

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**

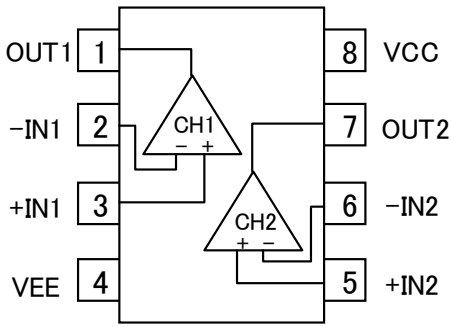


Figure 1. Simplified schematic (one channel only)

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

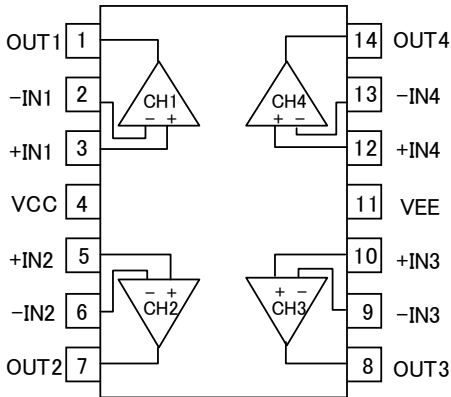
●Pin Configuration (TOP VIEW)

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

| | | |
|--|---|---|
| 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 |
| 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 |
| SSOP-B14 | | | | Reel of 2500 | BA3474FV-E2 |
| -40°C to +105°C | 4.0mA | | TSSOP-B14J | Reel of 2500 | BA3474FVJ-E2 |
| | 8.0mA | | MSOP8 | Reel of 3000 | BA3472RFVM-TR |
| | | | SSOP-B14 | Reel of 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 ^{*1*13} | - | - | - | mW |
| | | SSOP-B8 | 690 ^{*2*13} | - | - | - | |
| | | MSOP8 | 590 ^{*3*13} | - | 590 ^{*3*13} | - | |
| | | | - | - | 625 ^{*4*14} | - | |
| | | | - | - | 713 ^{*5*15} | - | |
| | | 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 | |
| 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 ^{*18} | Vio | - | 1 | 10 | mV | Vicm=0V, VOUT=0V |
| | | - | 1 | 10 | | VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2 |
| Input Offset Current ^{*18} | Iio | - | 6 | 75 | nA | Vicm=0V, VOUT=0V |
| Input Bias Current ^{*18} | 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 ^{*19} | Isource | 10 | 30 | - | mA | VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit |
| Output Sink Current ^{*19} | 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 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 |

^{*18} Absolute value^{*19} 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 ^{*20} | Vio | - | 1 | 10 | mV | Vicm=0V, VOUT=0V |
| | | - | 1 | 10 | | VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2 |
| Input Offset Current ^{*20} | Iio | - | 6 | 75 | nA | Vicm=0V, VOUT=0V |
| Input Bias Current ^{*20} | 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 ^{*21} | Isource | 10 | 30 | - | mA | VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit |
| Output Sink Current ^{*21} | 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 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 ^{*22} | Vio | - | 1 | 10 | mV | Vicm=0V, VOUT=0V |
| | | - | 1 | 10 | | VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2 |
| Input Offset Current ^{*22} | Iio | - | 6 | 75 | nA | Vicm=0V, VOUT=0V |
| Input Bias Current ^{*22} | 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 ^{*23} | Isource | 10 | 30 | - | mA | VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit |
| Output Sink Current ^{*23} | 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 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 |

*22 Absolute value

*23 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 ^{*24} | Vio | - | 1 | 10 | mV | Vicm=0V, VOUT=0V |
| | | - | 1 | 10 | | VCC=5V, VEE=0V, Vicm=0V VOUT=VCC/2 |
| Input Offset Current ^{*24} | Iio | - | 6 | 75 | nA | Vicm=0V, VOUT=0V |
| Input Bias Current ^{*24} | 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 ^{*25} | Isource | 10 | 30 | - | mA | VCC=5V, VIN+=1V VIN-=0V, VOUT=0V Only 1ch is short circuit |
| Output Sink Current ^{*25} | 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 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_T)

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

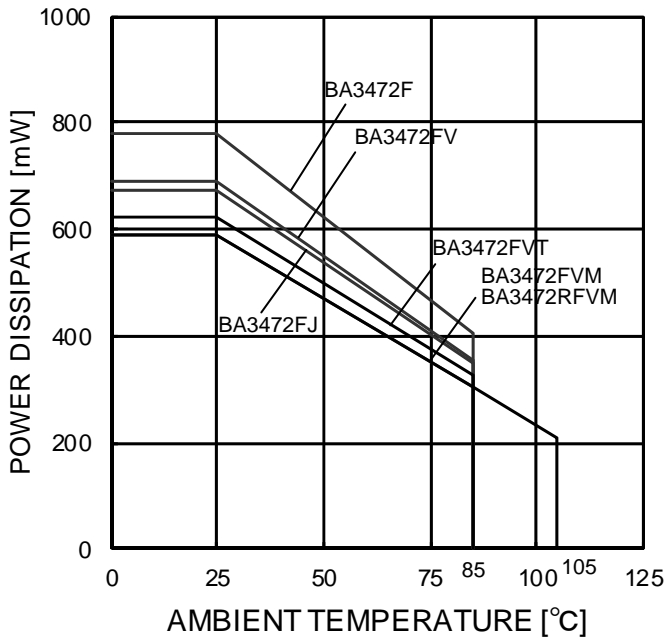


Figure 2.
Derating Curve

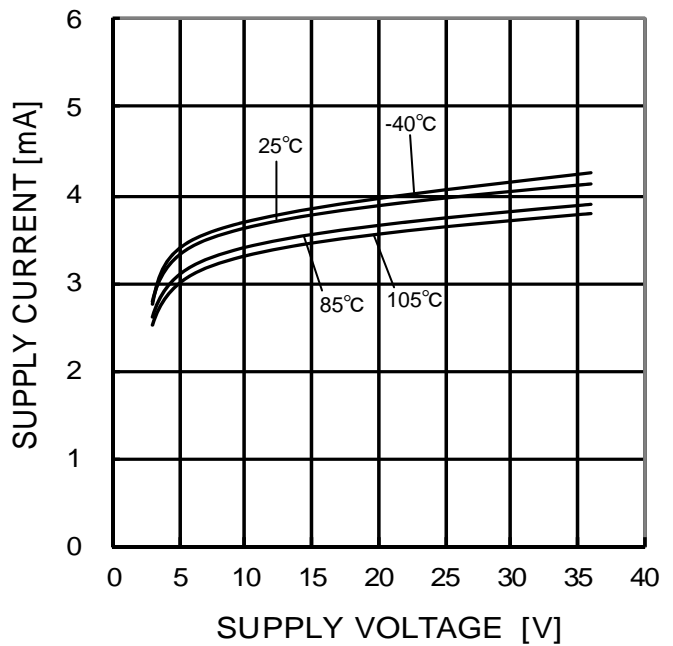


Figure 3.
Supply Current - Supply Voltage



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)

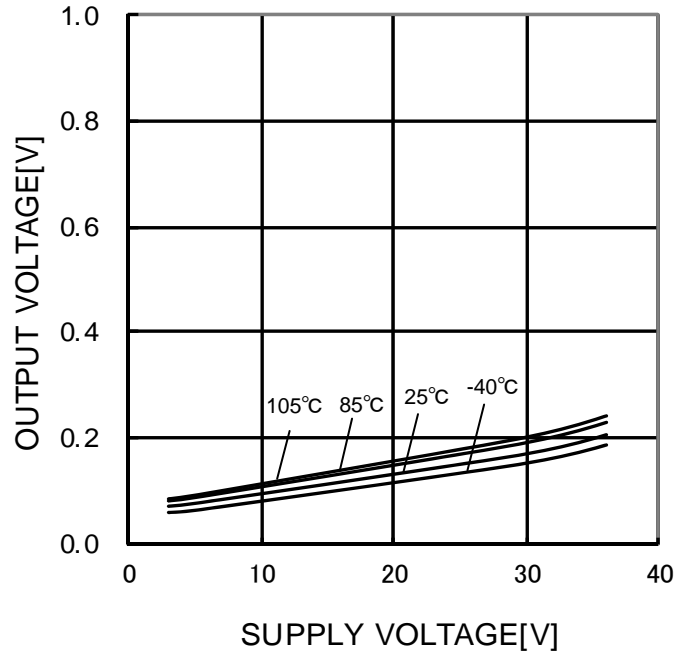


Figure 7.
Low level Output Voltage
- Supply Voltage
(RL=10kΩ)

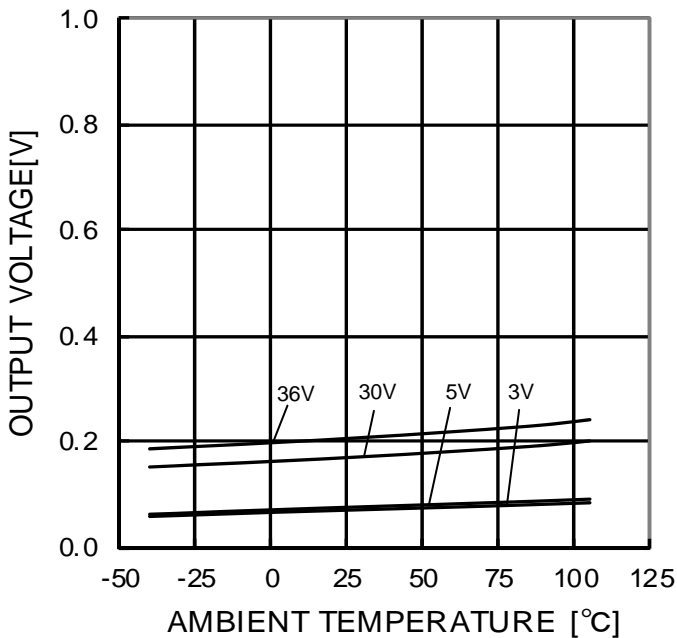


Figure 8.
Low level Output Voltage
- Ambient Temperature
(RL=10kΩ)

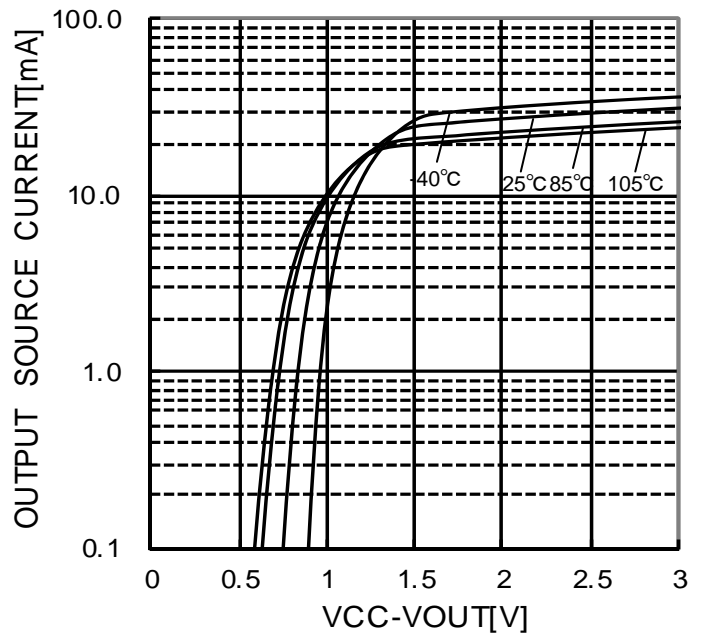


Figure 9.
Output Source Current - (VCC-VOUT)
(VCC/VEE=5V/0V)

(*) 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

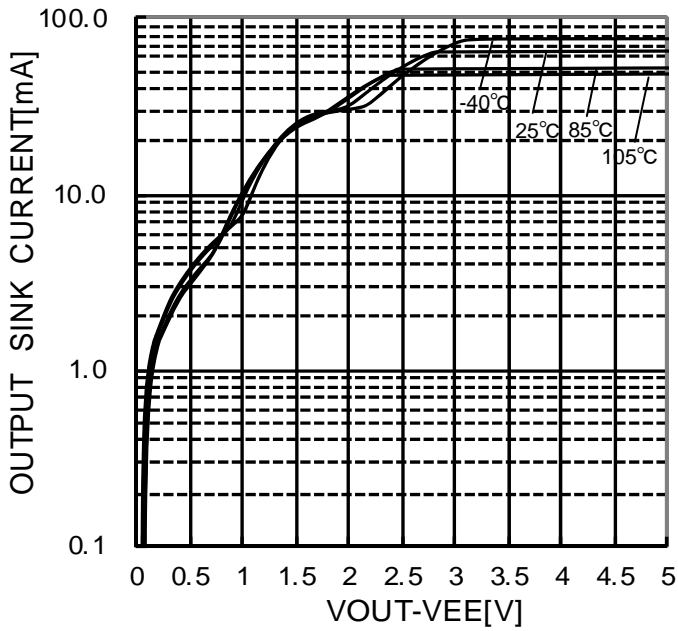


Figure 10.
Output Sink Current - (VOUT-VEE)
(VCC/VEE=5V/0V)

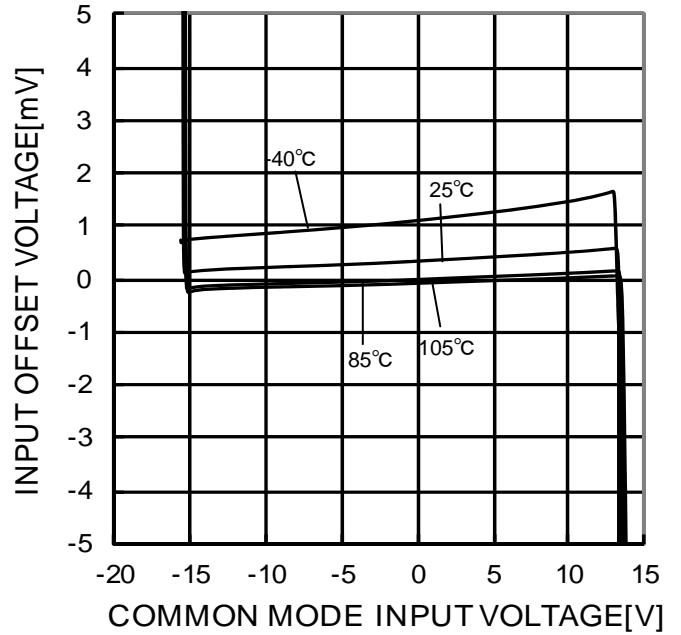


Figure 11.
Input Offset Voltage
- Common Mode Input Voltage
(VCC/VEE=15V/-15V)

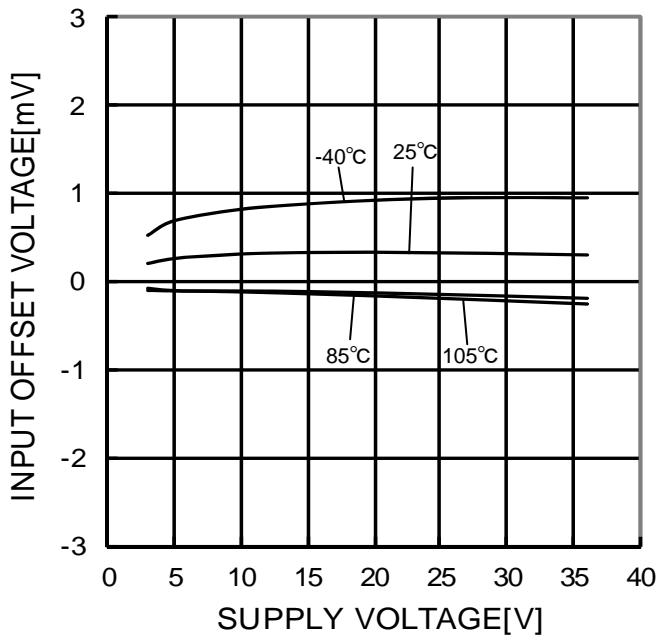


Figure 12.
Input Offset Voltage - Supply voltage

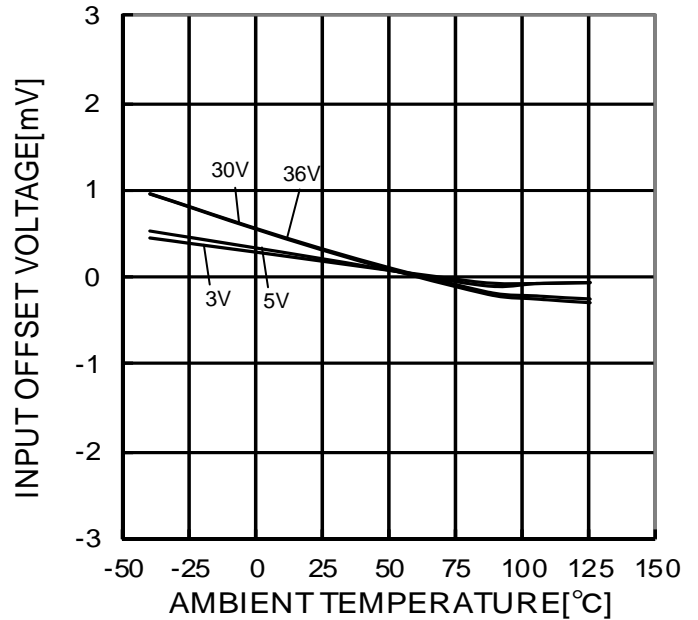


Figure 13.
Input Offset Voltage - Ambient Temperature

(*) 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

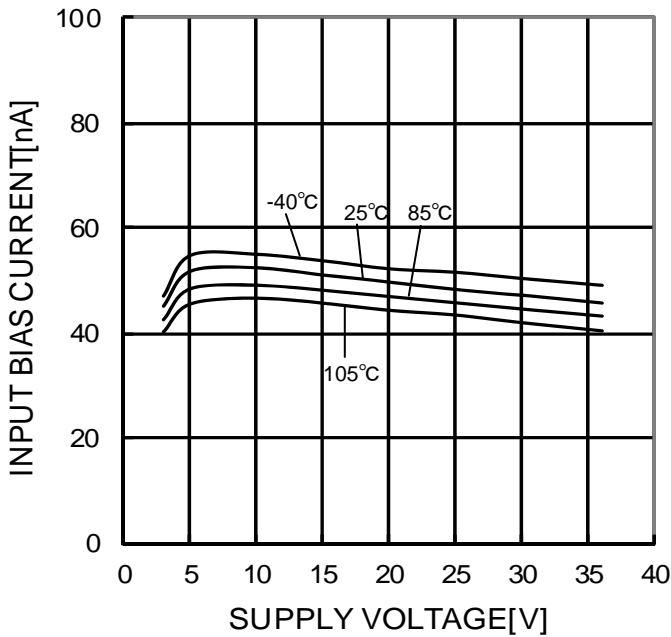


Figure 14.
Input Bias Current - Supply voltage

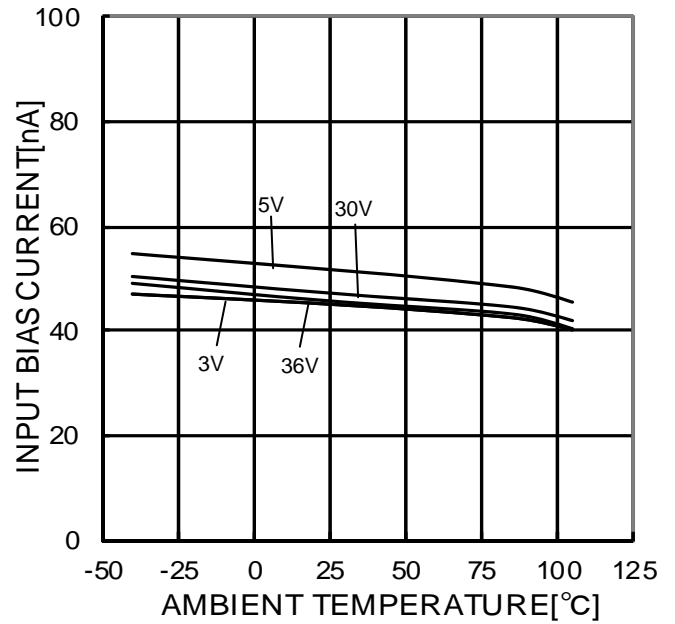


Figure 15.
Input Bias Current - Ambient Temperature

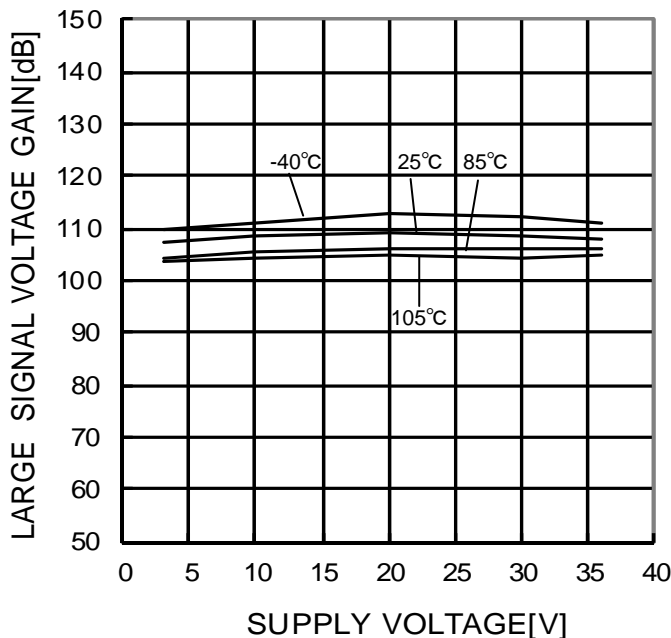


Figure 16.
Large Signal Voltage Gain
- Supply Voltage

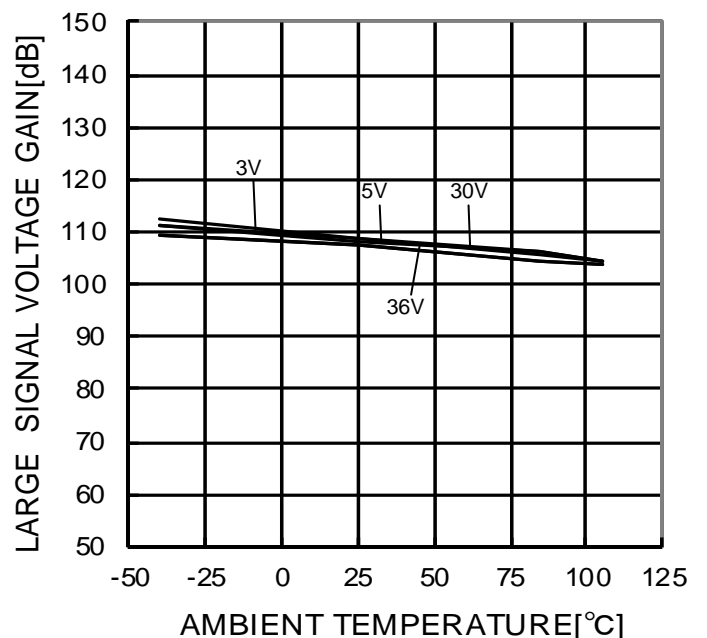


Figure 17.
Large Signal Voltage Gain
- Ambient Temperature

(*) 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

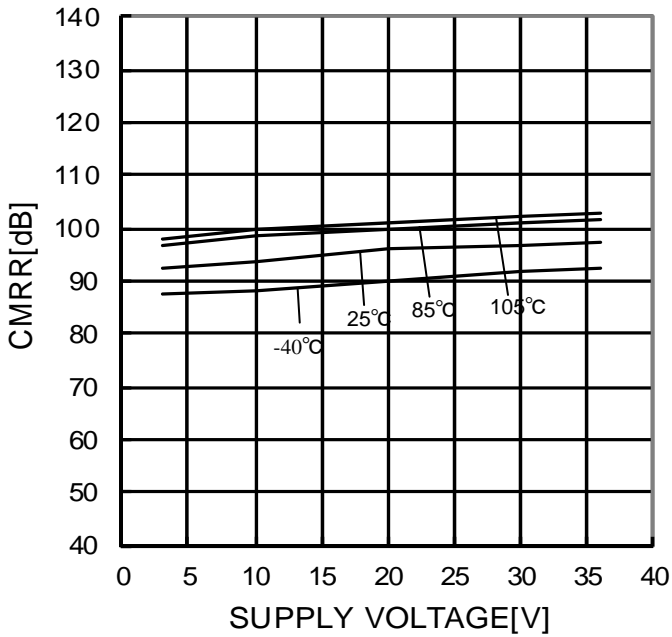


Figure 18.
Common Mode Rejection Ratio
- Supply Voltage

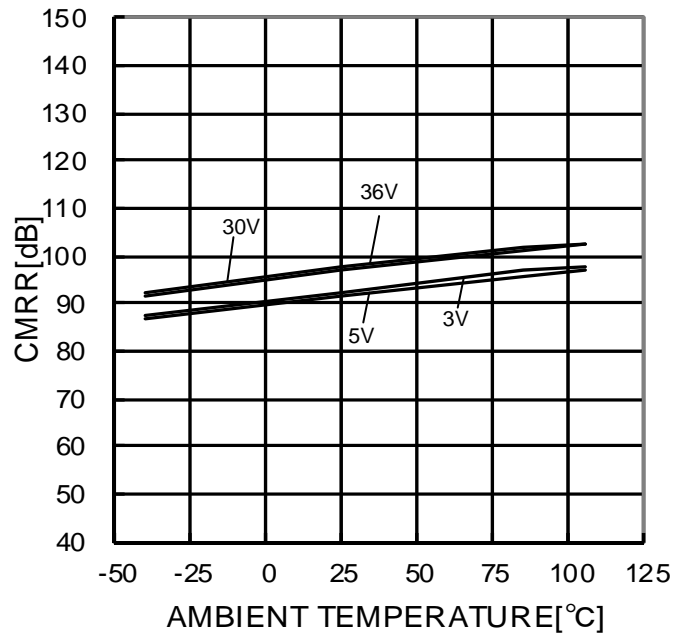


Figure 19.
Common Mode Rejection Ratio
- Ambient Temperature

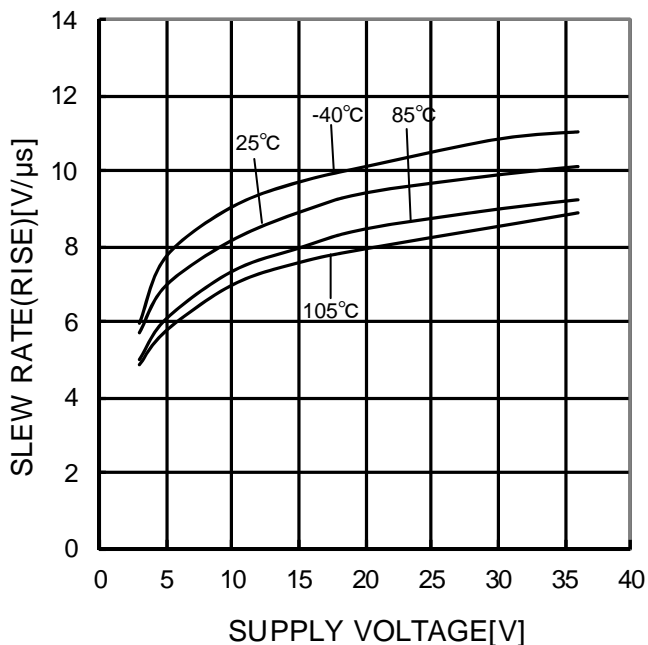


Figure 20.
Slew Rate L-H - Supply Voltage
(RL=10kΩ)

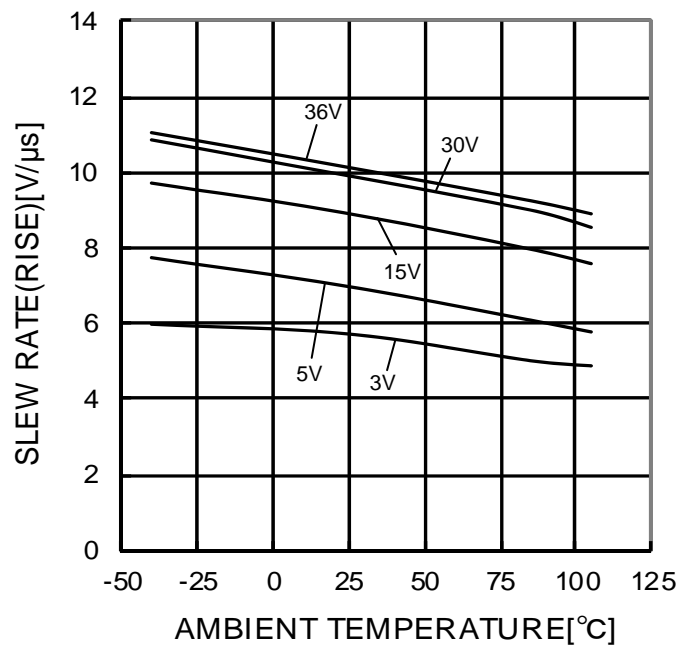


Figure 21.
Slew Rate L-H - Ambient Temperature
(RL=10kΩ)

(*) 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

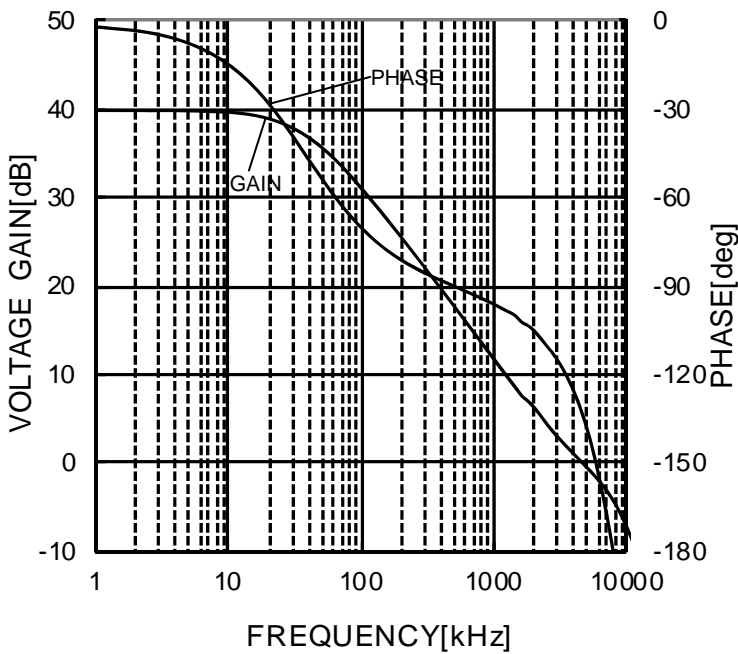


Figure 22.
Voltage Gain · Phase - Frequency
(VCC=7.5V/-7.5V, Av=40dB,
RL=2kΩ, CL=100pF, Ta=25°C)



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

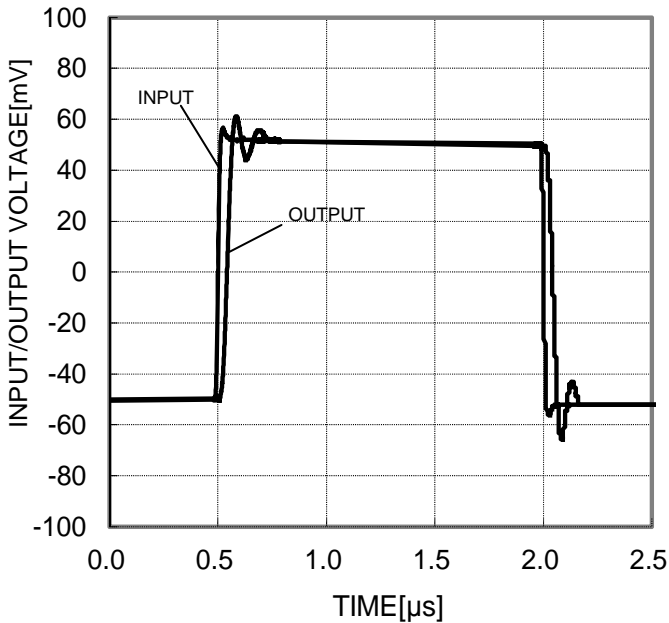


Figure 24.
Input / Output Voltage - Time
(VCC/VEE=15V/-15V, Av=0dB,
RL=2kΩ, CL=100pF, Ta=25°C)

(*) 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

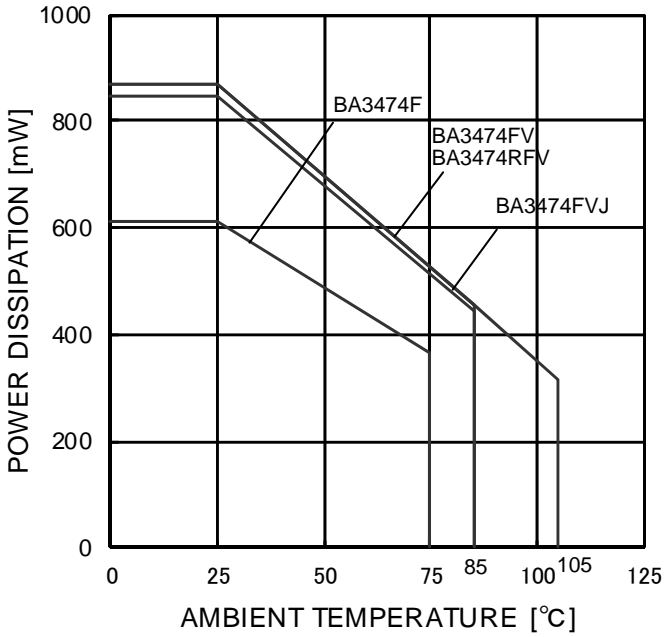


Figure 25.
Derating Curve



Figure 26.
Supply Current - Supply Voltage

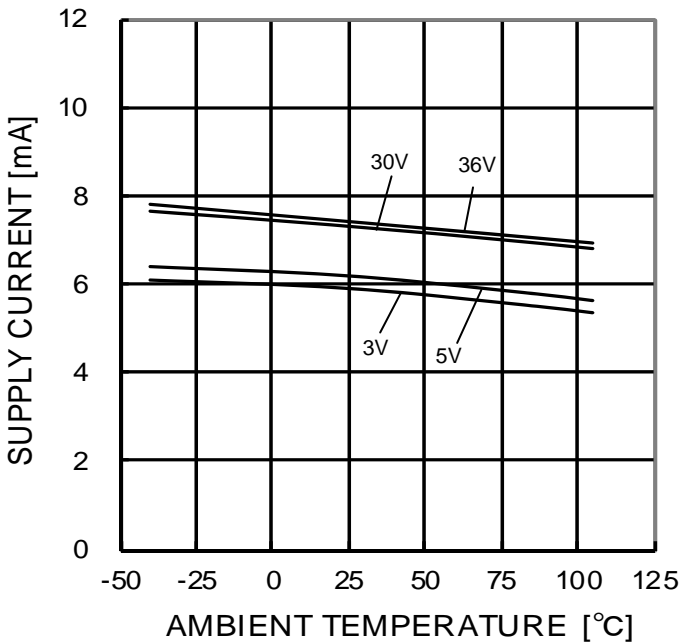


Figure 27.
Supply Current - Ambient Temperature



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

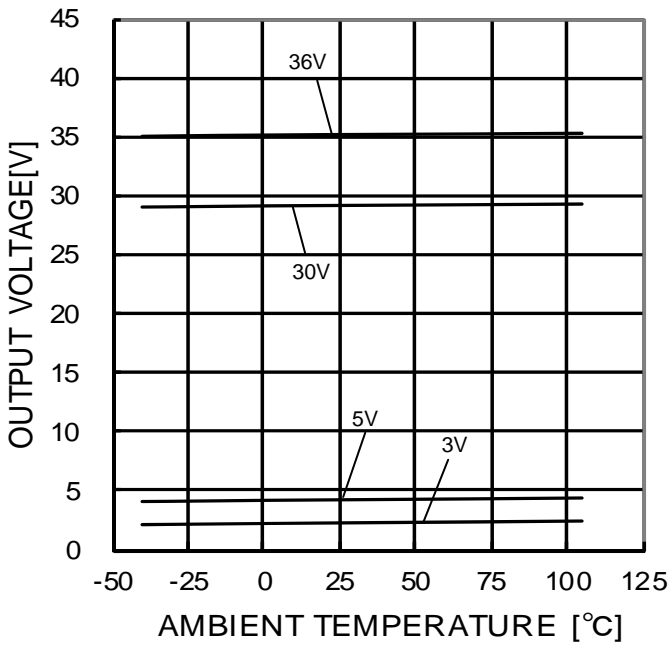


Figure 29.
High level Output Voltage
- Ambient Temperature
($R_L=10k\Omega$)

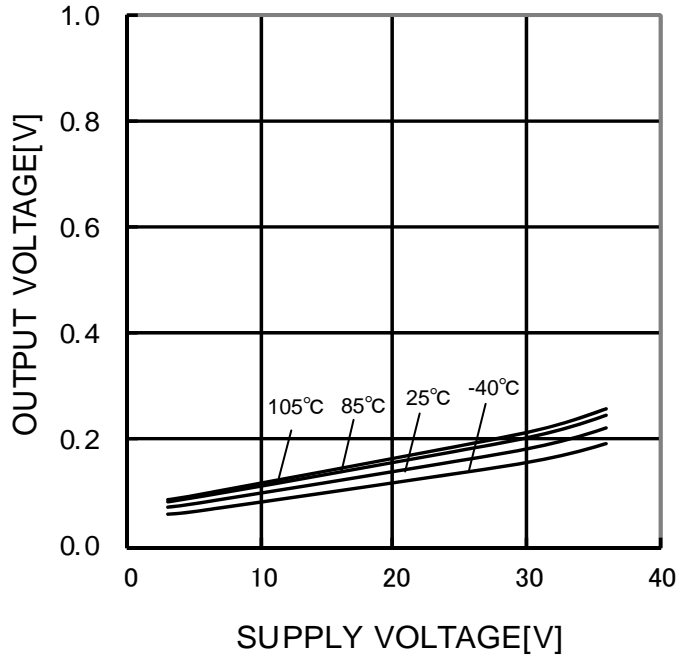


Figure 30.
Low level Output Voltage
- Supply Voltage
($R_L=10k\Omega$)

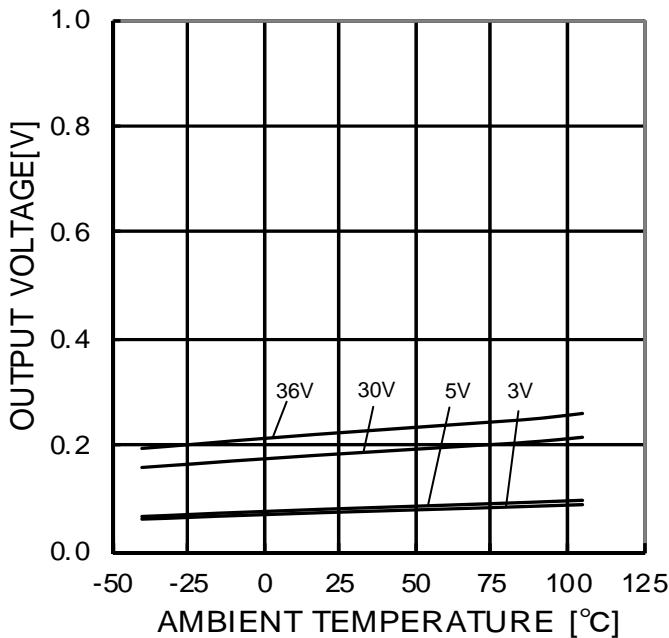


Figure 31.
Low level Output Voltage
- Ambient Temperature
($R_L=10k\Omega$)

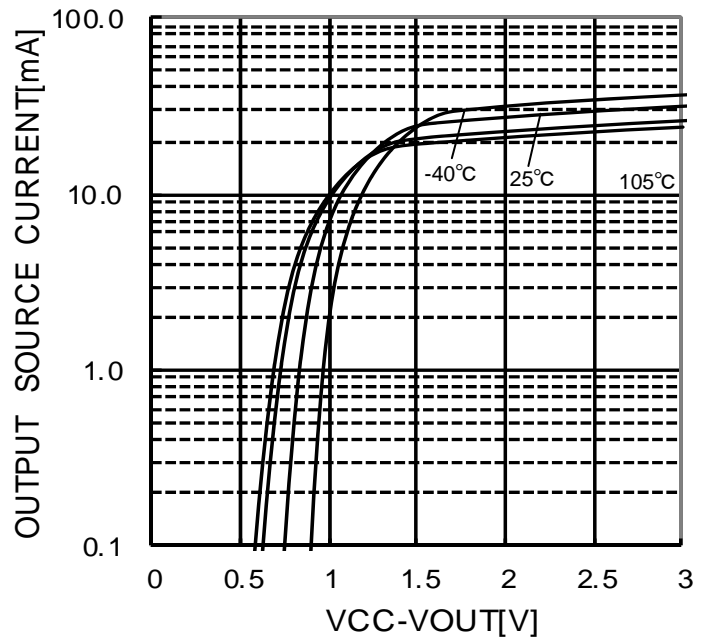


Figure 32.
Output Source Current - ($V_{CC}-V_{OUT}$)
($V_{CC}/V_{EE}=5V/0V$)

(*) 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)

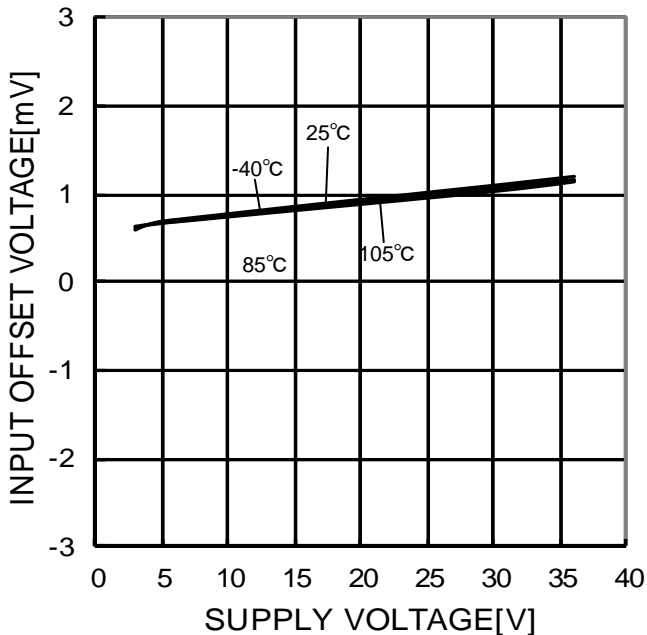


Figure 35.
Input Offset Voltage - Supply voltage

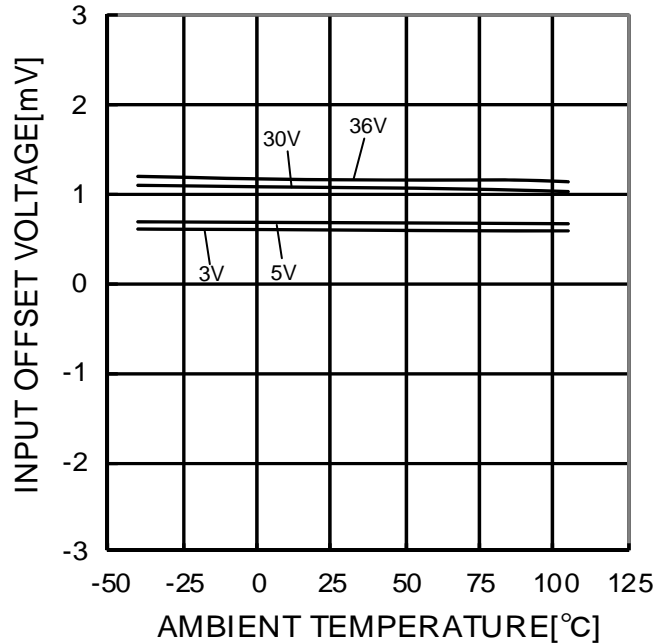


Figure 36.
Input Offset Voltage - Ambient Temperature

(*) 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

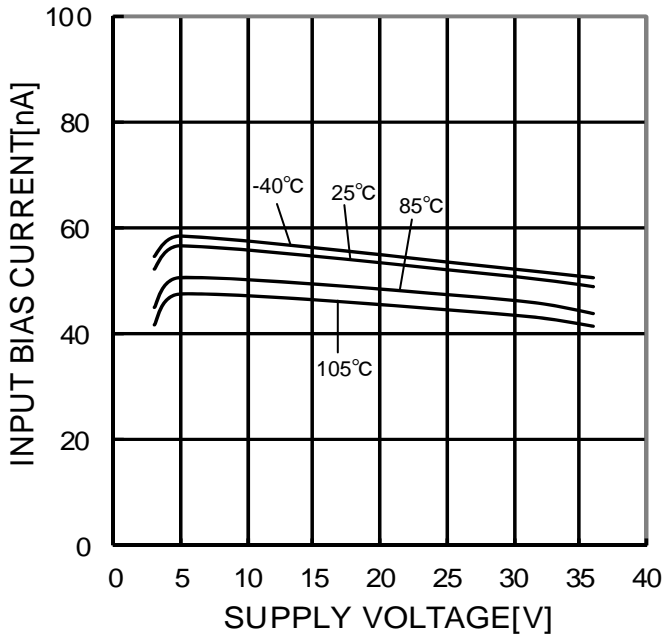


Figure 37.
Input Bias Current - Supply voltage



Figure 38.
Input Bias Current - Ambient Temperature



Figure 39.
Large Signal Voltage Gain
- Supply Voltage

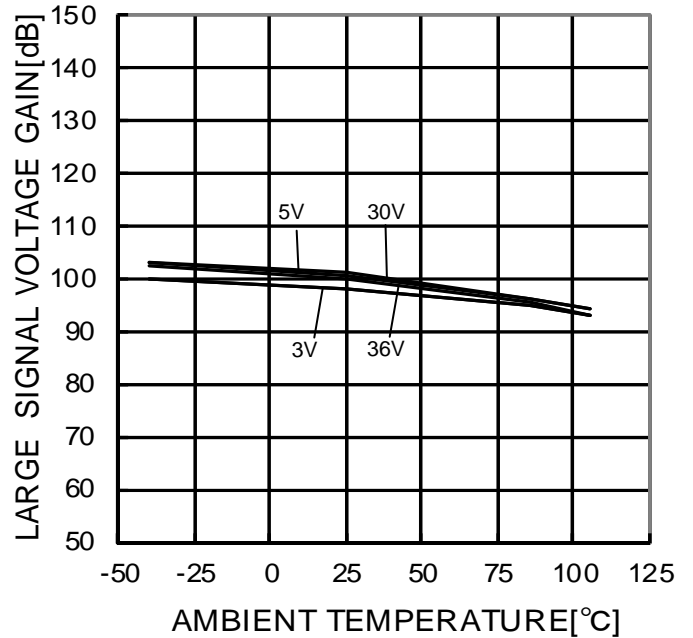


Figure 40.
Large Signal Voltage Gain
- Ambient Temperature

(*) 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

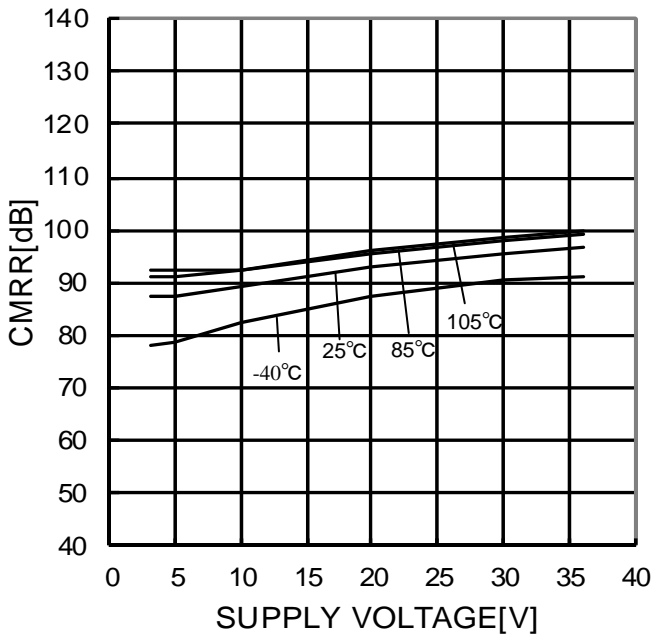


Figure 41.
Common Mode Rejection Ratio
- Supply Voltage

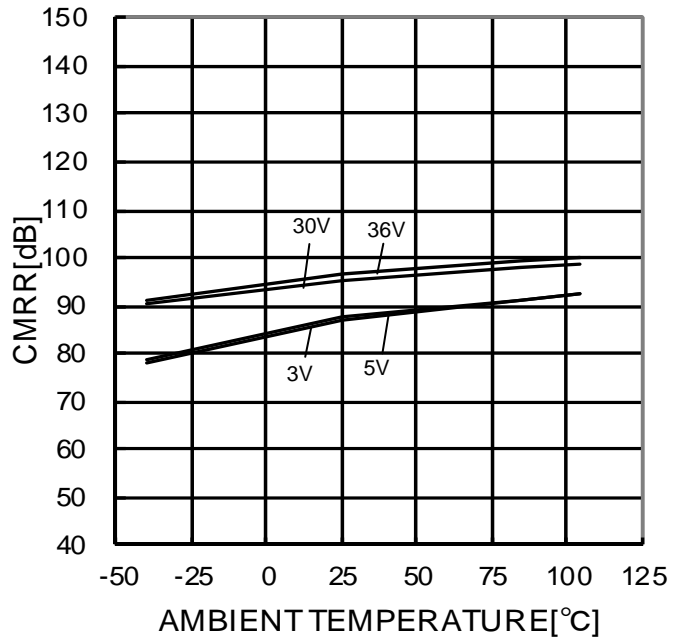


Figure 42.
Common Mode Rejection Ratio
- Ambient Temperature

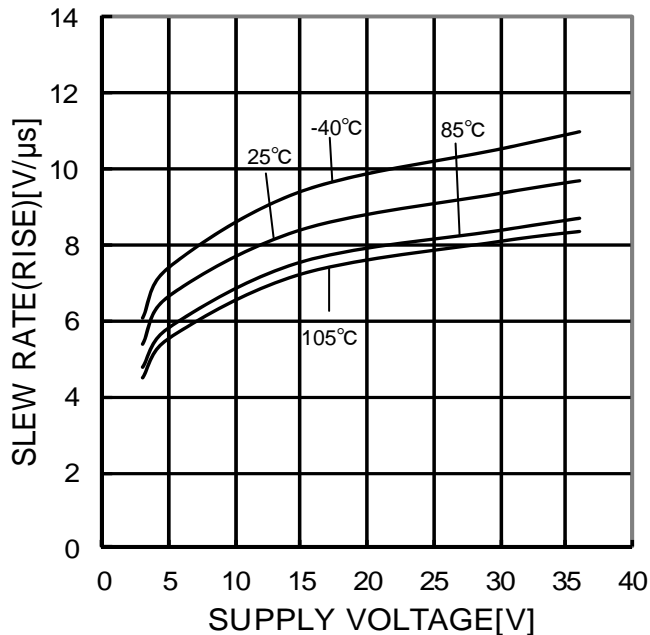


Figure 43.
Slew Rate L-H - Supply Voltage
(RL=10kΩ)

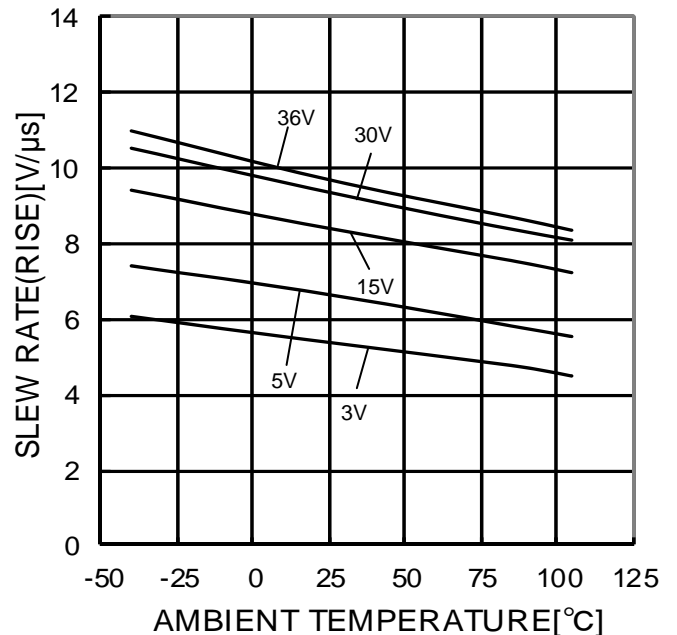


Figure 44.
Slew Rate L-H - Ambient Temperature
(RL=10kΩ)

(*) 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)

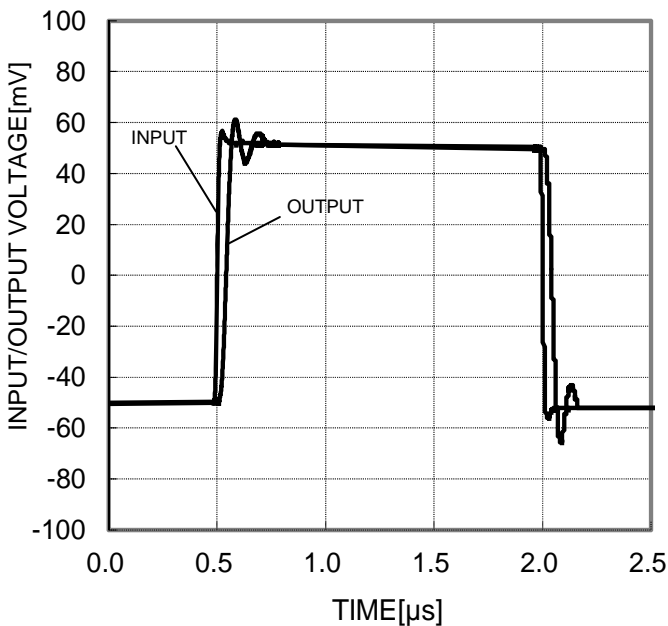


Figure 47.
Input / Output Voltage - Time
(VCC/VEE=15V/-15V, Av=0dB,
RL=2kΩ, CL=100pF, Ta=25°C)

(*) 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)

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

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)

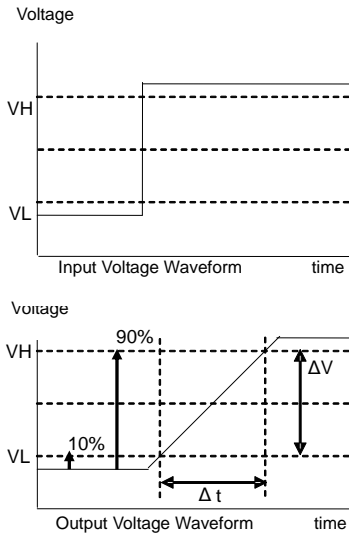


Figure 50. Slew rate input output wave

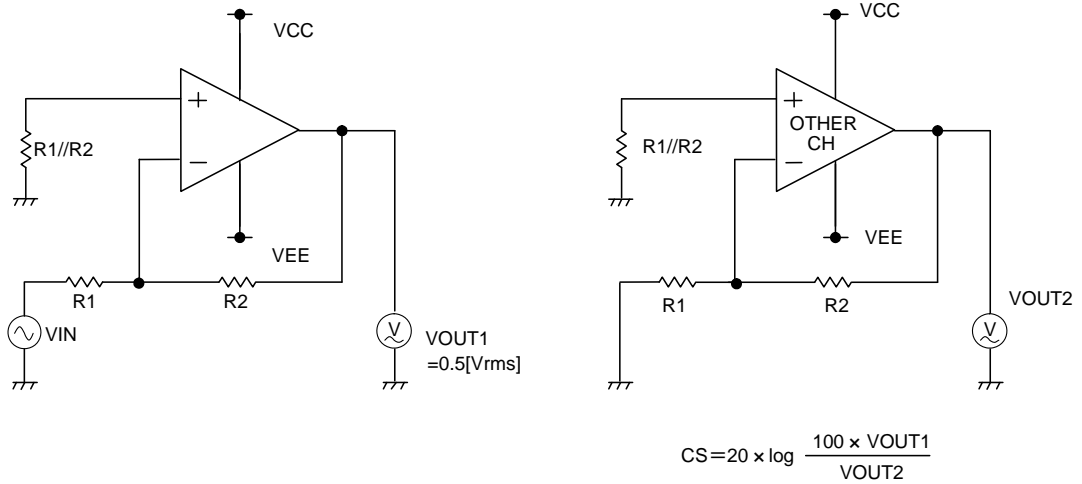


Figure 51. Test circuit 3 (Channel Separation)

● 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 θ_{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 θ_{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 θ_{ja} . Thermal resistance θ_{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.

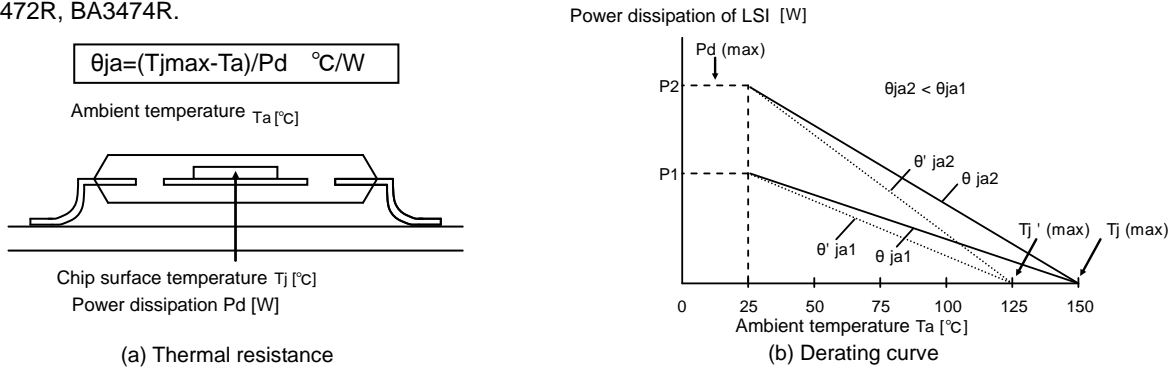
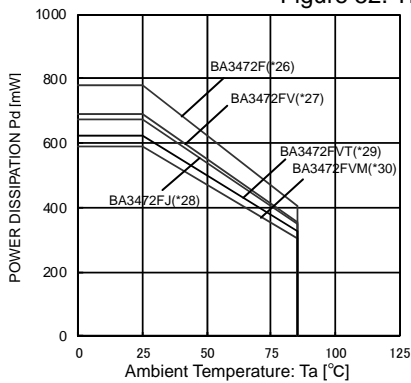
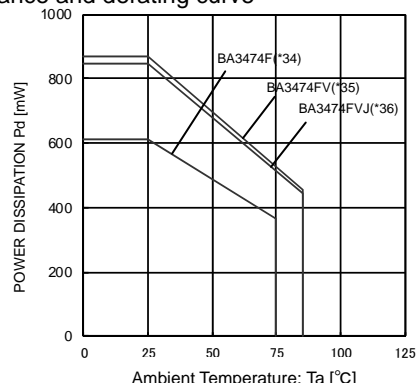


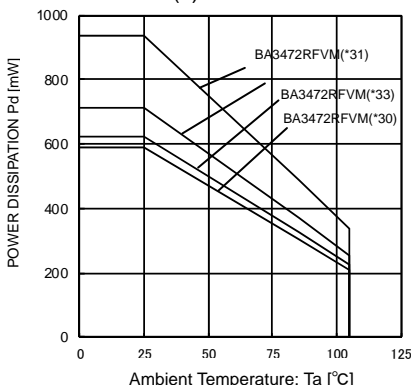
Figure 52. Thermal resistance and derating curve



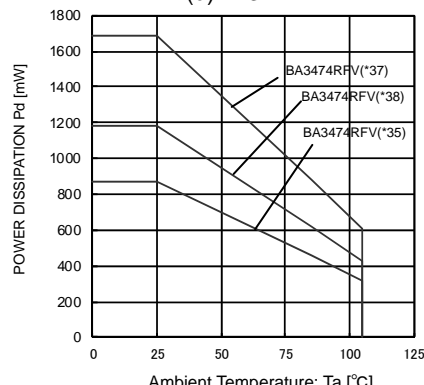
(c) BA3472



(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 Pd

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 μ F.

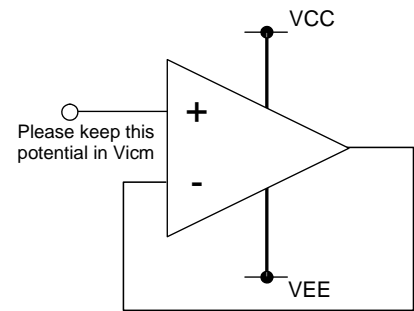


Figure 54. Unused circuit example

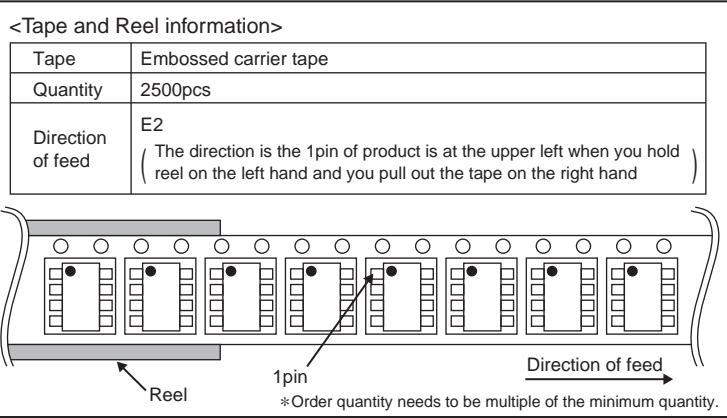
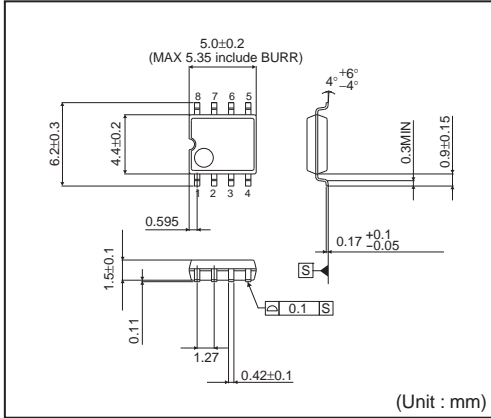
Status of this document

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.

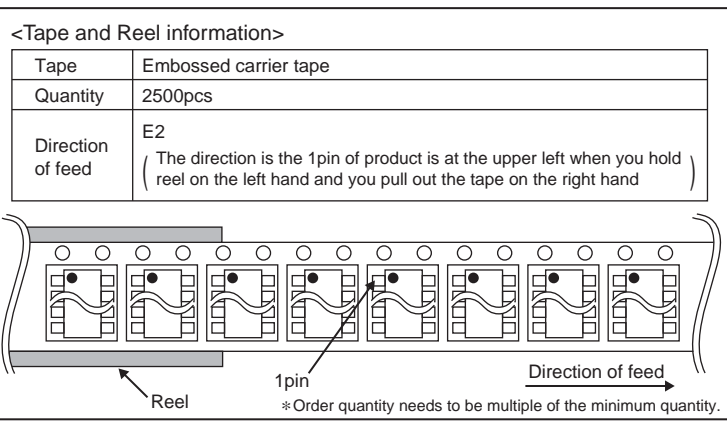
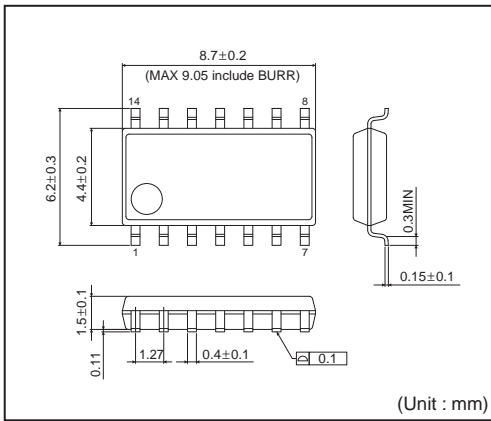
If there are any differences in translation version of this document formal version takes priority.

●Physical Dimensions Tape and Reel Information

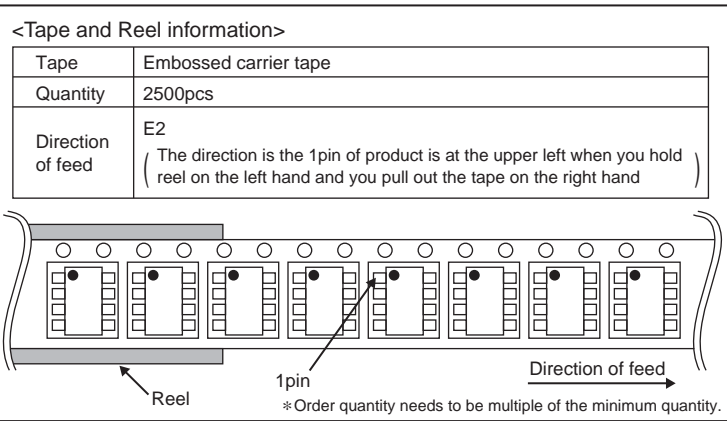
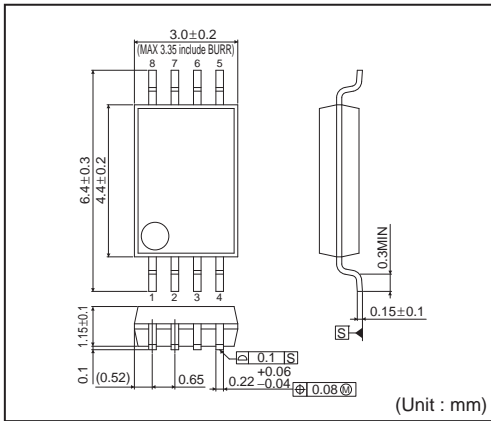
SOP8



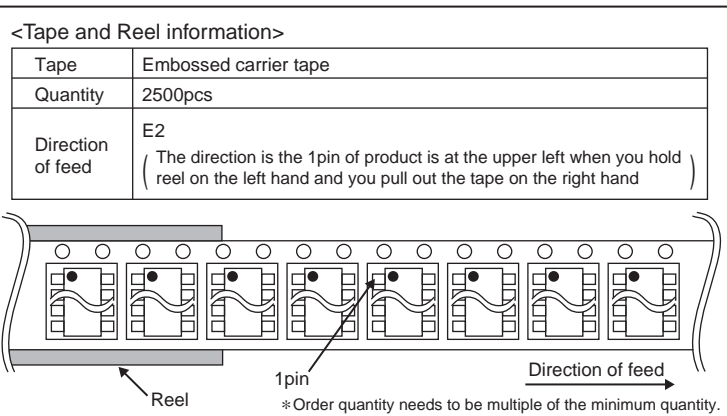
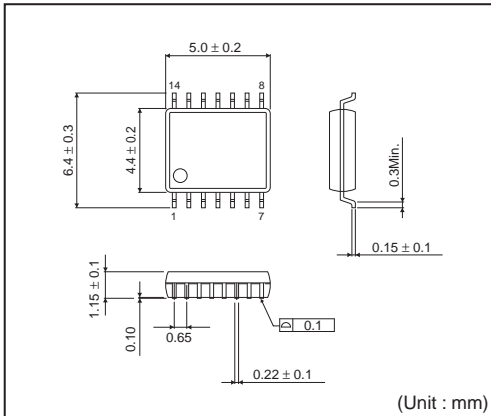
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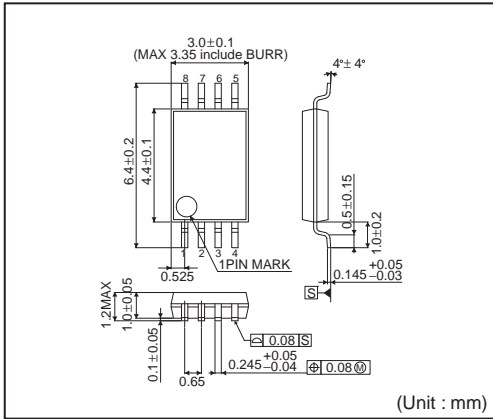
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SSOP-B14



TSSOP-B8

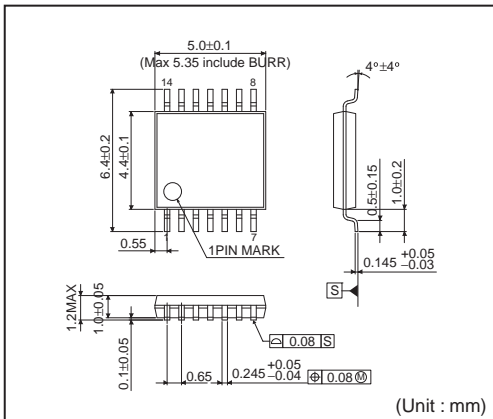


<Tape and Reel information>

| | |
|-------------------|---|
| Tape | Embossed carrier tape |
| Quantity | 3000pcs |
| Direction of feed | E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand) |

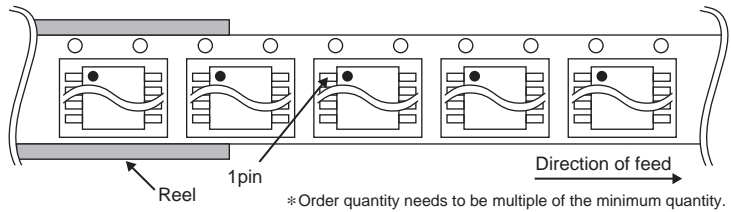


TSSOP-B14J

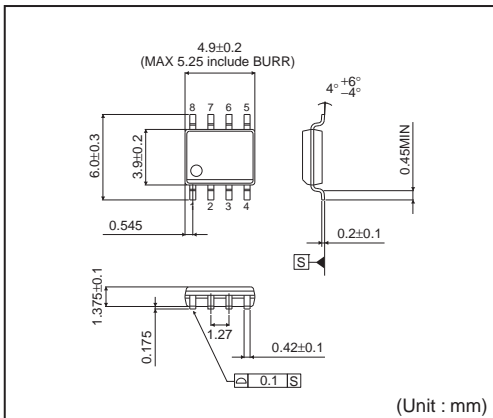


<Tape and Reel information>

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

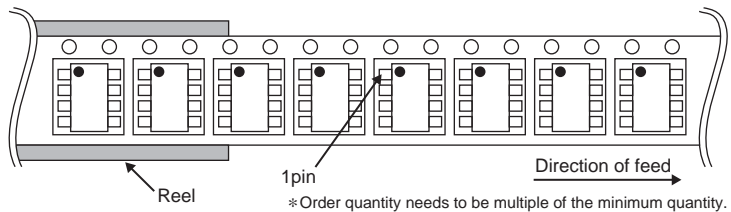


SOP-J8

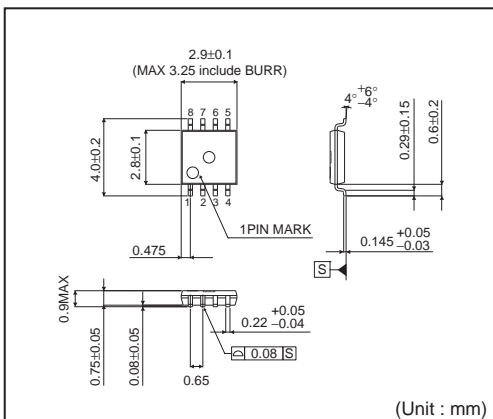


<Tape and Reel information>

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

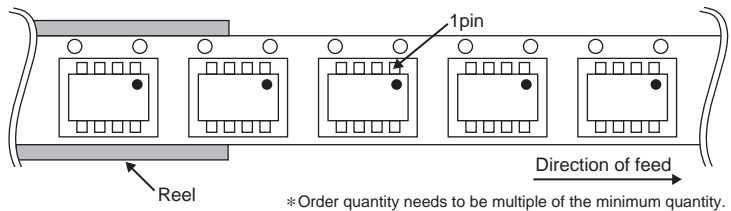


MSOP8

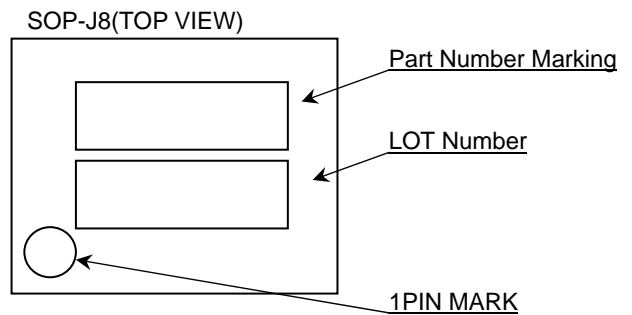
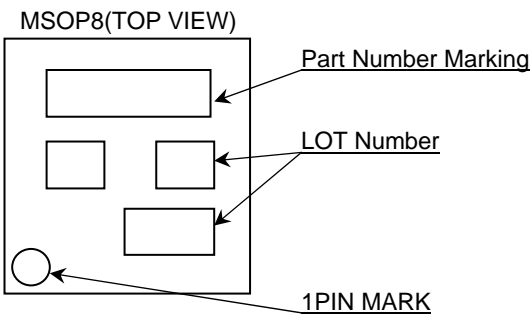
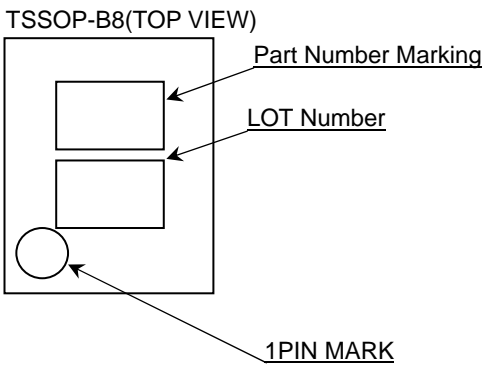
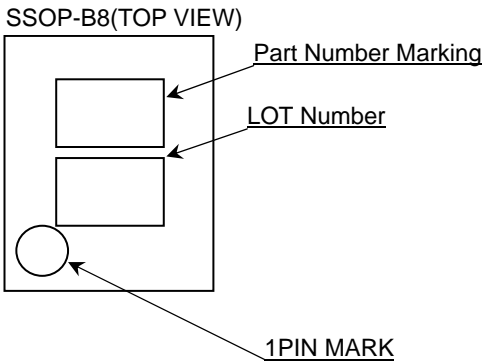
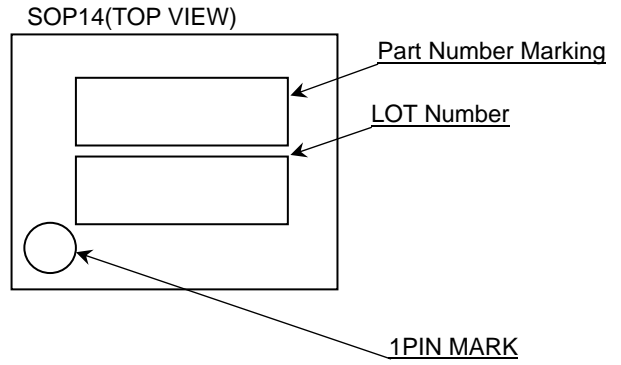
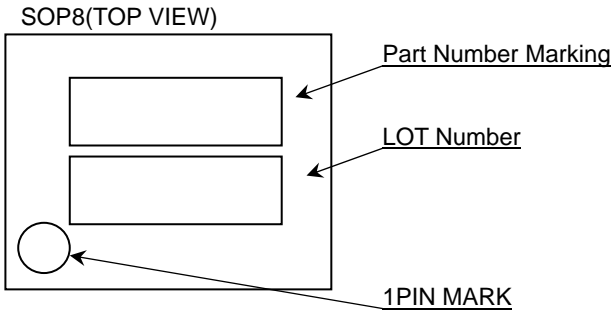


<Tape and Reel information>

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



●Marking Diagrams

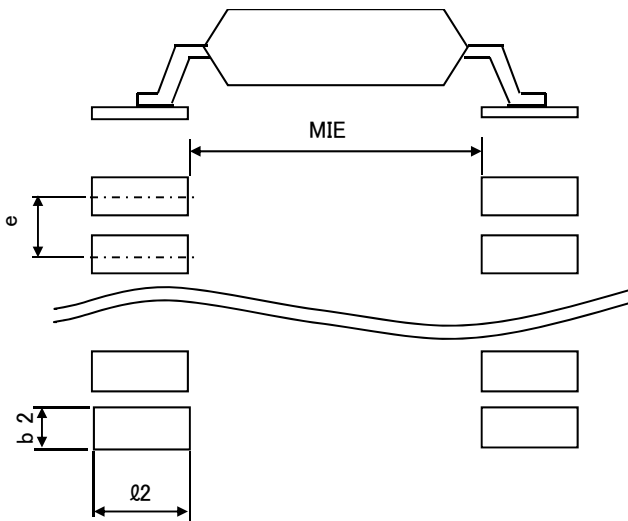


| Product Name | Package Type | Marking |
|--------------|--------------|------------|
| BA3472 | F | SOP8 |
| | FV | SSOP-B8 |
| | FVM | MSOP8 |
| | FJ | SOP-J8 |
| | FVT | TSSOP-B8 |
| BA3472R | FVM | MSOP8 |
| BA3474 | F | SOP14 |
| | FV | SSOP-B14 |
| | FVJ | TSSOP-B14J |
| BA3474R | FV | SSOP-B14 |

●Land pattern data

all dimensions in mm

| PKG | Land pitch e | Land space MIE | Land length $\geq \ell 2$ | Land width b2 |
|---------------------|-----------------|-------------------|------------------------------|------------------|
| SOP8 SOP14 | 1.27 | 4.60 | 1.10 | 0.76 |
| SOP-J8 | 1.27 | 3.90 | 1.35 | 0.76 |
| SSOP-B8 SSOP-B14 | 0.65 | 4.60 | 1.20 | 0.35 |
| MSOP8 | 0.65 | 2.62 | 0.99 | 0.35 |
| TSSOP-B8 | 0.65 | 4.60 | 1.20 | 0.35 |
| TSSOP-B14J | 0.65 | 4.60 | 1.20 | 0.35 |



●Revision History

| Date | Revision | Changes |
|-------------|----------|---|
| 27.Feb.2012 | 001 | New Release |
| 26.Oct.2012 | 002 | add BA3472FJ, BA3472FVT, BA3474FVJ add Land pattern data |

Notice

●General Precaution

- 1) Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.
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 - [a] Installation of protection circuits or other protective devices to improve system safety
 - [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure
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 - [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
 - [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
 - [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
 - [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
 - [f] Sealing or coating our Products with resin or other coating materials
 - [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
 - [h] Use of the Products in places subject to dew condensation
- 4) The Products are not subject to radiation-proof design.
- 5) Please verify and confirm characteristics of the final or mounted products in using the Products.
- 6) In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse) is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- 7) De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.
- 8) Confirm that operation temperature is within the specified range described in the product specification.
- 9) ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

●Precaution for Mounting / Circuit board design

- 1) When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- 2) In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

●Precautions Regarding Application Examples and External Circuits

- 1) If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
- 2) You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

●Precaution for Electrostatic

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

●Precaution for Storage / Transportation

- 1) Product performance and soldered connections may deteriorate if the Products are stored in the places where:
 - [a] the Products are exposed to sea winds or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - [b] the temperature or humidity exceeds those recommended by ROHM
 - [c] the Products are exposed to direct sunshine or condensation
 - [d] the Products are exposed to high Electrostatic
- 2) Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
- 3) Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
- 4) Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

●Precaution for Product Label

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

●Precaution for Disposition

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

●Precaution for Foreign Exchange and Foreign Trade act

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

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