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Datasheet

Operational Amplifier Series

Automotive Excellent EMI Characteristics Ground Sense Operational Amplifiers

BA82904Yxxx-C BA82902Yxxx-C

General Description

BA82904Yxxx-C and BA82902Yxxx-C are high-gain, ground sense input Op-Amps. These ICs are monolithic ICs integrated dual or quad independent Op-Amps on a single chip. These Op-Amps have some features of low power consumption, and can operate from 3V to 36V (single power supply). BA82904Yxxx-C and BA82902Yxxx-C are manufactured for automotive requirements of engine control unit, electric power steering, and so on.
Furthermore, they have the advantage of EMI tolerance dose. It is easy to replace with conventional products, and the EMI design is simple.

Features

- AEC-Q100 Qualified*(Note 1)*
- Single or Dual Power Supply Operation
- Wide Operating Supply Voltage Range
- Standard Op-Amp Pin-assignments
- Operable from Almost GND Level for Both Input and Output
- Low Supply Current
- High Open Loop Voltage Gain
- Internal ESD Protection Circuit
- Wide Operating Temperature Range
- Integrated EMI Filter

(Note 1) Grade 1

Applications

- Engine Control Unit
- Electric Power Steering (EPS)
- Anti-Lock Braking System (ABS)
- Automotive Electronics

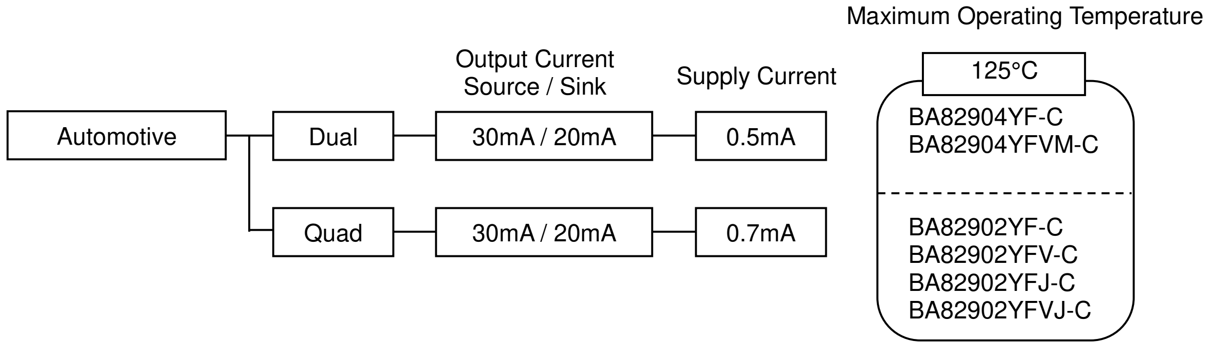
Key Specifications

- Operating Supply Voltage Range
  - Single Supply: 3V to 36V
  - Dual Supply: ±1.5V to ±18.0V
- Low Supply Current
  - BA82904Yxxx-C 0.5mA (Typ)
  - BA82902Yxxx-C 0.7mA (Typ)
- Input Bias Current: 20nA (Typ)
- Input Offset Current: 2nA (Typ)
- Operating Temperature Range: -40°C to +125°C

Packages

Packages	W(Typ) x D(Typ) x H(Max)
SOP8	5.00mm x 6.20mm x 1.71mm
SOP14	8.70mm x 6.20mm x 1.71mm
SSOP-B14	5.00mm x 6.40mm x 1.35mm
MSOP8	2.90mm x 4.00mm x 0.90mm
SOP-J14	8.65mm x 6.00mm x 1.65mm
TSSOP-B14J	5.00mm x 6.40mm x 1.20mm

Selection Guide



○Product structure : Silicon monolithic integrated circuit ○This product has no designed protection against radioactive rays

Equivalent Circuit

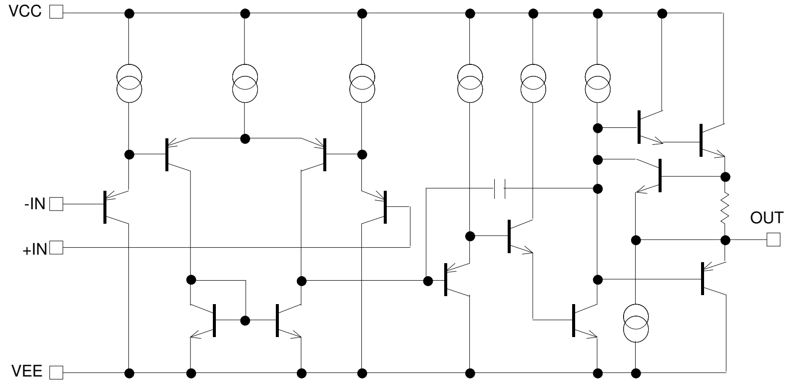
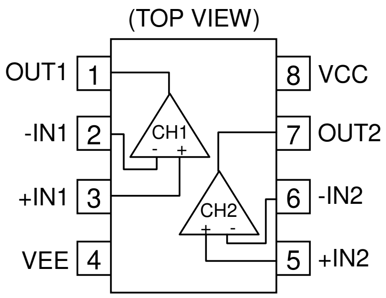


Figure 1. Equivalent Circuit (One Channel Only)

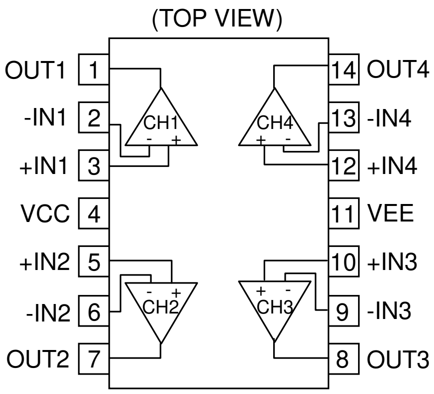
Pin Configuration

BA82904YF-C: SOP8
BA82904YFVM-C: MSOP8



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

BA82902YF-C: SOP14
BA82902YFV-C: SSOP-B14
BA82902YFJ-C: SOP-J14
BA82902YFVJ-C: TSSOP-B14J



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

Absolute Maximum Ratings (Ta = 25°C)

Parameter	Symbol	Rating	Unit
Supply Voltage	V_{CC}-V_{EE}	36	V
Differential Input Voltage(Note 1)	V_{ID}	36	V
Input Common-mode Voltage Range	V_{ICM}	(V_{EE}-0.3) to (V_{EE}+36)	V
Input Current	I_I	-10	mA
Storage Temperature Range	Tstg	-55 to +150	°C
Maximum Junction Temperature	Tjmax	150	°C

Caution 1: *Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.*

Caution 2: *Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design PCB boards with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

(Note 1) The voltage difference between inverting input and non-inverting input is the differential input voltage. Then the input pin voltage is set to V_{EE} or more.

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating Supply Voltage	Vopr	3 (±1.5)	5 (±2.5)	36 (±18)	V
Operating Temperature	Topr	-40	+25	+125	°C

Thermal Resistance*(Note 1)*

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s*(Note 3)*	2s2p*(Note 4)*	
MSOP8				
Junction to Ambient	θ_{JA}	284.1	135.4	°C/W
Junction to Top Characterization Parameter*(Note 2)*	Ψ_{JT}	21	11	°C/W
SOP8				
Junction to Ambient	θ_{JA}	197.4	109.8	°C/W
Junction to Top Characterization Parameter*(Note 2)*	Ψ_{JT}	21	19	°C/W
SOP14				
Junction to Ambient	θ_{JA}	166.5	108.1	°C/W
Junction to Top Characterization Parameter*(Note 2)*	Ψ_{JT}	26	22	°C/W
SSOP-B14				
Junction to Ambient	θ_{JA}	159.6	92.8	°C/W
Junction to Top Characterization Parameter*(Note 2)*	Ψ_{JT}	13	9	°C/W
SOP-J14				
Junction to Ambient	θ_{JA}	118.5	67.2	°C/W
Junction to Top Characterization Parameter*(Note 2)*	Ψ_{JT}	10	10	°C/W
TSSOP-B14J				
Junction to Ambient	θ_{JA}	185.4	98.4	°C/W
Junction to Top Characterization Parameter*(Note 2)*	Ψ_{JT}	16	14	°C/W

(Note 1) Based on JESD51-2A(Still-Air).
(Note 2) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.
(Note 3) Using a PCB board based on JESD51-3.
(Note 4) Using a PCB board based on JESD51-7.

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3mm x 76.2mm x 1.57mmt

Top	
Copper Pattern	Thickness
Footprints and Traces	70μm

Layer Number of Measurement Board	Material	Board Size
4 Layers	FR-4	114.3mm x 76.2mm x 1.6mmt

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70μm	74.2mm x 74.2mm	35μm	74.2mm x 74.2mm	70μm

Electrical Characteristics

○BA82904Yxxx-C (Unless otherwise specified V_{CC}=5V, V_{EE}=0V)

Parameter	Symbol	Temperature Range	Limits			Unit	Conditions
			Min	Typ	Max		
Input Offset Voltage(Note 1)	V_{IO}	25°C	-	2	6	mV	V_{OUT}=1.4V
		Full range	-	-	9		V_{CC}=5V to 30V, V_{OUT}=1.4V
Input Offset Current(Note 1)	I_{IO}	25°C	-	2	40	nA	V_{OUT}=1.4V
		Full range	-	-	50		
Input Bias Current(Note 1)	I_B	25°C	-	20	60	nA	V_{OUT}=1.4V
		Full range	-	-	100		
Supply Current	I_{CC}	25°C	-	0.5	1.2	mA	R_L=∞, All Op-Amps
		Full range	-	-	1.2		
Maximum Output Voltage (High)	V_{OH}	25°C	3.5	-	-	V	R_L=2kΩ
		Full range	3.2	-	-		
			27	28	-		V_{CC}=30V, R_L=10kΩ
Maximum Output Voltage(Low)	V_{OL}	Full range	-	5	20	mV	R_L=∞, All Op-Amps
Large Signal Voltage Gain	A_V	25°C	25	100	-	dB	R_L≥2kΩ, V_{CC}=15V V_{OUT}=1.4V to 11.4V
		Full range	25	-	-		
Input Common-mode Voltage Range	V_{ICM}	25°C	0	-	V_{CC}-1.5	V	(V_{CC}-V_{EE})=5V V_{OUT}=V_{EE}+1.4V
		Full range	0	-	V_{CC}-2.0		
Common-mode Rejection Ratio	CMRR	Full range	70	80	-	dB	V_{OUT}=1.4V
Power Supply Rejection Ratio	PSRR	Full range	70	100	-	dB	V_{CC}=5V to 30V
Output Source Current(Note 2)	I_{SOURCE}	25°C	20	30	-	mA	V_{+IN}=1V, V_{-IN}=0V V_{OUT}=0V 1CH is short circuit
		Full range	10	-	-		
Output Sink Current(Note 2)	I_{SINK}	25°C	10	20	-	mA	V_{+IN}=0V, V_{-IN}=1V V_{OUT}=5V 1CH is short circuit
		Full range	2	-	-		
		25°C	12	40	-	μA	V_{+IN}=0V, V_{-IN}=1V V_{OUT}=200mV
Slew Rate	SR	25°C	-	0.2	-	V/μs	V_{CC}=15V, A_V=0dB R_L=2kΩ, C_L=100pF
Gain Bandwidth Product	GBW	25°C	-	0.5	-	MHz	V_{CC}=30V, R_L=2kΩ C_L=100pF
Channel Separation	CS	25°C	-	120	-	dB	f=1kHz, input referred

(Note 1) Absolute value

(Note 2) Under high temperatures, it is important to consider the Tjmax and Thermal Resistance when selecting the output current.
When the output pin is continuously shorted, the output current may reduce because of the internal temperature rise by heating.

Electrical Characteristics - continued

○BA82902Yxxx-C (Unless otherwise specified V_{CC}=5V, V_{EE}=0V)

Parameter	Symbol	Temperature Range	Limits Min	Limits Typ	Limits Max	Unit	Conditions
Input Offset Voltage(Note 1)	V_{IO}	25°C	-	2	6	mV	V_{OUT}=1.4V
		Full range	-	-	9		V_{CC}=5V to 30V, V_{OUT}=1.4V
Input Offset Current(Note 1)	I_{IO}	25°C	-	2	40	nA	V_{OUT}=1.4V
		Full range	-	-	50		
Input Bias Current(Note 1)	I_B	25°C	-	20	60	nA	V_{OUT}=1.4V
		Full range	-	-	100		
Supply Current	I_{CC}	25°C	-	0.7	2	mA	R_L=∞, All Op-Amps
		Full range	-	-	3		
Maximum Output Voltage (High)	V_{OH}	25°C	3.5	-	-	V	R_L=2kΩ
		Full range	3.2	-	-		
			27	28	-		V_{CC}=30V, R_L=10kΩ
Maximum Output Voltage(Low)	V_{OL}	Full range	-	5	20	mV	R_L=∞, All Op-Amps
Large Signal Voltage Gain	A_V	25°C	25	100	-	dB	R_L≥2kΩ, V_{CC}=15V V_{OUT}=1.4V to 11.4V
		Full range	25	-	-		
Input Common-mode Voltage Range	V_{ICM}	25°C	0	-	V_{CC}-1.5	V	(V_{CC}-V_{EE})=5V V_{OUT}=V_{EE}+1.4V
		Full range	0	-	V_{CC}-2.0		
Common-mode Rejection Ratio	CMRR	Full range	70	80	-	dB	V_{OUT}=1.4V
Power Supply Rejection Ratio	PSRR	Full range	70	100	-	dB	V_{CC}=5V to 30V
Output Source Current(Note 2)	I_{SOURCE}	25°C	20	30	-	mA	V_{+IN}=1V, V_{-IN}=0V V_{OUT}=0V 1CH is short circuit
		Full range	10	-	-		
Output Sink Current(Note 2)	I_{SINK}	25°C	10	20	-	mA	V_{+IN}=0V, V_{-IN}=1V V_{OUT}=5V 1CH is short circuit
		Full range	2	-	-		
		25°C	12	40	-	μA	V_{+IN}=0V, V_{-IN}=1V V_{OUT}=200mV
Slew Rate	SR	25°C	-	0.2	-	V/μs	V_{CC}=15V, Av=0dB R_L=2kΩ, C_L=100pF
Gain Bandwidth Product	GBW	25°C	-	0.5	-	MHz	V_{CC}=30V, R_L=2kΩ C_L=100pF
Channel Separation	CS	25°C	-	120	-	dB	f=1kHz, input referred

(Note 1) Absolute value

(Note 2) Under high temperatures, it is important to consider the Tjmax and Thermal Resistance when selecting the output current.
When the output pin is continuously shorted, the output current may reduce because of the internal temperature rise by heating.

Description of Electrical Characteristics

Described below are descriptions of the relevant electrical terms used in this datasheet. Items and symbols used are also shown. Note that item name and symbol and their meaning may differ from those on another manufacturer's or general document.

1. Absolute Maximum Ratings

Absolute maximum rating items indicate the condition which must not be exceeded even momentarily. Applying of voltage in excess of absolute maximum rating or use at outside the temperature range which is provided in the absolute maximum ratings may cause deteriorating the characteristics of the IC or destroying it.

1.1 Supply Voltage (V_{CC}-V_{EE})
Indicates the maximum voltage that can be applied between the positive power supply pin and negative power supply pin without deteriorating the characteristics of internal circuit or destroying the IC.

1.2 Differential Input Voltage (V_{ID})
Indicates the maximum voltage that can be applied between non-inverting pin and inverting pin without deteriorating the characteristics of the IC or without destroying it.

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

1.4 Storage Temperature Range (Tstg)
The storage temperature range denotes the range of temperatures the IC can be stored without causing excessive deteriorating the characteristics of the IC.

2. Electrical Characteristics

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

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

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

2.4 Supply Current (I_{CC})
Indicates the current that flows within the IC under no-load conditions.

2.5 Maximum Output Voltage (High) / Maximum Output Voltage (Low) (V_{OH}/V_{OL})
Indicates the voltage range of the output under specified load condition. It is typically divided into maximum output voltage High and maximum output voltage Low. Maximum output voltage (High) indicates the upper limit of output voltage while maximum output voltage (Low) indicates the lower limit.

2.6 Large Signal Voltage Gain (A_V)
Indicates the amplifying rate (gain) of output voltage regarding the voltage difference between non-inverting pin and inverting pin. It is normally the amplifying rate (gain) with reference to DC voltage.

A_V = (Output Voltage) / (Differential Input Voltage)

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

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

CMRR = (Change of Input Common-mode Voltage) / (Input Offset Voltage 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 Voltage Fluctuation)

Description of Electrical Characteristics - continued

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

2.11 Slew Rate (SR)
This parameter indicates the operation speed of the Op-Amps. Indicates the rate at which the output voltage can change per specified unit time.

2.12 Gain Bandwidth Product (GBW)
This indicates the product of an arbitrary frequency and its gain in the range of the gain slope of 6 dB/octave.

2.13 Channel Separation (CS)
Indicates the fluctuation in the output voltage of the other channel regarding the change of output voltage of the channel which is driven.

Typical Performance Curves

○BA82904Yxxx-C

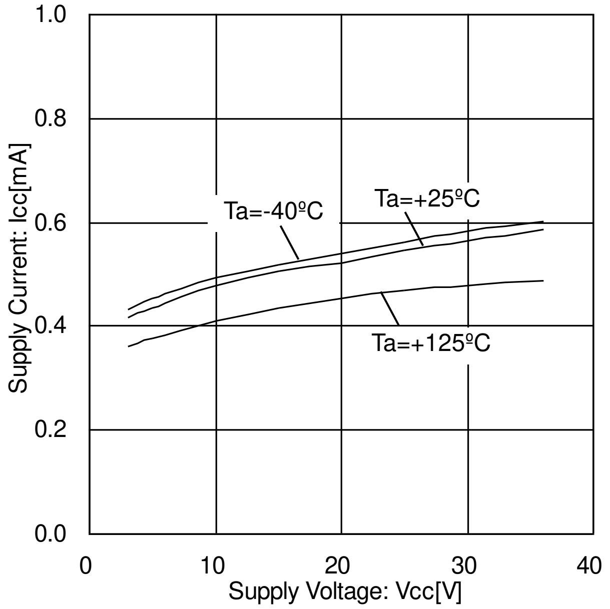


Figure 2. Supply Current vs Supply Voltage

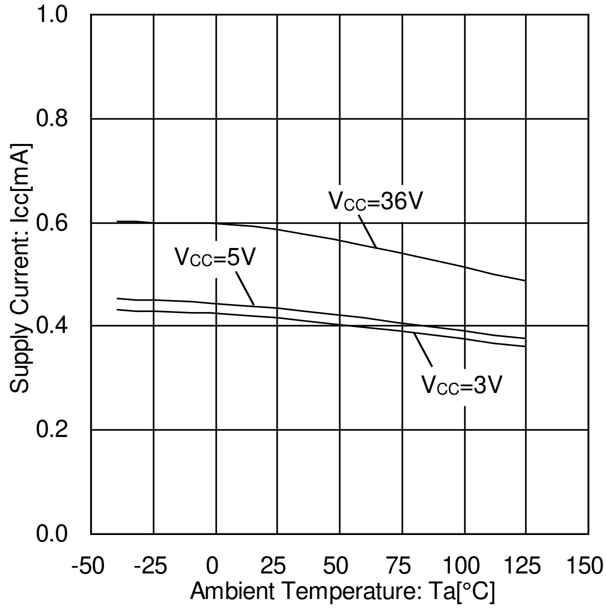


Figure 3. Supply Current vs Ambient Temperature

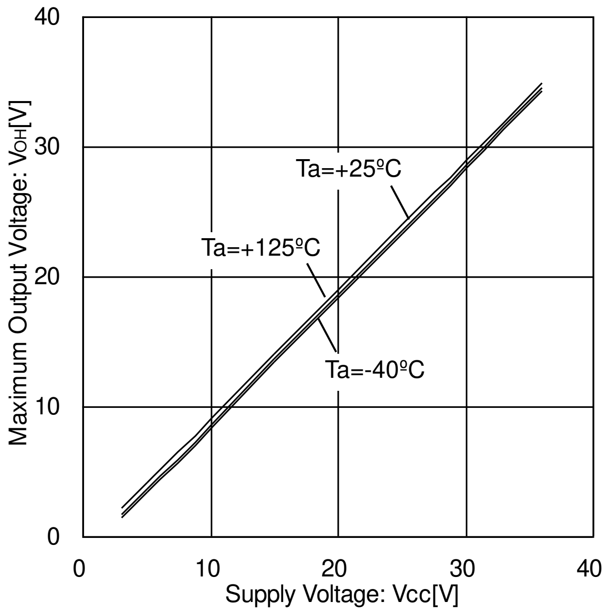


Figure 4. Maximum Output Voltage vs Supply Voltage (R_L=10kΩ)

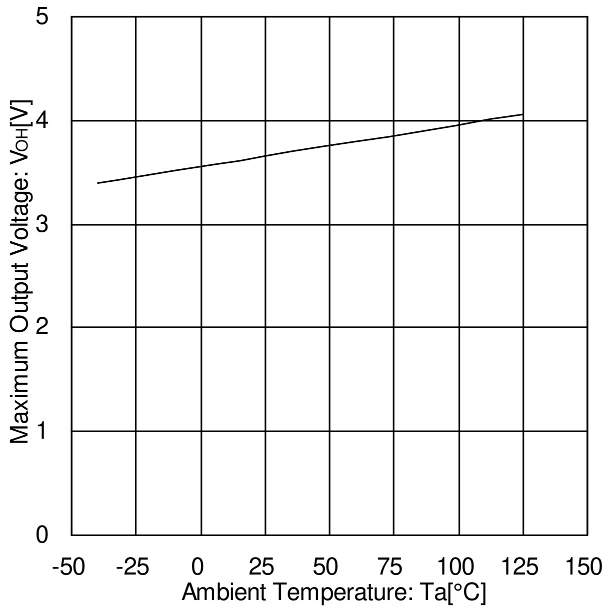


Figure 5. Maximum Output Voltage vs Ambient Temperature (V_{CC}=5V, R_L=2kΩ)

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

Typical Performance Curves - continued

○BA82904Yxxx-C

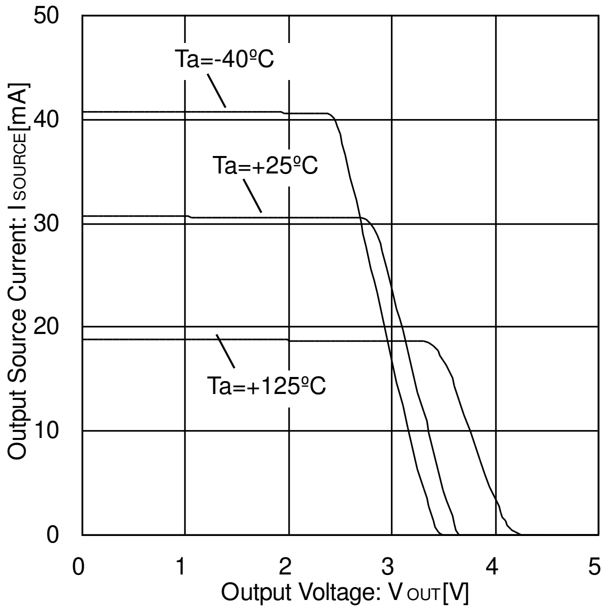


Figure 6. Output Source Current vs Output Voltage (V_{CC}=5V)

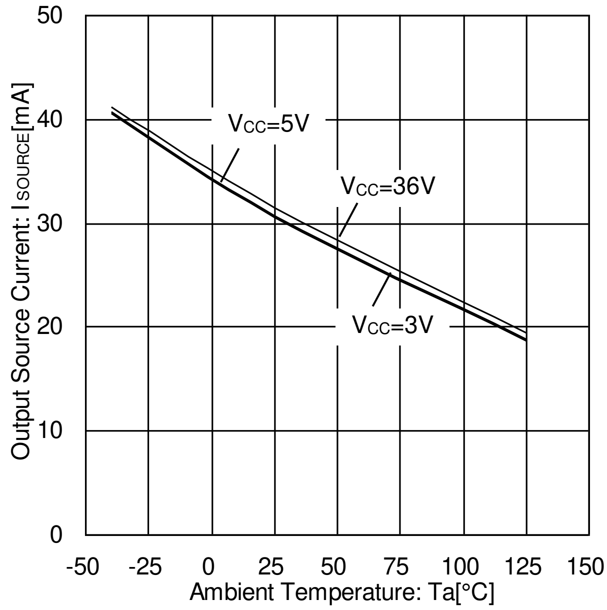


Figure 7. Output Source Current vs Ambient Temperature (V_{OUT}=0V)

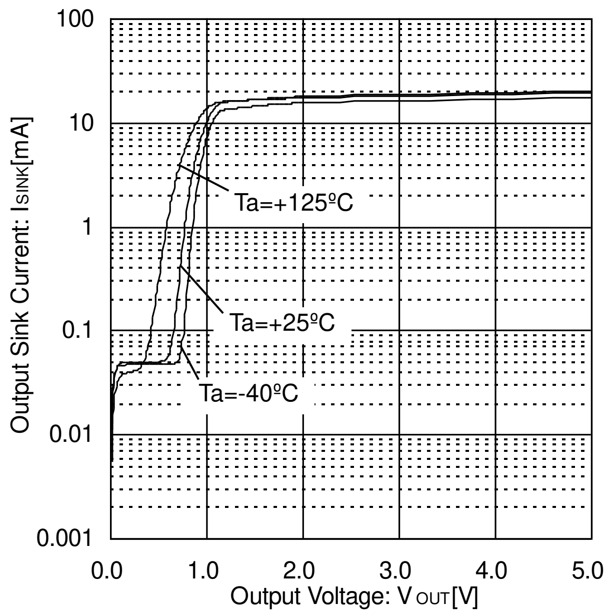


Figure 8. Output Sink Current vs Output Voltage (V_{CC}=5V)

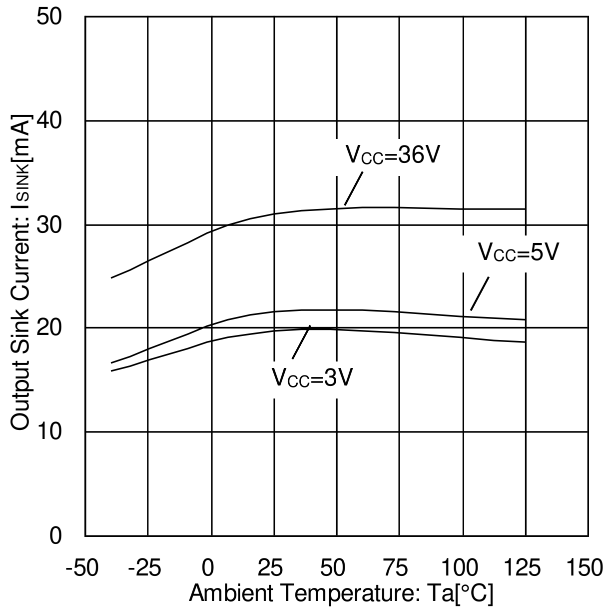


Figure 9. Output Sink Current vs Ambient Temperature (V_{OUT}=V_{CC})

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

Typical Performance Curves - continued

○BA82904Yxxx-C

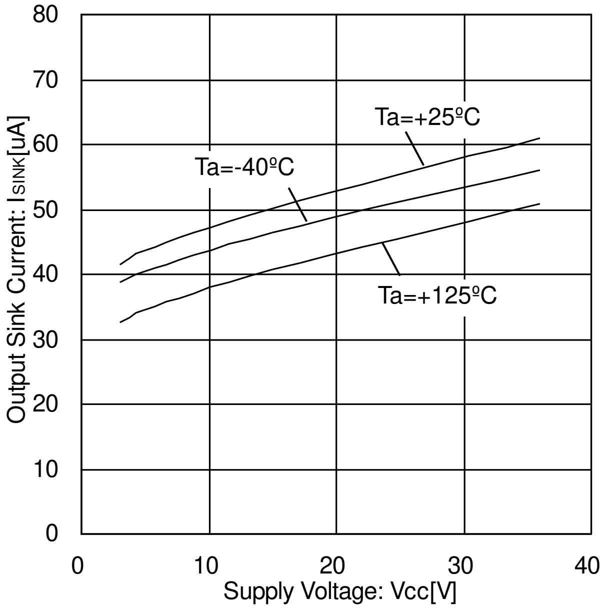


Figure 10. Output Sink Current vs Supply Voltage
(V_{OUT}=0.2V)

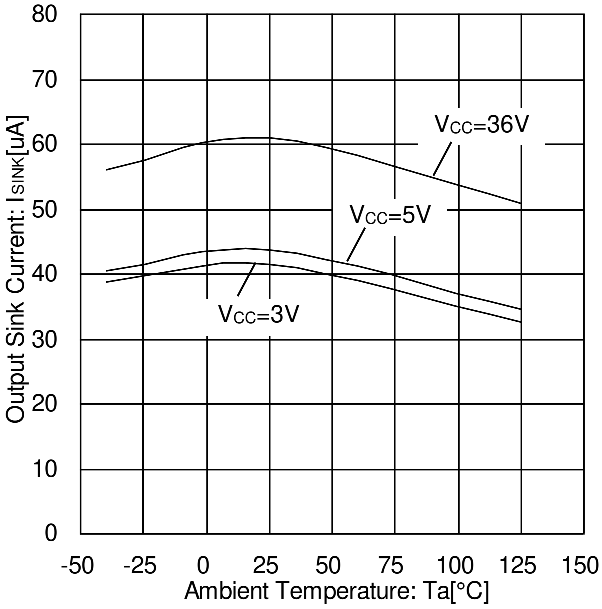


Figure 11. Output Sink Current vs Ambient Temperature
(V_{OUT}=0.2V)

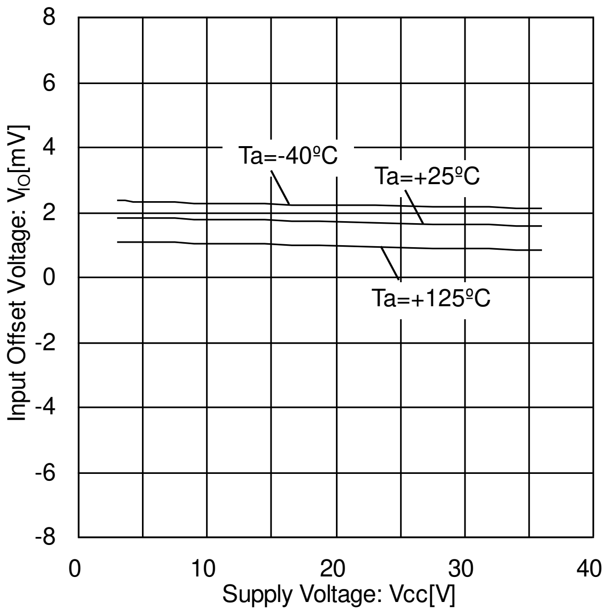


Figure 12. Input Offset Voltage vs Supply Voltage
(V_{ICM}=0V, V_{OUT}=1.4V)

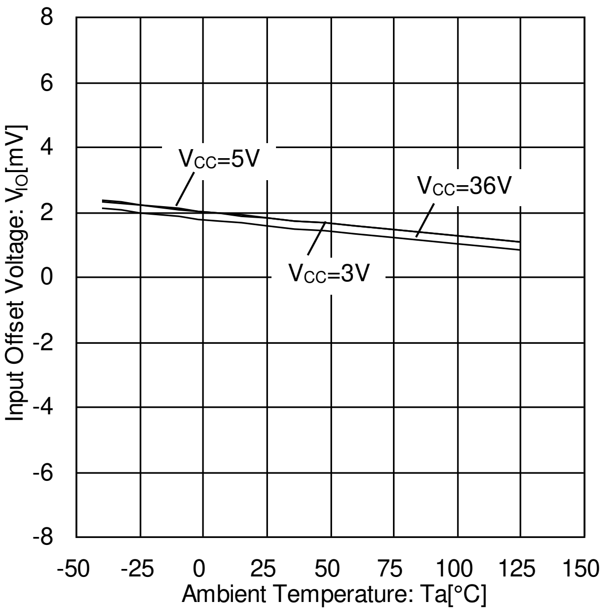


Figure 13. Input Offset Voltage vs Ambient Temperature
(V_{ICM}=0V, V_{OUT}=1.4V)

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

Typical Performance Curves - continued

○BA82904Yxxx-C

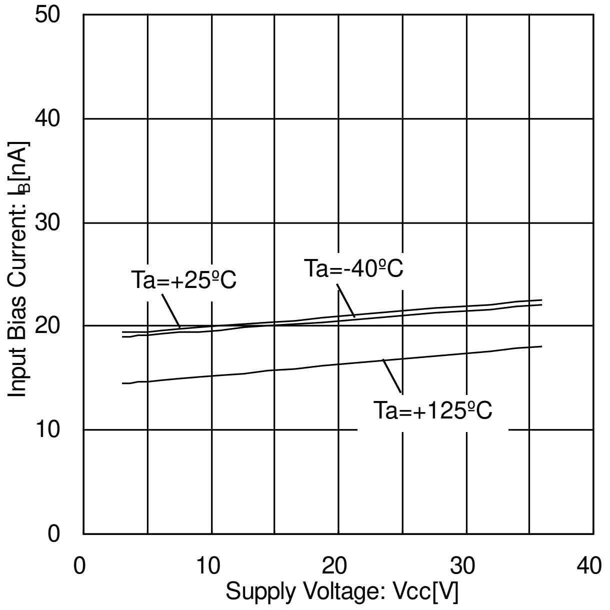


Figure 14. Input Bias Current vs Supply Voltage
(V_{ICM}=0V, V_{OUT}=1.4V)

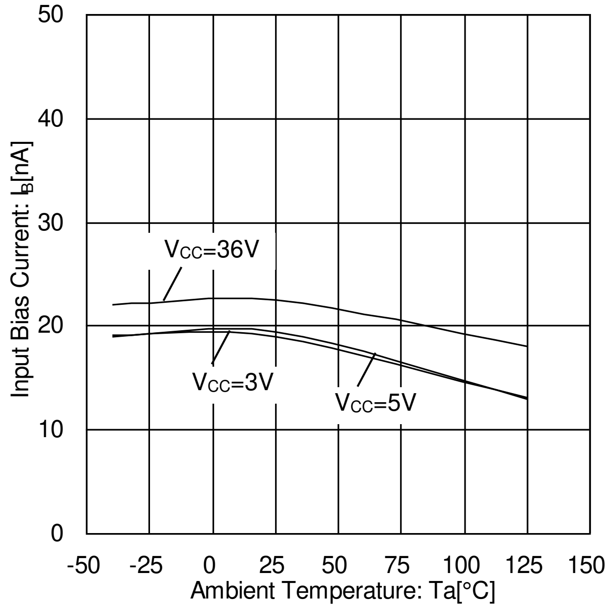


Figure 15. Input Bias Current vs Ambient Temperature
(V_{ICM}=0V, V_{OUT}=1.4V)

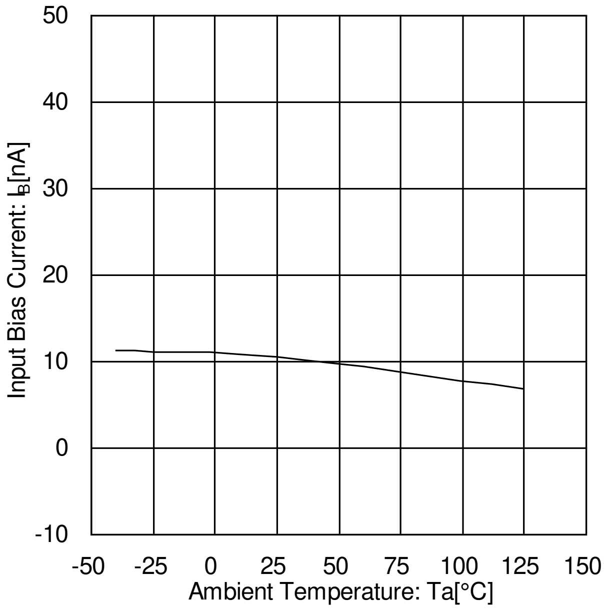


Figure 16. Input Bias Current vs Ambient Temperature
(V_{CC}=30V, V_{ICM}=28V, V_{OUT}=1.4V)

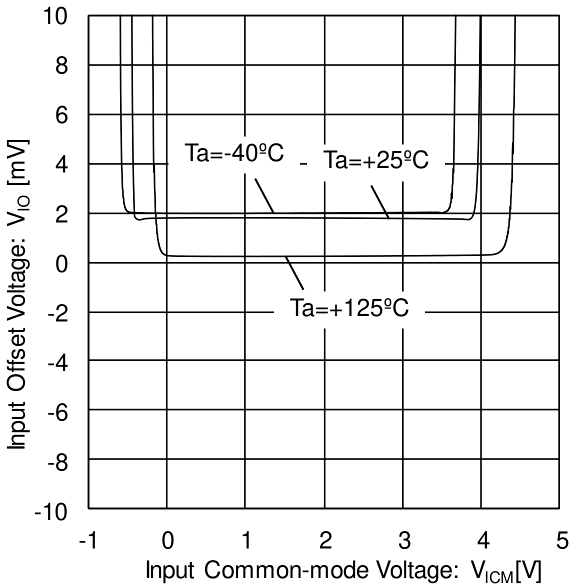


Figure 17. Input Offset Voltage vs
Input Common-mode Voltage
(V_{CC}=5V)

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

Typical Performance Curves - continued

○BA82904Yxxx-C

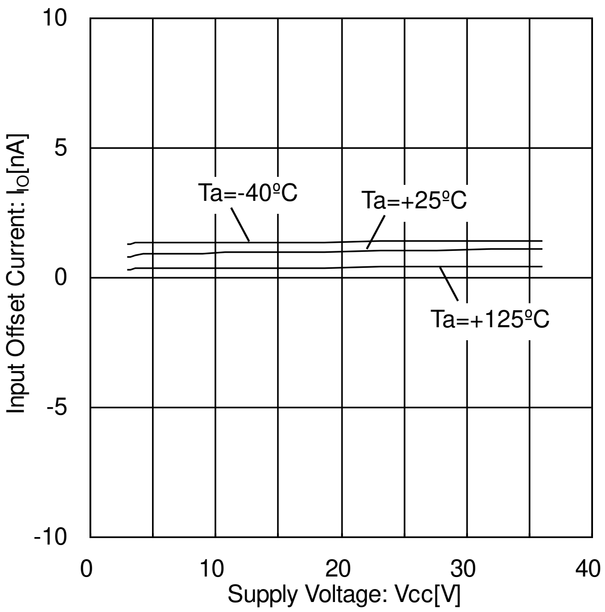


Figure 18. Input Offset Current vs Supply Voltage (V_{ICM}=0V, V_{OUT}=1.4V)

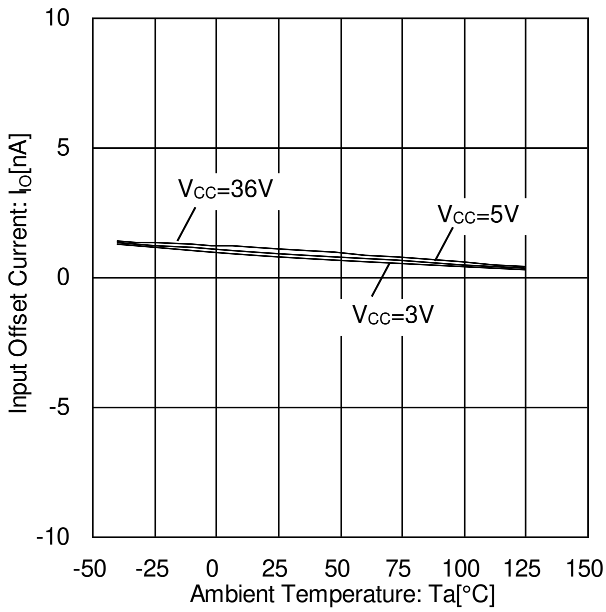


Figure 19. Input Offset Current vs Ambient Temperature (V_{ICM}=0V, V_{OUT}=1.4V)

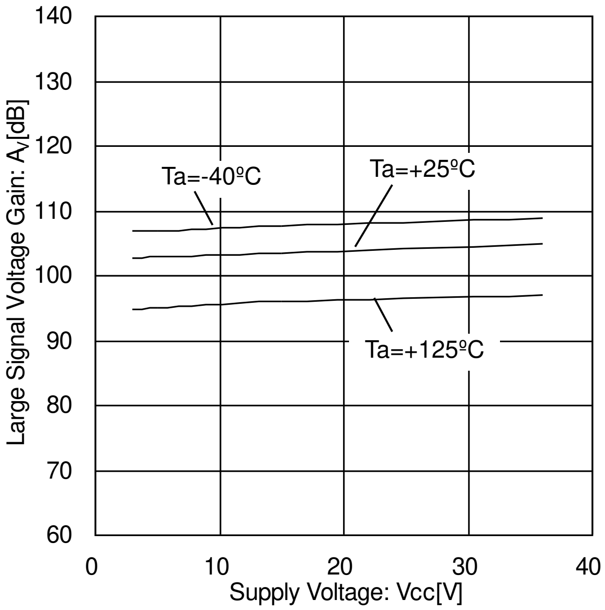


Figure 20. Large Signal Voltage Gain vs Supply Voltage (R_L=2kΩ)

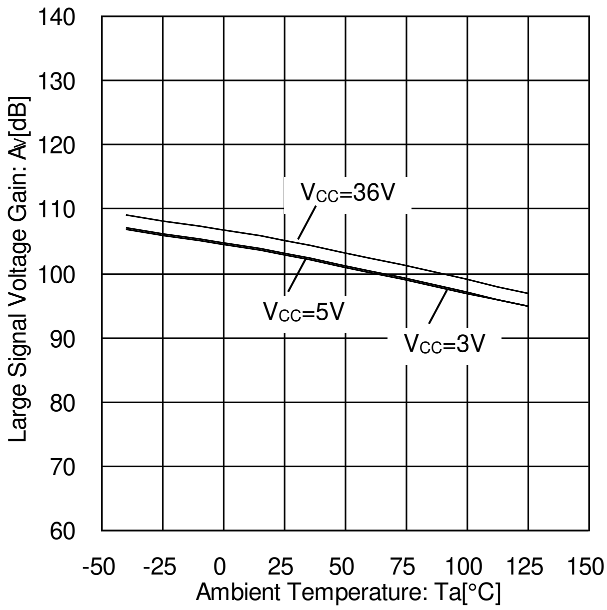


Figure 21. Large Signal Voltage Gain vs Ambient Temperature (R_L=2kΩ)

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

Typical Performance Curves - continued

○BA82904Yxxx-C

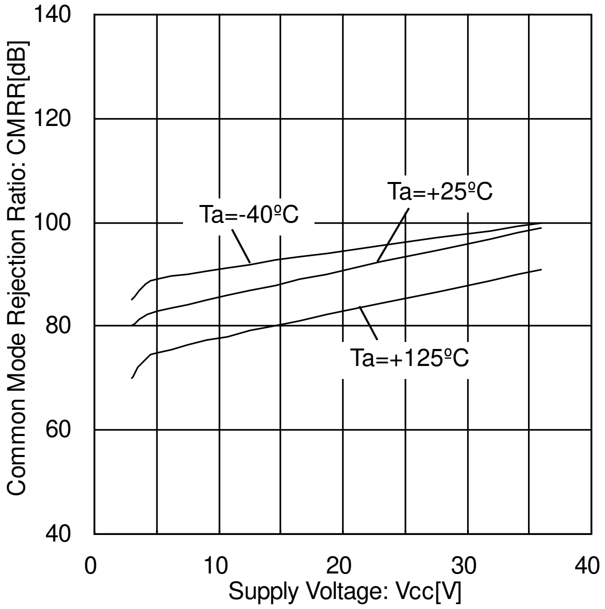


Figure 22. Common Mode Rejection Ratio vs Supply Voltage
(V_{OUT}=1.4V)

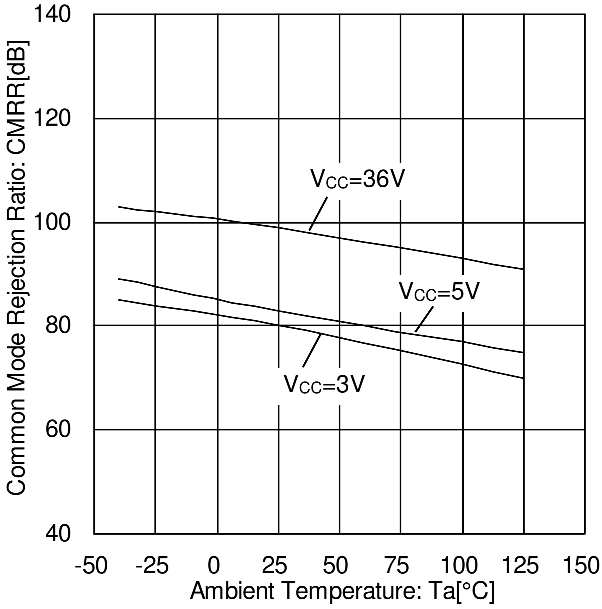


Figure 23. Common Mode Rejection Ratio vs Ambient Temperature
(V_{OUT}=1.4V)

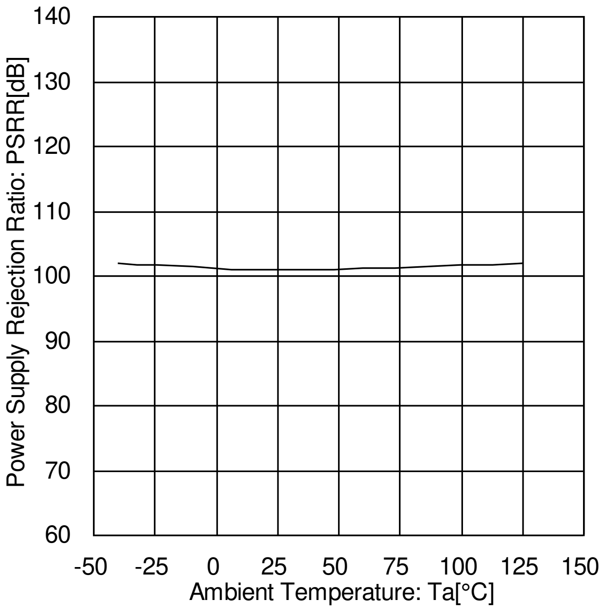


Figure 24. Power Supply Rejection Ratio vs Ambient Temperature
(V_{CC}=5V)

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

Typical Performance Curves - continued

○BA82902Yxxx-C

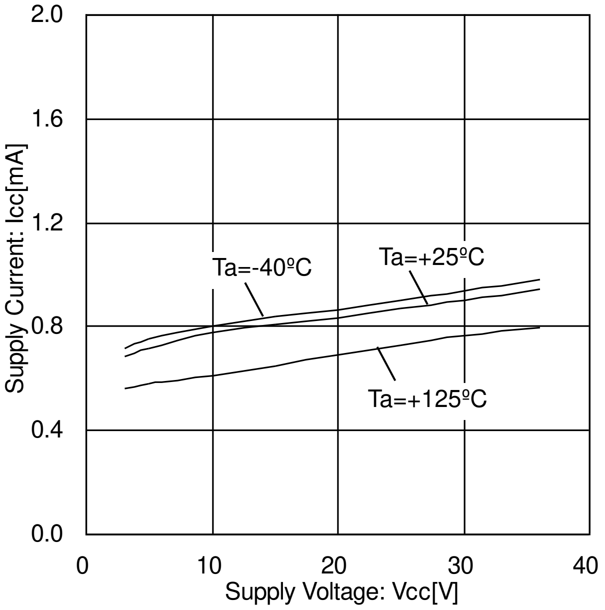


Figure 25. Supply Current vs Supply Voltage

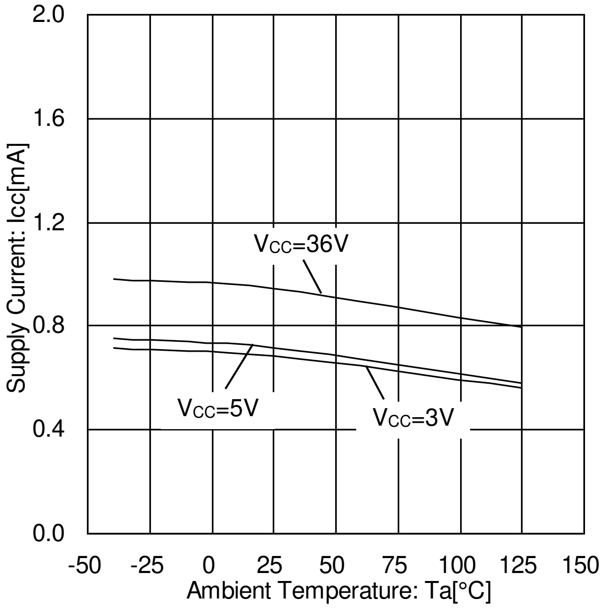


Figure 26. Supply Current vs Ambient Temperature

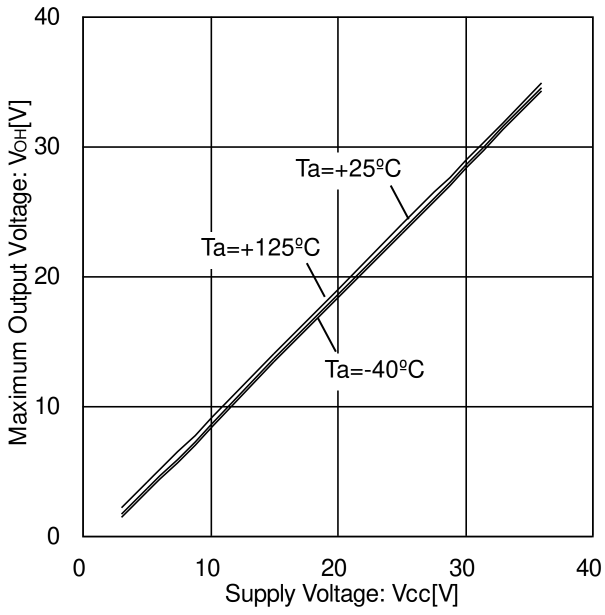


Figure 27. Maximum Output Voltage vs Supply Voltage (R_L=10kΩ)

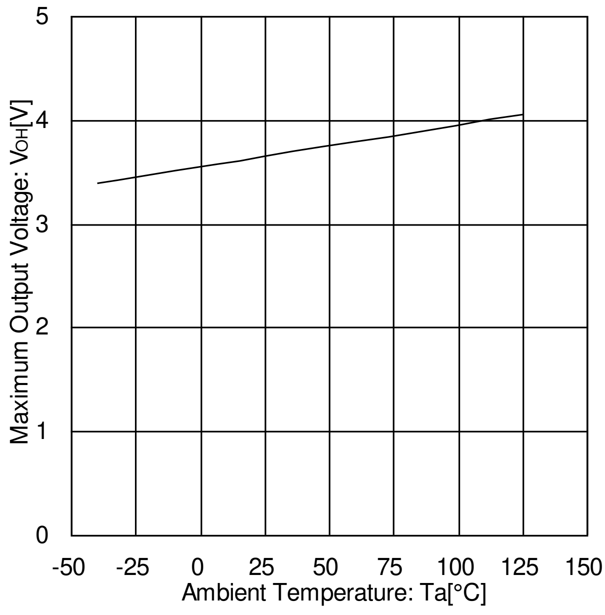


Figure 28. Maximum Output Voltage vs Ambient Temperature (V_{CC}=5V, R_L=2kΩ)

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

Typical Performance Curves - continued

○BA82902Yxxx-C

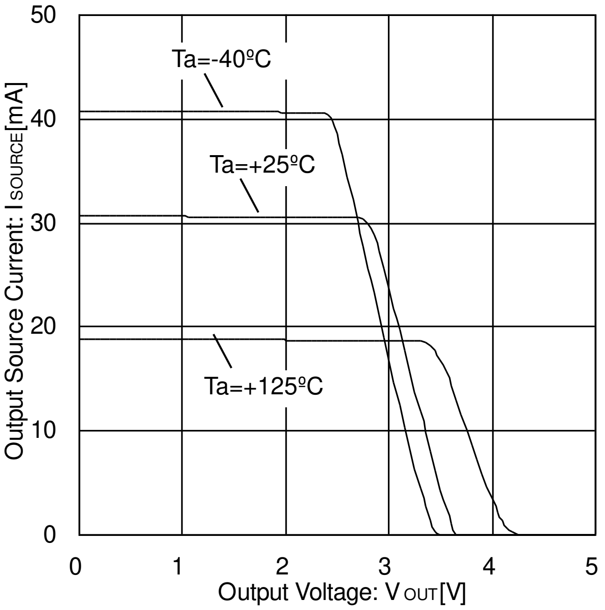


Figure 29. Output Source Current vs Output Voltage (V_{CC}=5V)

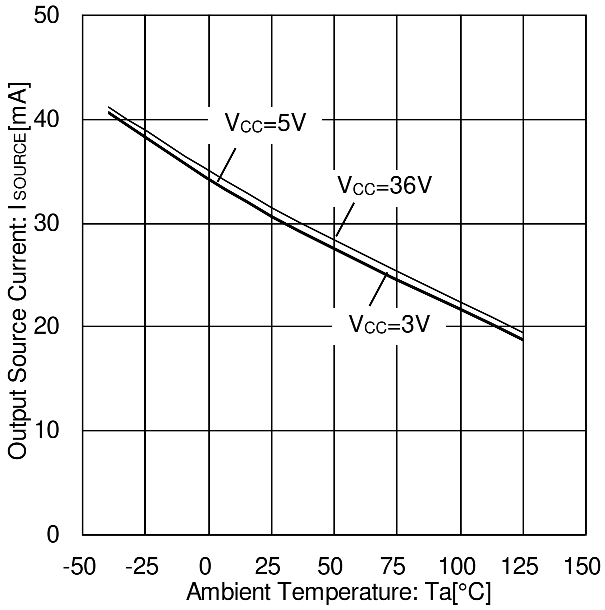


Figure 30. Output Source Current vs Ambient Temperature (V_{OUT}=0V)

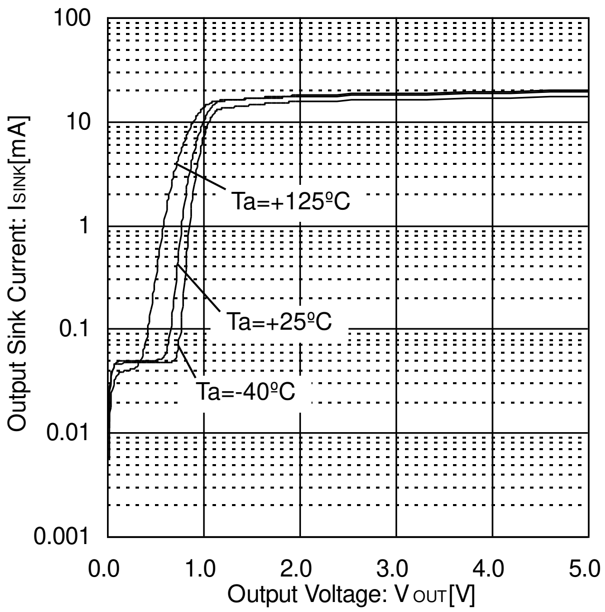


Figure 31. Output Sink Current vs Output Voltage (V_{CC}=5V)

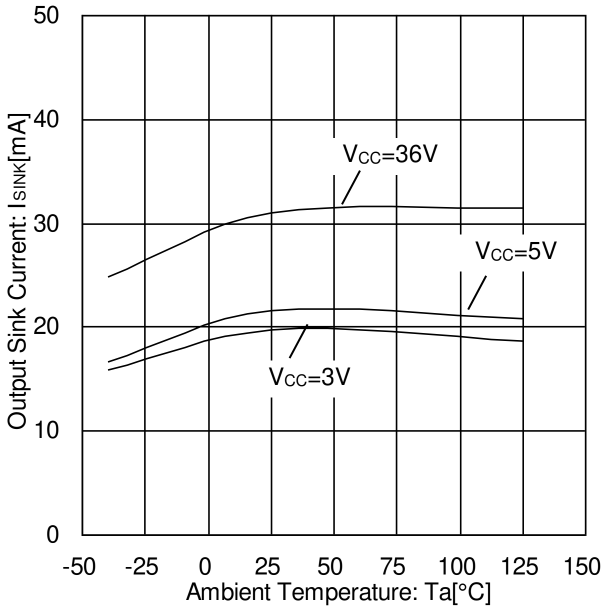


Figure 32. Output Sink Current vs Ambient Temperature (V_{OUT}=V_{CC})

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

Typical Performance Curves - continued

○BA82902Yxxx-C

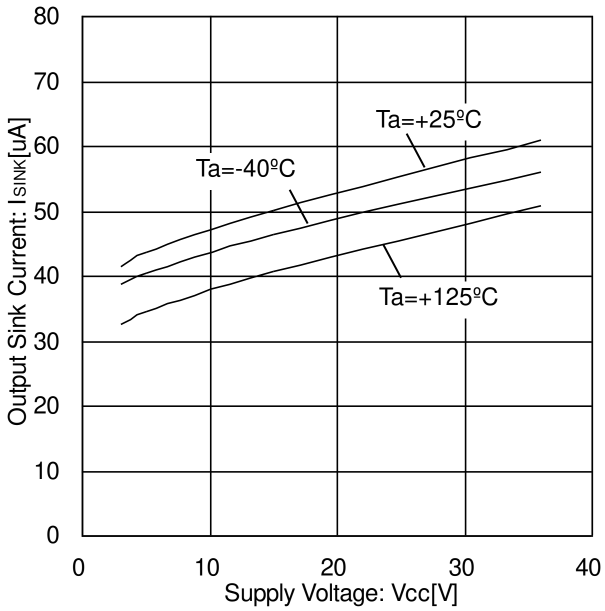


Figure 33. Output Sink Current vs Supply Voltage (V_{OUT}=0.2V)

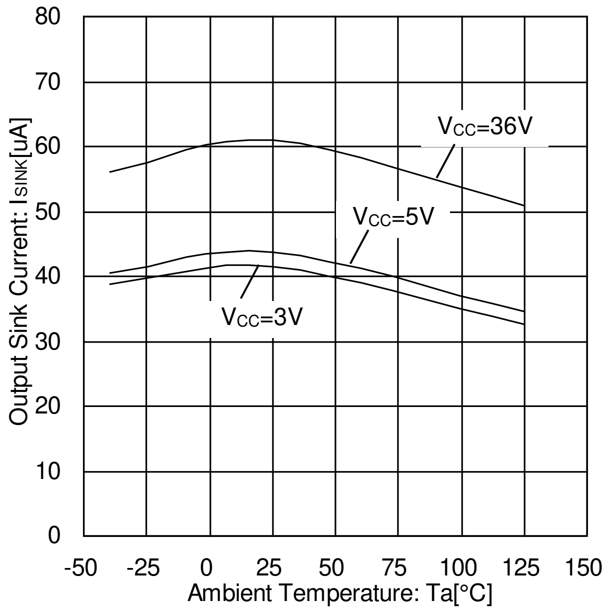


Figure 34. Output Sink Current vs Ambient Temperature (V_{OUT}=0.2V)

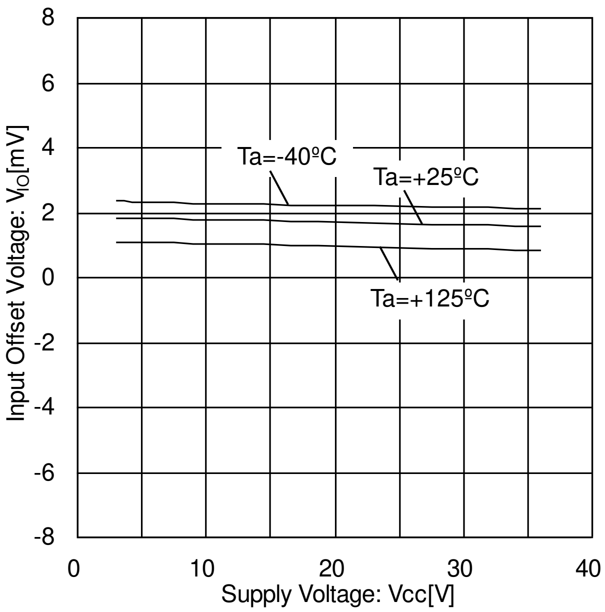


Figure 35. Input Offset Voltage vs Supply Voltage (V_{ICM}=0V, V_{OUT}=1.4V)

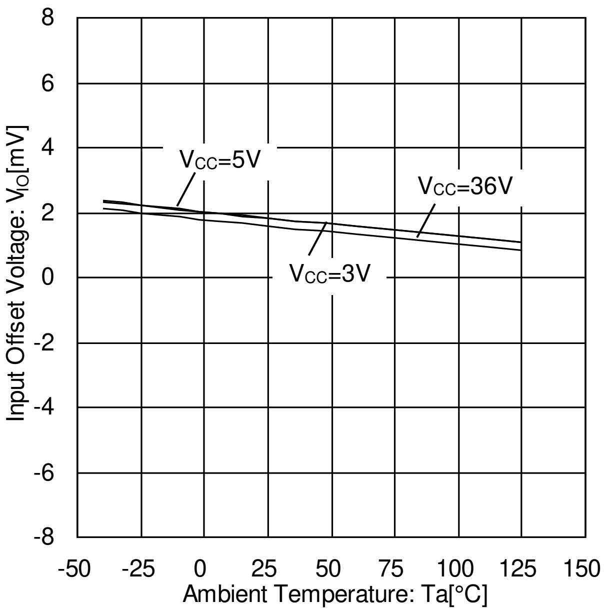


Figure 36. Input Offset Voltage vs Ambient Temperature (V_{ICM}=0V, V_{OUT}=1.4V)

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

Typical Performance Curves - continued

○BA82902Yxxx-C

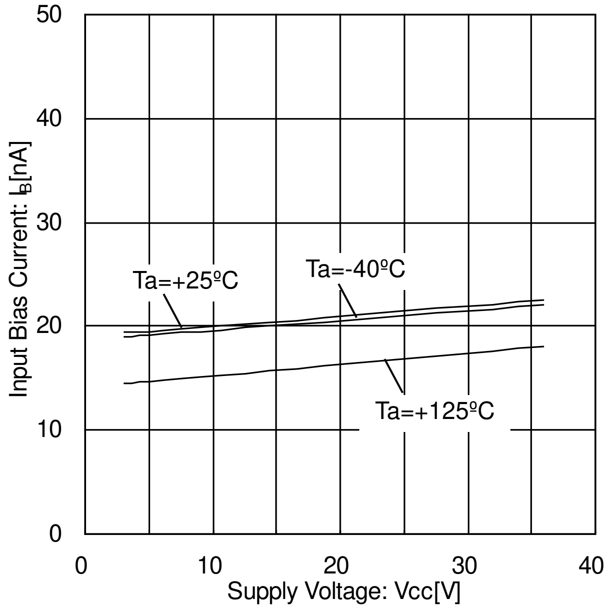


Figure 37. Input Bias Current vs Supply Voltage
(V_{ICM}=0V, V_{OUT}=1.4V)

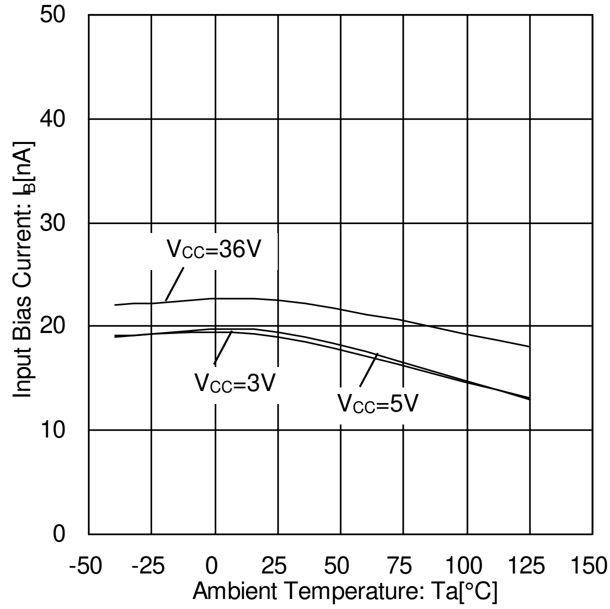


Figure 38. Input Bias Current vs Ambient Temperature
(V_{ICM}=0V, V_{OUT}=1.4V)

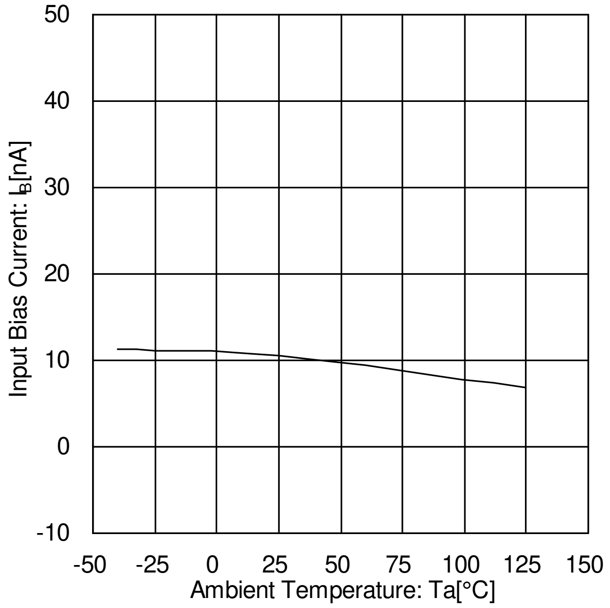


Figure 39. Input Bias Current vs Ambient Temperature
(V_{CC}=30V, V_{ICM}=28V, V_{OUT}=1.4V)

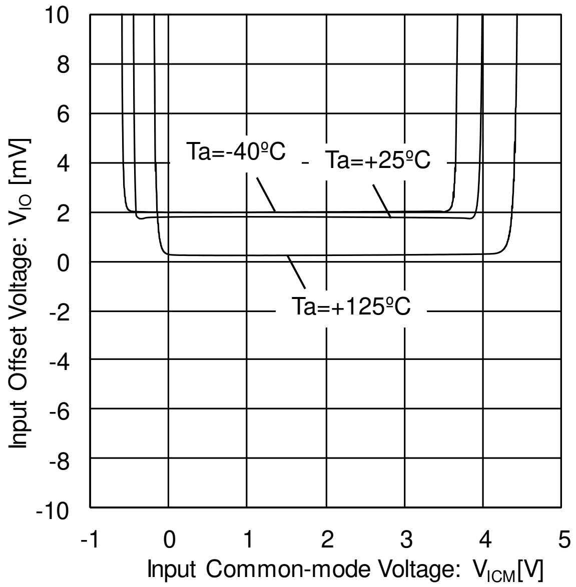


Figure 40. Input Offset Voltage vs
Input Common-mode Voltage
(V_{CC}=5V)

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

Typical Performance Curves - continued

○BA82902Yxxx-C

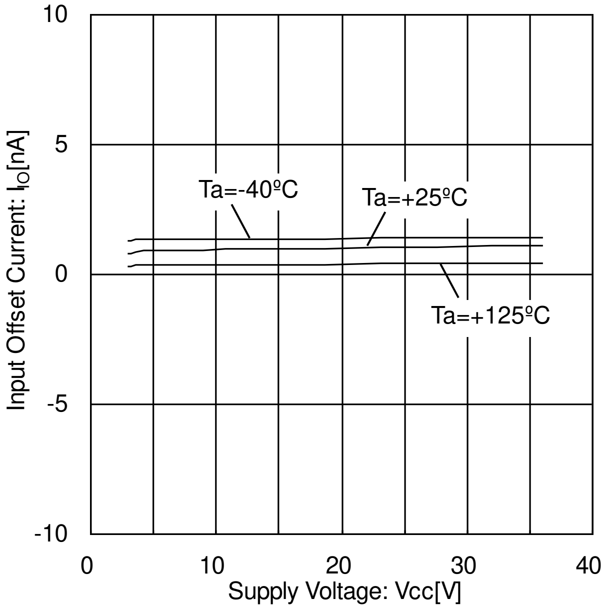


Figure 41. Input Offset Current vs
Supply Voltage
(V_{ICM}=0V, V_{OUT}=1.4V)

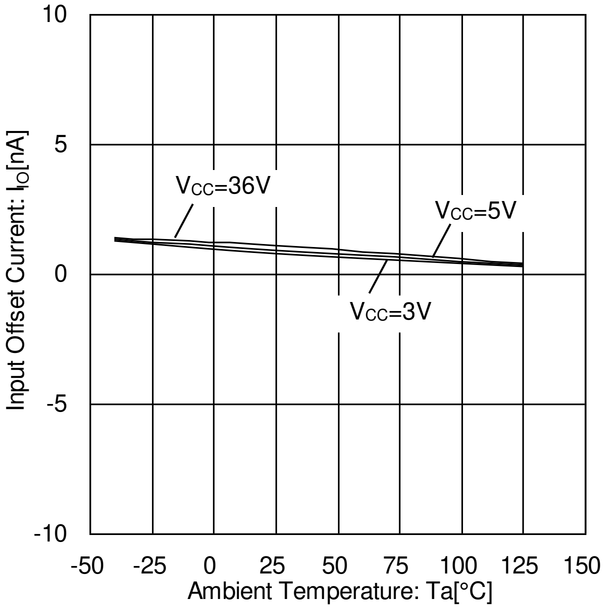


Figure 42. Input Offset Current vs
Ambient Temperature
(V_{ICM}=0V, V_{OUT}=1.4V)

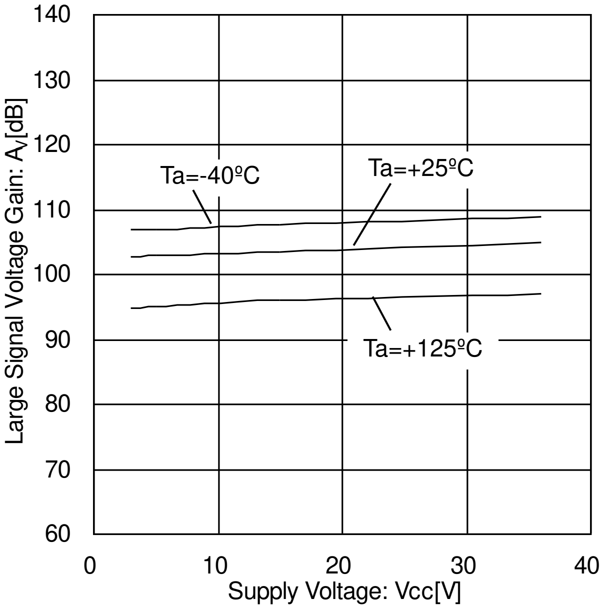


Figure 43. Large Signal Voltage Gain vs
Supply Voltage
(R_L=2kΩ)

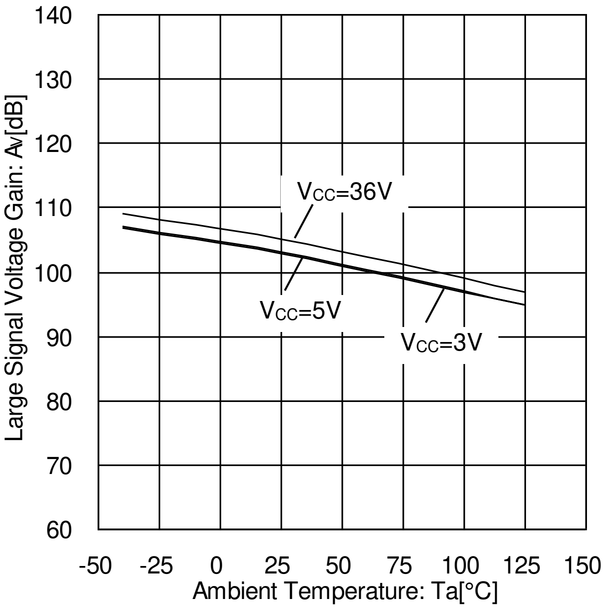


Figure 44. Large Signal Voltage Gain vs
Ambient Temperature
(R_L=2kΩ)

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

Typical Performance Curves - continued

○BA82902Yxxx-C

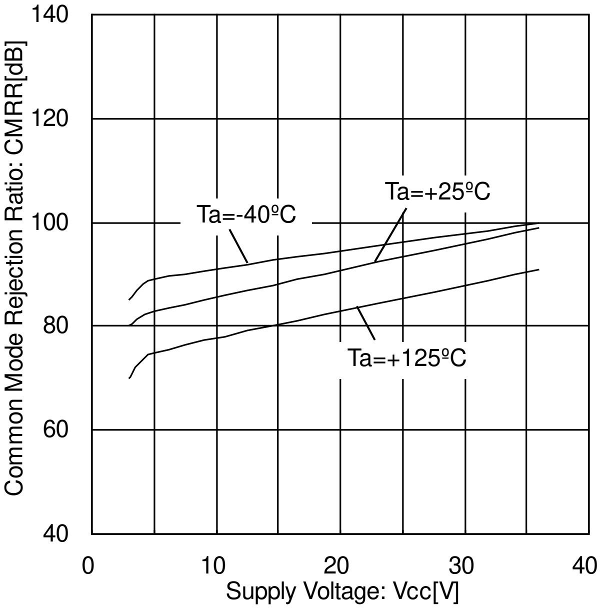


Figure 45. Common Mode Rejection Ratio vs Supply Voltage
(V_{OUT}=1.4V)

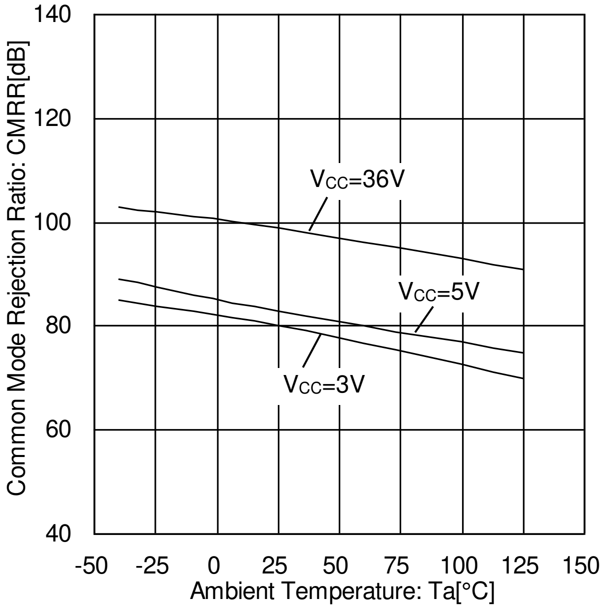


Figure 46. Common Mode Rejection Ratio vs Ambient Temperature
(V_{OUT}=1.4V)

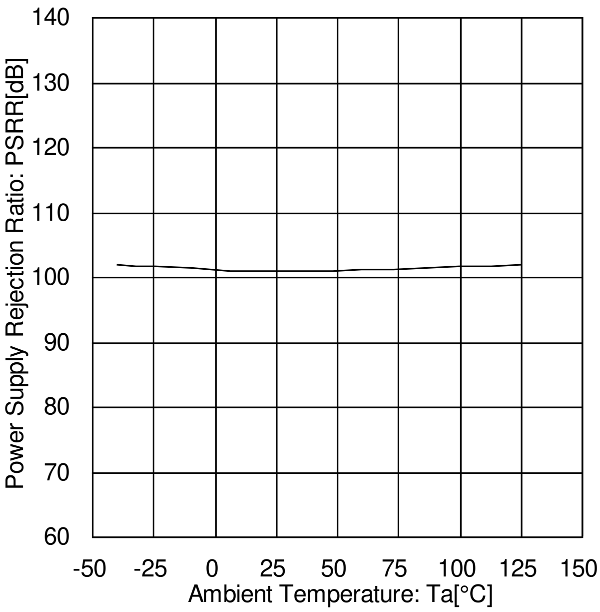


Figure 47. Power Supply Rejection Ratio vs Ambient Temperature

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

Application Information

Test Circuit 1: Measurement Condition

V_{CC}, V_{EE}, V_{EK}, V_{ICM} Unit: V

Parameter	V_F	SW1	SW2	SW3	V_{CC}	V_{EE}	V_{EK}	V_{ICM}	Calculation
Input Offset Voltage	V_{F1}	ON	ON	OFF	5 to 30	0	-1.4	0	1
Input Offset Current	V_{F2}	OFF	OFF	OFF	5	0	-1.4	0	2
Input Bias Current	V_{F3}	OFF	ON	OFF	5	0	-1.4	0	3
	V_{F4}	ON	OFF						
Large Signal Voltage Gain	V_{F5}	ON	ON	ON	15	0	-1.4	0	4
	V_{F6}				15	0	-11.4	0	
Common-mode Rejection Ratio (Input Common-mode Voltage Range)	V_{F7}	ON	ON	OFF	5	0	-1.4	0	5
	V_{F8}				5	0	-1.4	3.5	
Power Supply Rejection Ratio	V_{F9}	ON	ON	OFF	5	0	-1.4	0	6
	V_{F10}				30	0	-1.4	0	

- Calculation -

1. Input Offset Voltage (V_{IO})

$$V_{IO} = \frac{|V_{F1}|}{1+R_F/R_S} \quad [V]$$

2. Input Offset Current (I_{IO})

$$I_{IO} = \frac{|V_{F2} - V_{F1}|}{R_I \times (1+R_F/R_S)} \quad [A]$$

3. Input Bias Current (I_B)

$$I_B = \frac{|V_{F4} - V_{F3}|}{2 \times R_I \times (1+R_F/R_S)} \quad [A]$$

4. Large Signal Voltage Gain (A_V)

$$A_V = 20 \times Log \frac{\Delta V_{EK} \times (1+R_F/R_S)}{|V_{F5} - V_{F6}|} \quad [dB]$$

5. Common-mode Rejection Ration (CMRR)

$$CMRR = 20 \times Log \frac{\Delta V_{ICM} \times (1+R_F/R_S)}{|V_{F8} - V_{F7}|} \quad [dB]$$

6. Power Supply Rejection Ratio (PSRR)

$$PSRR = 20 \times Log \frac{\Delta V_{CC} \times (1+R_F/R_S)}{|V_{F10} - V_{F9}|} \quad [dB]$$

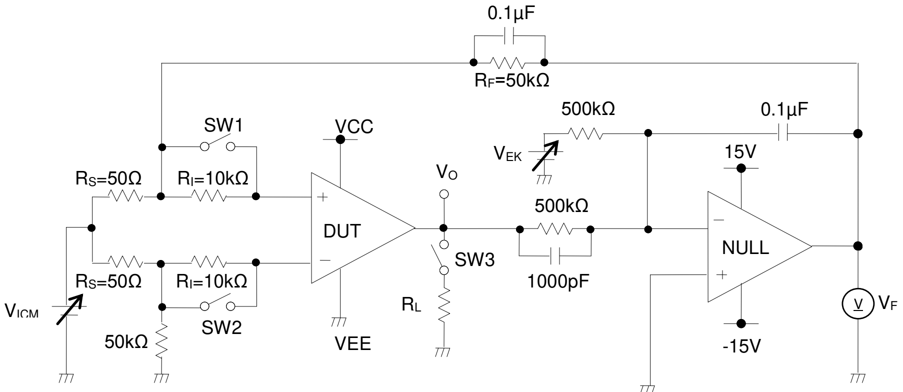


Figure 48. Test Circuit 1 (One Channel Only)

Application Information - continued

Test Circuit 2: Switch Condition

SW No.	SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7	SW 8	SW 9	SW 10	SW 11	SW 12	SW 13	SW 14
Supply Current	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
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	ON	OFF	OFF	OFF
Gain Bandwidth Product	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
Equivalent Input Noise Voltage	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF

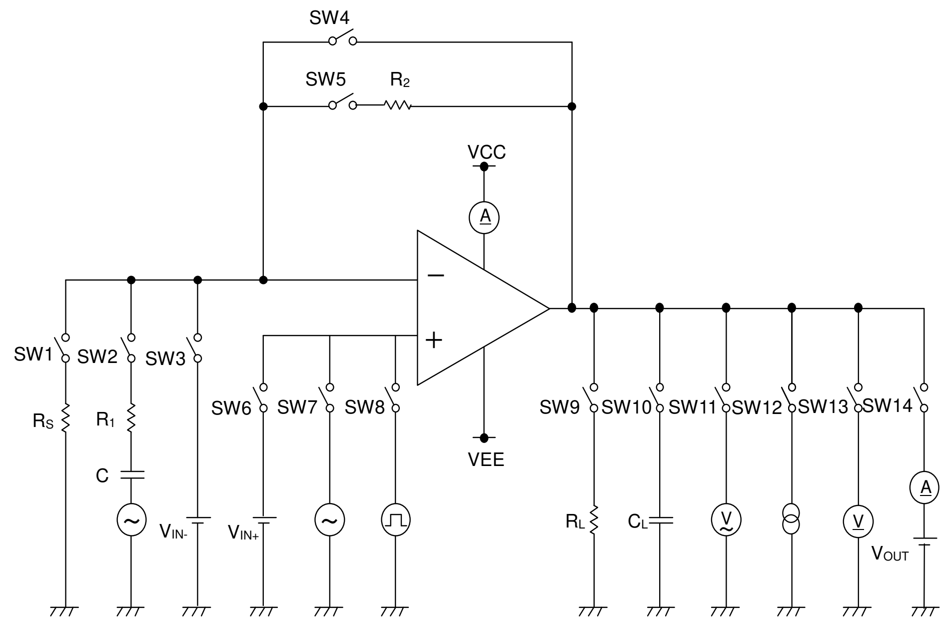


Figure 49. Test Circuit 2 (One Channel Only)

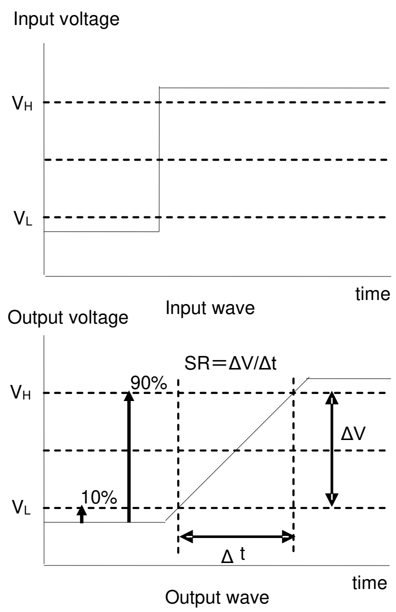
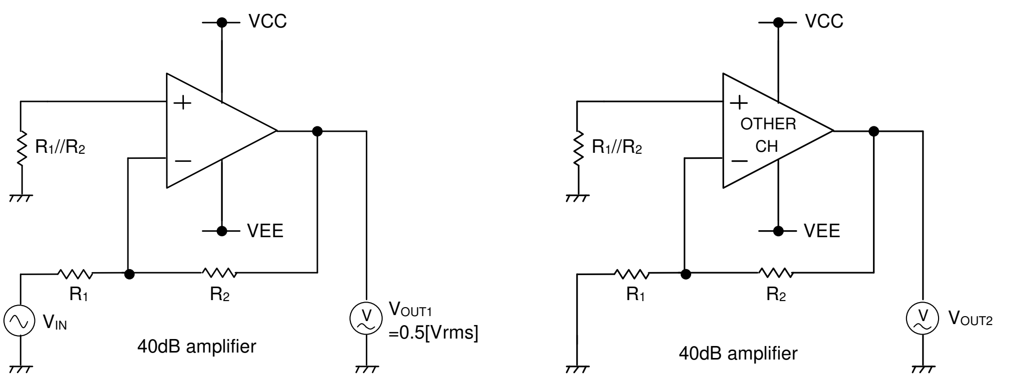


Figure 50. Slew Rate Waveform

Test Circuit 3: Channel Separation Measurement Condition



$$CS = 20 \times \log \frac{100 \times V_{OUT1}}{V_{OUT2}}$$

(R_1=1kΩ, R_2=100kΩ)

Figure 51. Test Circuit 3

Application Information - continued

EMI Immunity

BA82904Yxxx-C and BA82902Yxxx-C have high tolerance for electromagnetic interference from the outside because they have EMI filter, and the EMI design is simple. The data of the IC simple substance on ROHM board are as follows. They are most suitable to replace from conventional products. The test condition is based on ISO11452-2.

<Test Condition> Based on ISO11452-2
Test Circuit: Voltage Follower
V_{CC}: 12V
V_{IN+}: 6V
Test Method: Substituted Law
(Progressive Wave)
Field Intensity: 200V/m
Test Wave: CW (Continuous Wave)
Frequency: 200MHz – 1000MHz (2% step)

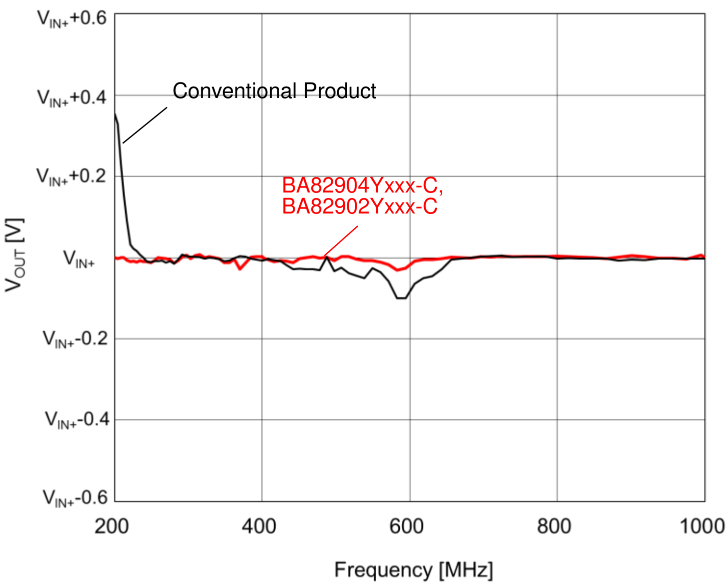


Figure 52. EMI Characteristics

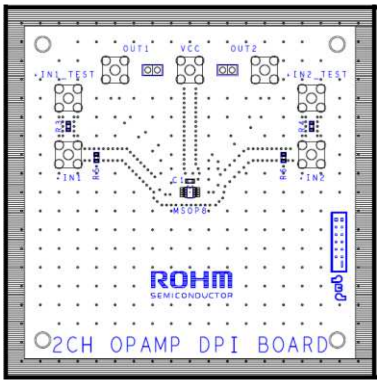


Figure 53. EMI Evaluation Board (BA82904Yxxx-C)

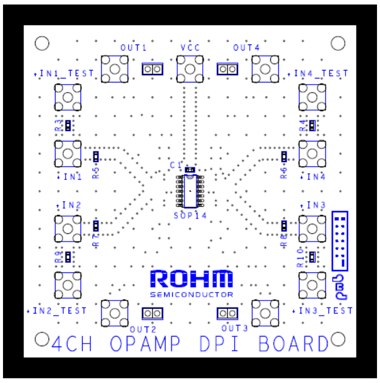


Figure 54. EMI Evaluation Board (BA82902Yxxx-C)

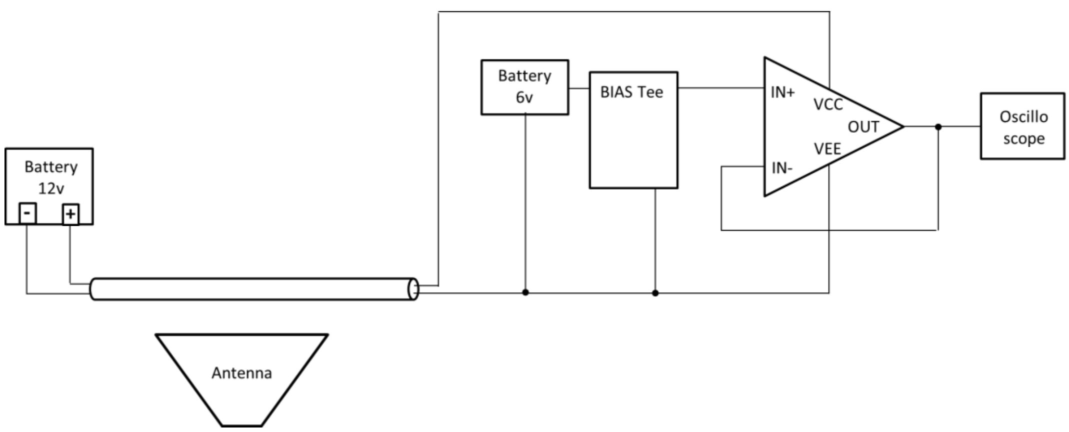


Figure 55. Measurement Circuit of EMI Evaluation

(Note) The above data is obtained using typical IC simple substance on ROHM board. These values are not guaranteed.
Design and Evaluate in actual application before use.

Application Information - continued

1. Unused Circuits
When there are unused circuits, it is recommended that they are connected as in Figure 56, and set the non-inverting input pin to electric potential within the input common-mode voltage range (V_{ICM}).

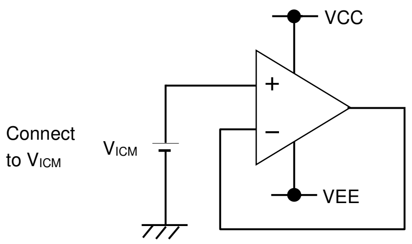


Figure 56. Example of Application Circuit for Unused Op-amp

2. Input Voltage
Applying V_{EE}+36V to the input pin is possible without causing deterioration of the electrical characteristics or destruction, regardless of the supply voltage. However, this does not ensure normal circuit operation. Note that the circuit operates normally only when the input voltage is within the common-mode input voltage range of the electric characteristics.

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

4. IC Operation
The output stage of the IC is configured using Class C push-pull circuits. Therefore, when the load resistor is connected to the middle potential of V_{CC} and V_{EE}, crossover distortion occurs at the changeover between discharging and charging of the output current. Connecting a resistor between the output pin and the VEE pin, and increasing the bias current for Class A operation will suppress crossover distortion.

5. Output Capacitor
When the VCC pin is shorted to V_{EE}(GND) electric potential in a state where electric charge is accumulated in the external capacitor that is connected to the output pin, the accumulated electric charge will flow through parasitic elements or pin protection elements inside the circuit and discharges to the VCC pin. It may cause damage to the elements inside the circuit (thermal destruction). When using this IC as an application circuit which does not constitute a negative feedback circuit and does not occur the oscillation by an output capacitive load such as a voltage comparator, set the value of the capacitor connected to the output pin to 0.1uF or less to prevent IC damage caused by the accumulation of electric charge as mentioned above.

6. Oscillation by Output Capacitor
Pay attention to the oscillation by capacitive load in designing an application which constitutes a negative feedback loop circuit with these ICs.

7. IC handling
Applying mechanical stress to the IC by deflecting or bending the board may cause fluctuations of the electrical characteristics due to the piezo resistance effects. Pay attention to defecting or bending the board.

Operational Notes

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

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

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

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

5. **Recommended Operating Conditions**
   The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

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

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

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

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

10. **Unused Input Pins**
    Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.