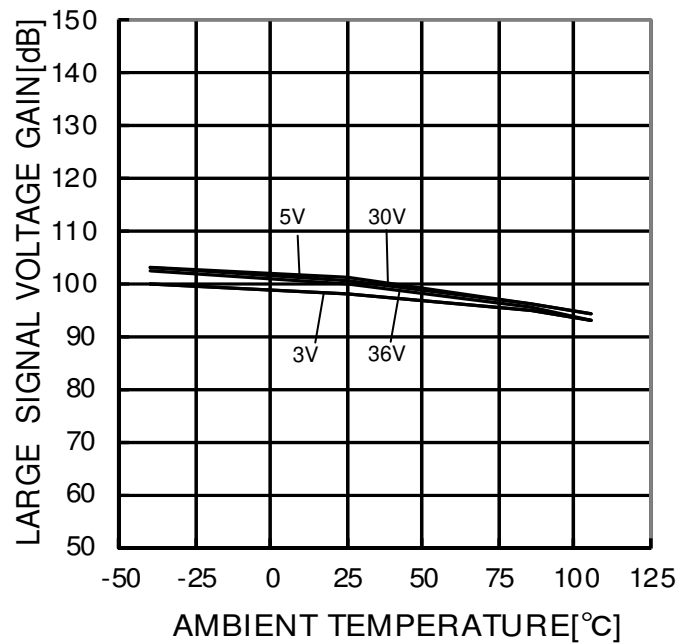


Figure 40.  
Large Signal Voltage Gain  
- Ambient Temperature

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

OBA3474, BA3474R

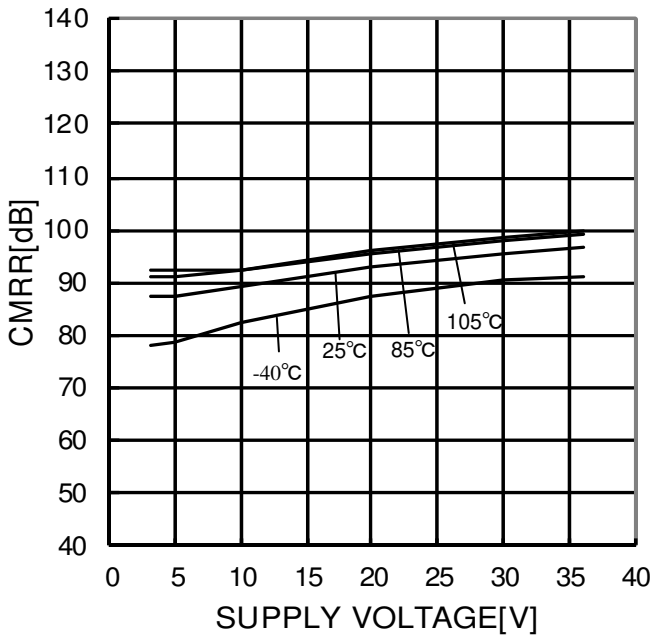


Figure 41.  
Common Mode Rejection Ratio  
- Supply Voltage

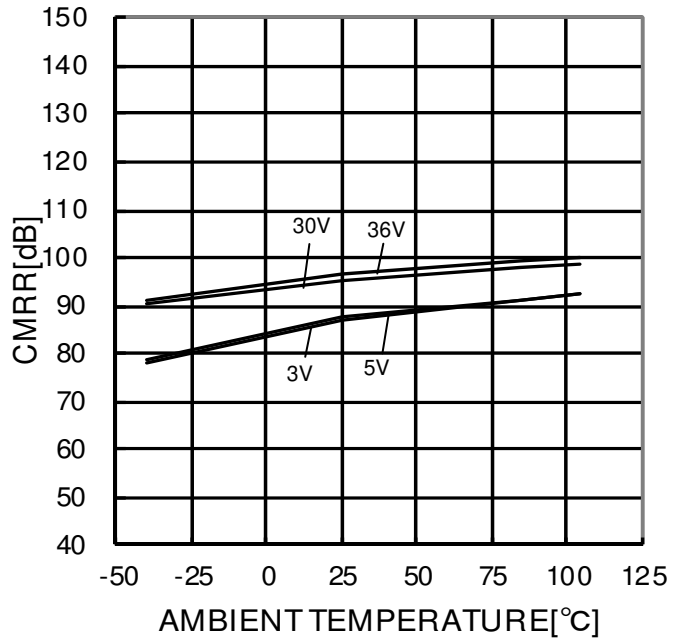


Figure 42.  
Common Mode Rejection Ratio  
- Ambient Temperature

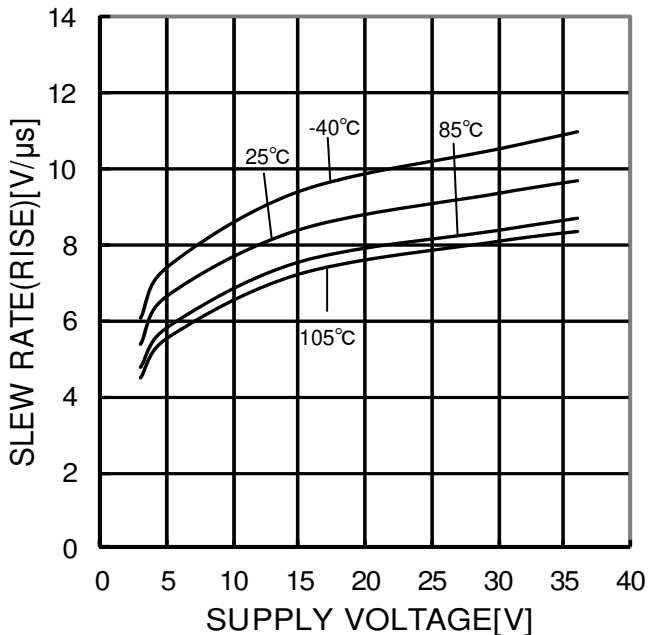


Figure 43.  
Slew Rate L-H - Supply Voltage  
(RL=10kΩ)

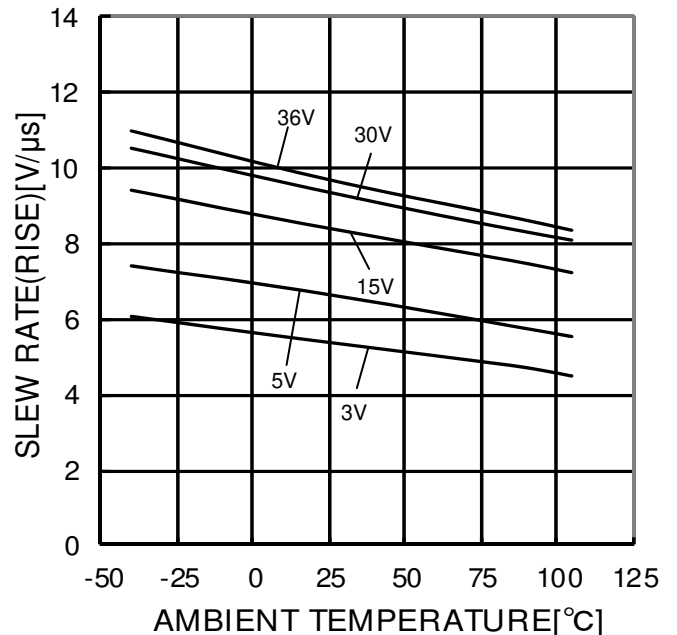


Figure 44.  
Slew Rate L-H - Ambient Temperature  
(RL=10kΩ)

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

OBA3474, BA3474R

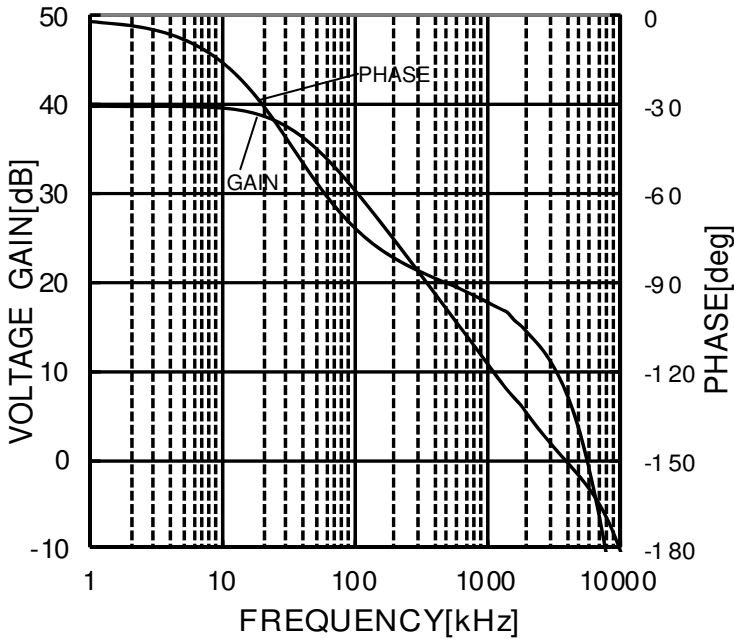


Figure 45.  
Voltage Gain · Phase - Frequency  
(VCC=7.5V/-7.5V, Av=40dB,  
RL=2kΩ, CL=100pF, Ta=25°C)

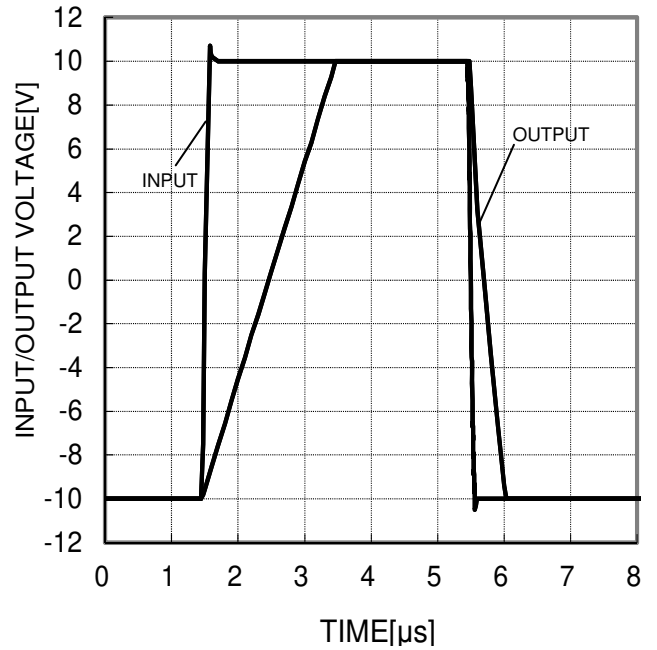


Figure 46.  
Input / Output Voltage - Time  
(VCC/VEE=15V/-15V, Av=0dB,  
RL=2kΩ, CL=100pF, Ta=25°C)

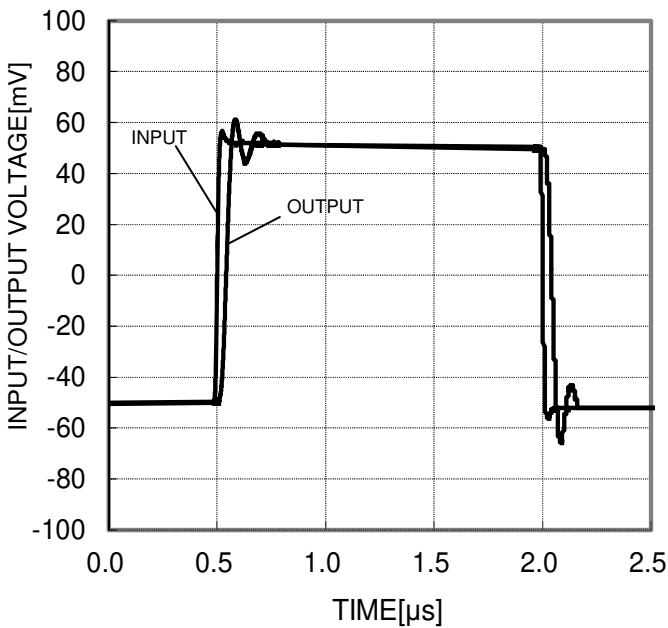


Figure 47.  
Input / Output Voltage - Time  
(VCC/VEE=15V/-15V, Av=0dB,  
RL=2kΩ, CL=100pF, Ta=25°C)

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

●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)

$$V_{io} = \frac{|VF1|}{1 + R_f / R_s} \text{ [V]}$$

2. Input Offset Current (Iio)

$$I_{io} = \frac{|VF2 - VF1|}{R_i \times (1 + R_f / R_s)} \text{ [A]}$$

3. Input Bias Current (Ib)

$$I_b = \frac{|VF4 - VF3|}{2 \times R_i \times (1 + R_f / R_s)} \text{ [A]}$$

4. Large Signal Voltage Gain (Av)

$$A_v = 20 \times \text{Log} \frac{\Delta E_k \times (1 + R_f / R_s)}{|VF5 - VF6|} \text{ [dB]}$$

5. Common-mode Rejection Ratio (CMRR)

$$\text{CMRR} = 20 \times \text{Log} \frac{\Delta V_{icm} \times (1 + R_f / R_s)}{|VF8 - VF7|} \text{ [dB]}$$

6. Power Supply Rejection Ratio (PSRR)

$$\text{PSRR} = 20 \times \text{Log} \frac{\Delta V_{cc} \times (1 + R_f / R_s)}{|VF10 - VF9|} \text{ [dB]}$$

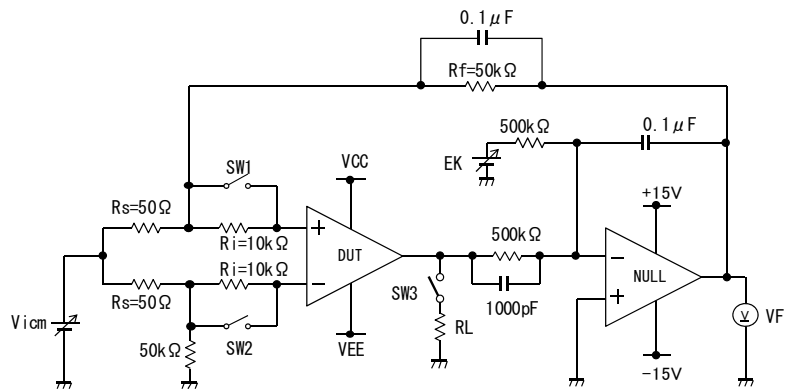


Figure 48. Test circuit 1 (one channel only)

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

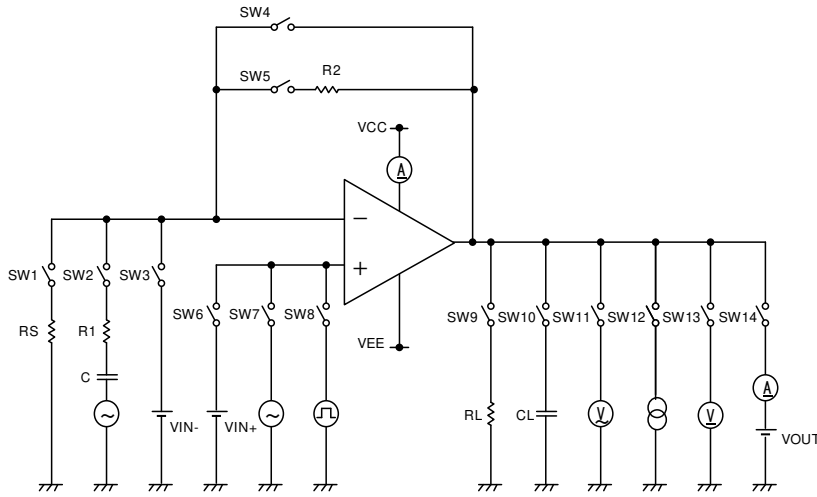


Figure 49. Test circuit 2 (one channel only)

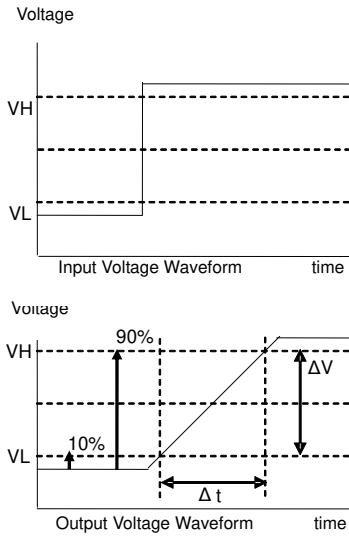


Figure 50. Slew rate input output wave

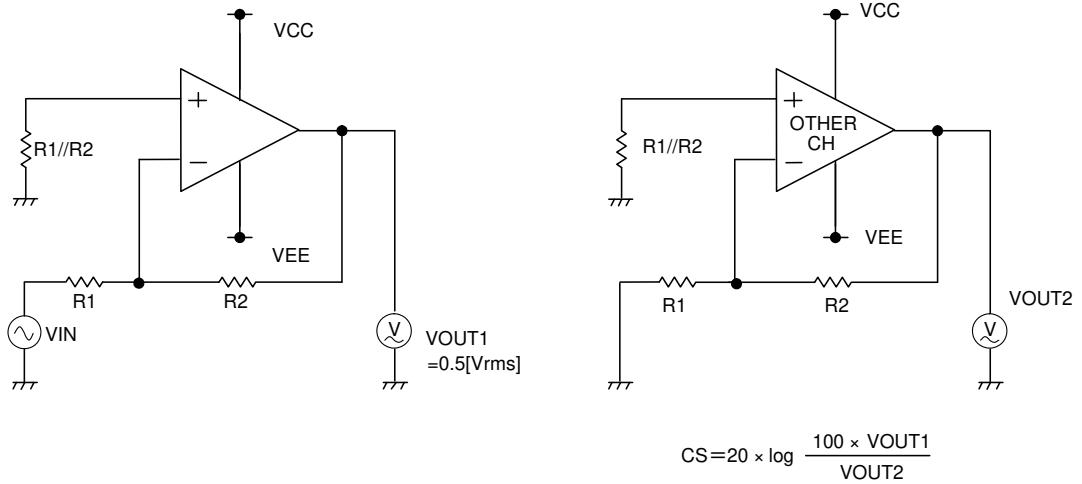


Figure 51. Test circuit 3 (Channel Separation)



● Power Dissipation

Power dissipation(total loss) indicates the power that can be consumed by IC at Ta=25°C(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  $\theta_{ja}$ °C/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  $\theta_{ja}$ , ambient temperature Ta, maximum junction temperature Tjmax, and power dissipation Pd can be calculated by the equation below:

$$\theta_{ja} = (T_{jmax} - T_a) / P_d \quad \text{°C/W} \quad \dots \dots (I)$$

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 is determined by thermal resistance  $\theta_{ja}$ . Thermal resistance  $\theta_{ja}$  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 53. (c) ~ (f) shows a derating curve for an example of BA3472, BA3474, BA3472R, BA3474R.

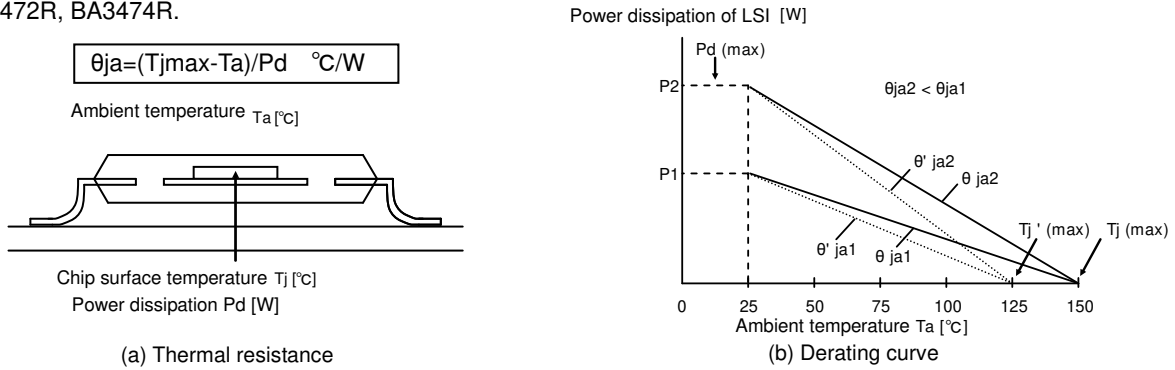
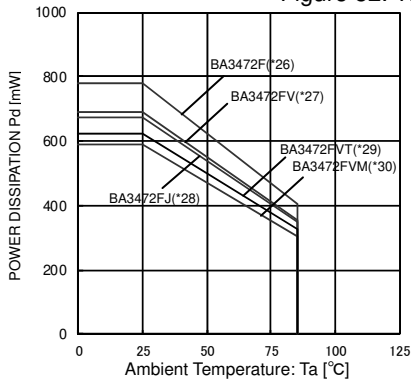
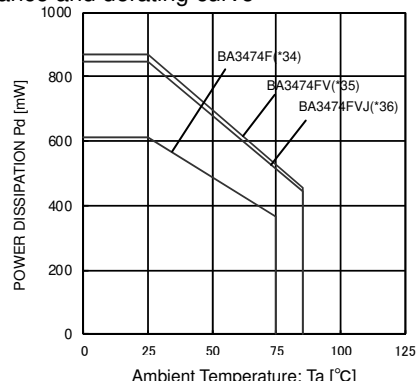


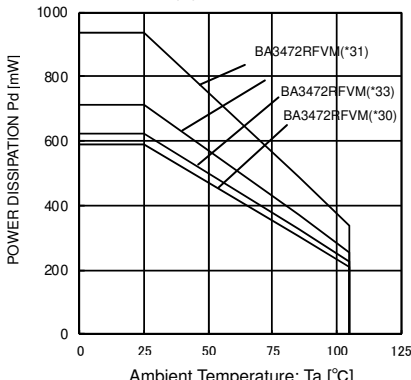
Figure 52. Thermal resistance and derating curve



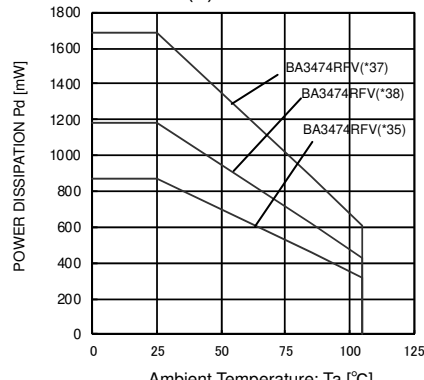
(c)BA3472



(d)BA3474



(e)BA3472R



(f)BA3474R

(*26)	(*27)	(*28)	(*29)	(*30)	(*31)	(*32)	(*33)	(*34)	(*35)	(*36)	(*37)	(*38)	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/°C

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

(\*26)(\*27)(\*28)(\*29)(\*30)(\*34)(\*35)(\*36) Mounted on a FR4 glass epoxy 1 layers PCB 70mm × 70mm × 1.6mm (occupied copper area : below 3%).

(\*33) Mounted on a FR4 glass epoxy 2 layers PCB 70mm × 70mm × 1.6mm (occupied copper area : 15mm × 15mm).

(\*32) (\*38) Mounted on a FR4 glass epoxy 2 layers PCB 70mm × 70mm × 1.6mm (occupied copper area : 70mm × 70mm).

(\*31) (\*37) Mounted on a FR4 glass epoxy 4 layers PCB 70mm × 70mm × 1.6mm (occupied copper area : 70mm × 70mm).

Figure 53. Derating curve

### ●Operational Notes

#### 1) Unused circuits

When there are unused circuits it is recommended that they are connected as in Figure 54, setting the non-inverting input terminal to a potential within input common-mode voltage range ( $V_{icm}$ ).

#### 2) Input terminal voltage

Applying GND + 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 specified voltage supplied is between VCC and VEE. Therefore, the single supply op-amp can be used as dual supply op-amp as well.

#### 4) Power dissipation $P_d$

Using the unit in excess of the rated power dissipation may cause deterioration in electrical characteristics due to a rise in chip temperature, including reduced current capability. Therefore, please take into consideration the power dissipation ( $P_d$ ) 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 particles 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 fluctuations in the electrical characteristics due to piezo resistance effects.

#### 9) 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.

#### 10) 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 0.1  $\mu$ F.

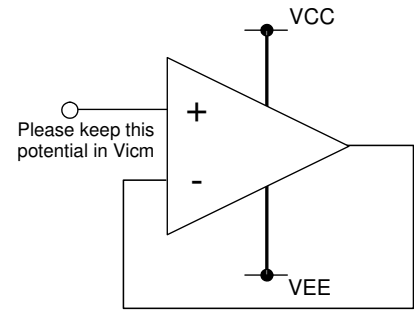


Figure 54. Unused circuit example

### 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.