钍地半导体
Tudi Semiconductor

Product Specification

TUDI-BA2904

Ground Sense Operational Amplifiers

网址 www.sztdbdt.com

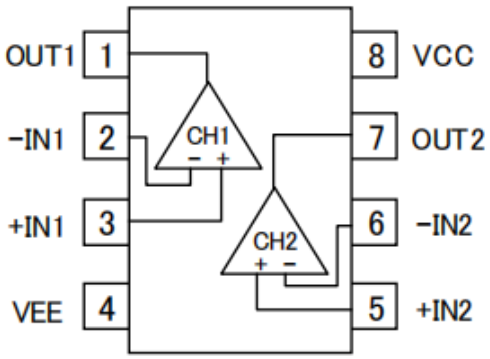
用芯智造·卓越品质

semiconductor device manufacturer

- Design
- research and development
- production
- and sales

Features

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



SOP8 /TSSOP8

Application

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

General Description

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

Selection Guide

		Output Current Source/Sink	Input Offset Voltage	Maximum operating temperature		
				+85°C	+105°C	+125°C
Normal	Dual	20mA/20mA	7mV	BA10358F BA10358FV BA10358FJ		
	Quad	35mA/20mA	7mV	BA10324AF BA10324AFV BA10324AFJ		
High-reliability	Dual	30mA/20mA	7mV		BA2904SF BA2904SFV BA2904SFVM	BA2904F BA2904FV BA2904FVM
			2mV			BA2904WF BA2904WFV
	Quad	30mA/20mA	7mV		BA2902SF BA2902SFV	BA2902F BA2902FV

Simplified schematic

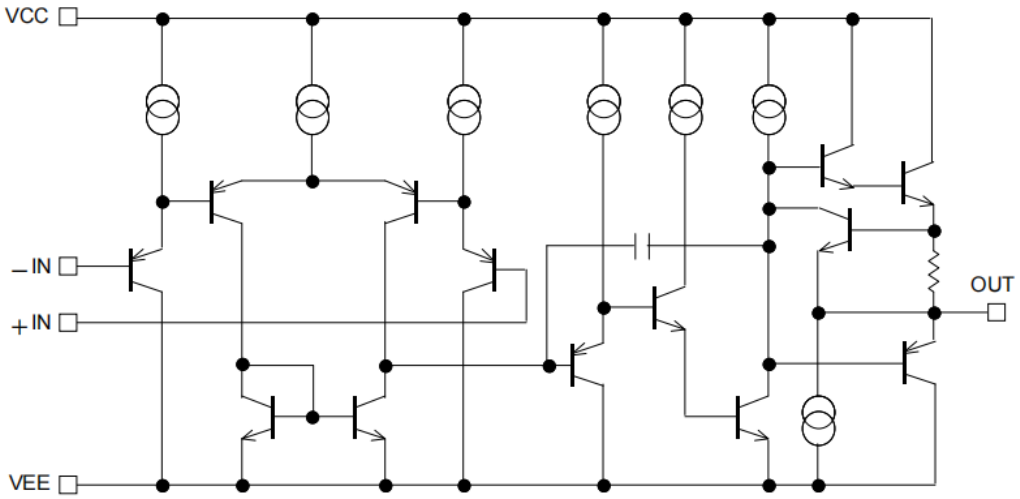


Figure 1. Simplified schematic（one channel only）

Line-up

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

Absolute Maximum Ratings (T_A=25°C)

○BA10358, BA10324A

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

Note: Absolute maximum rating item indicates the condition which must not be exceeded. Application if voltage in excess of absolute maximum rating or use out of absolute maximum rated temperature environment may cause deterioration of characteristics.

(Note 1) To use at temperature above T_A=25°C reduce 6.2mW.

(Note 2) To use at temperature above T_A=25°C reduce 5.4mW

(Note 3) To use at temperature above T_A=25°C reduce 5.0mW.

(Note 4) To use at temperature above T_A=25°C reduce 4.5mW.

(Note 5) To use at temperature above T_A=25°C reduce 8.2mW

(Note 6) To use at temperature above T_A=25°C reduce 7.0mW.

(Note 7) Mounted on a FR4 glass epoxy PCB 70mm×70mm×1.6mm (Copper foil area less than 3%).

(Note 8) The voltage difference between inverting input and non-inverting input is the differential input voltage. Then input terminal voltage is set to more than VEE.

(Note 9) An excessive input current will flow when input voltages of less than VEE-0.6V are applied. The input current can be set to less than the rated current by adding a limiting resistor.

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

Absolute Maximum Ratings (T_A=25°C)

○BA2904, BA2902

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

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

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

Electrical Characteristics

OBA10358 (Unless otherwise specified VCC=+5V, VEE=0V, T_A=25°C)

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

(Note 18) Absolute value

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

OBA10324A (Unless otherwise specified VCC=+5V, VEE=0V, T_A=25°C)

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

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

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

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

(Note 22) Absolute value
(Note 23) BA2904S :Full range -40 to +105°C BA2904 :Full range -40 to +125°C
(Note 24) Under high temperatures, please consider the power dissipation when selecting the output current.
When the output terminal is continuously shorted the output current reduces the internal temperature by flushing.

OBA2904W (Unless otherwise specified VCC=+5V, VEE=0V)

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

(Note 25) Absolute value

(Note 26) Under high temperatures, please consider the power dissipation when selecting the output current.
When the output terminal is continuously shorted the output current reduces the internal temperature by flushing.

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

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

(Note 27) Absolute value
(Note 28) BA2902S :Full range -40 to +105°C ,BA2902 :Full range -40 to +125°C
(Note 29) Under high temperatures, please consider the power dissipation when selecting the output current.
When the output terminal is continuously shorted the output current reduces the internal temperature by flushing.

Description of Electrical Characteristics

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

1. Absolute maximum ratings

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

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

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

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

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

2. Electrical characteristics

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

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

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

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

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

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

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

(8) Large Signal Voltage Gain (Av)
Indicates the amplifying rate (gain) of output voltage against the voltage difference between non-inverting terminal and inverting terminal. It is normally the amplifying rate (gain) with reference to DC voltage.
Av = (Output voltage) / (Differential Input voltage)

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

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

(11) Power Supply Rejection Ratio (PSRR)
Indicates the ratio of fluctuation of input offset voltage when supply voltage is changed.
It is normally the fluctuation of DC.
PSRR= (Change of power supply voltage)/(Input offset fluctuation)

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

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

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

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

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

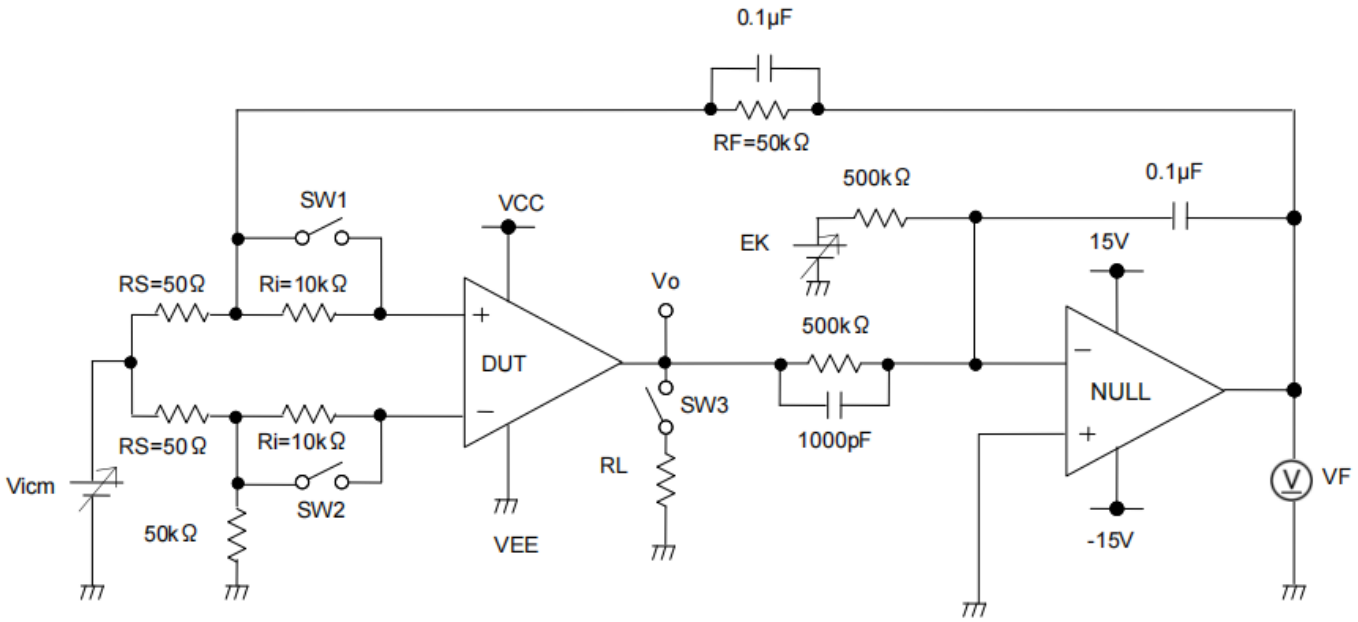


Figure . 98 Test circuit1 (one channel only)

Application Information

NULL method condition for Test Circuit 1

VCC, VEE, E_K, V_{ICM} Unit : V

Parameter	VF	S1	S2	S3	BA10358 BA10324A				BA2904 BA2902				calculation
					VCC	VEE	E_K	V_{ICM}	VCC	VEE	E_K	V_{ICM}	
Input Offset Voltage	V_{F1}	ON	ON	OFF	5	0	-1.4	0	5 to 30	0	-1.4	0	1
Input Offset Current	V_{F2}	OFF	OFF	OFF	5	0	-1.4	0	5	0	-1.4	0	2
Input Bias Current	V_{F3}	OFF	ON	OFF	5	0	-1.4	0	5	0	-1.4	0	3
	V_{F4}	ON	OFF										
Large Signal Voltage Gain	V_{F5}	ON	ON	ON	15	0	-1.4	0	15	0	-1.4	0	4
	V_{F6}				15	0	-11.4	0	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	0	-1.4	0	5
	V_{F8}				5	0	-1.4	3.5	5	0	-1.4	3.5	
Power Supply Rejection Ratio	V_{F9}	ON	ON	OFF	5	0	-1.4	0	5	0	-1.4	0	6
	V_{F10}				30	0	-1.4	0	30	0	-1.4	0	

-Calculation-

1. Input Offset Voltage (Vio)

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

2. Input Offset Current (Iio)

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

3. Input Bias Current (Ib)

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

4. Large Signal Voltage Gain (Av)

$$A_V = 20\text{Log} \frac{10 \times (1+R_F/R_S)}{|V_{F5}-V_{F6}|} \text{ [dB]}$$

5. Common-mode Rejection Ration (CMRR)

$$\text{CMRR} = 20\text{Log} \frac{3.5 \times (1+R_F/R_S)}{|V_{F8}-V_{F7}|} \text{ [dB]}$$

6. Power supply rejection ratio (PSRR)

$$\text{PSRR} = 20\text{Log} \frac{25 \times (1+R_F/R_S)}{|V_{F10}-V_{F9}|} \text{ [dB]}$$

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

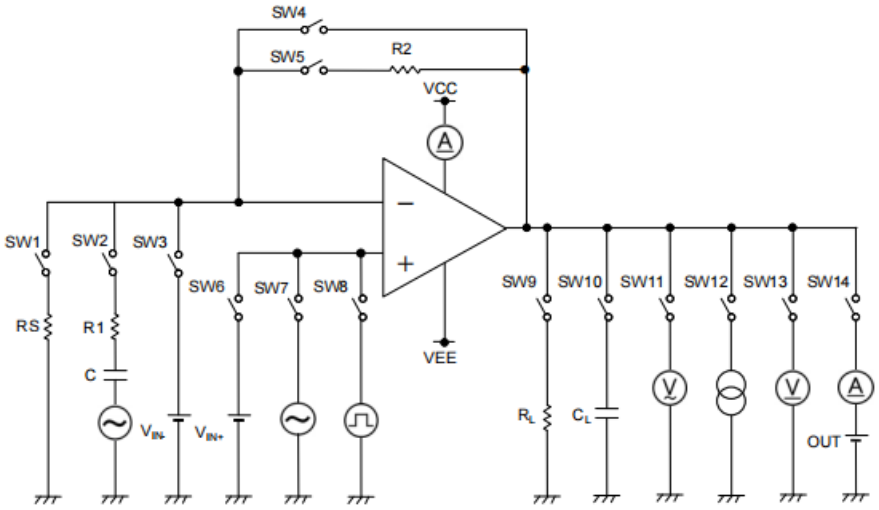


Figure 99. Test Circuit 2 (each Op-Amp)

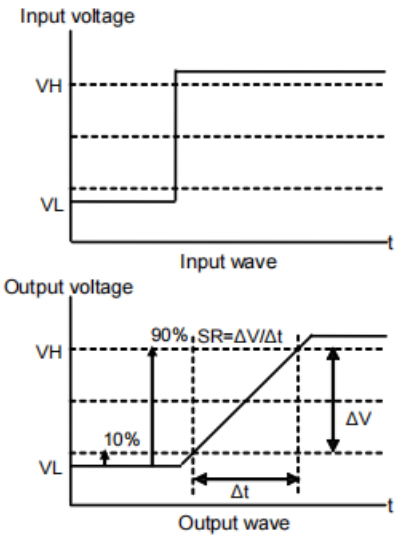


Figure 100. Slew Rate Input Waveform

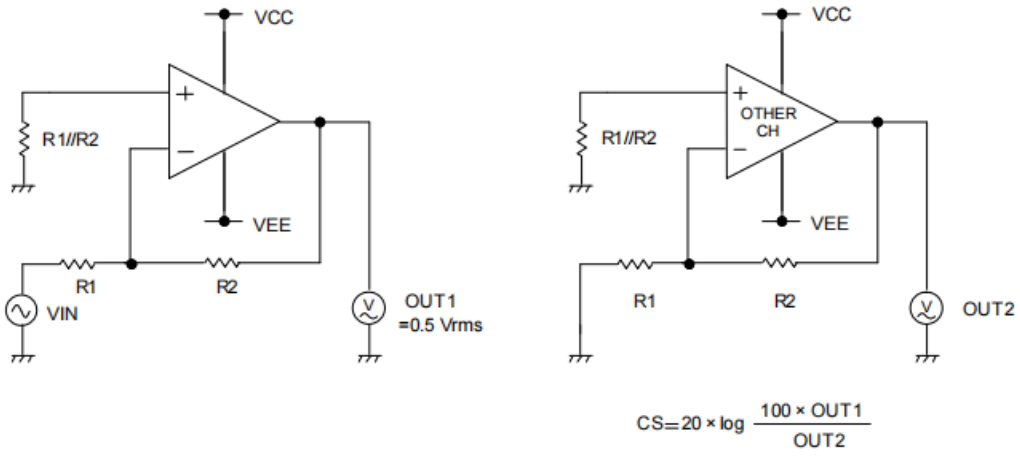
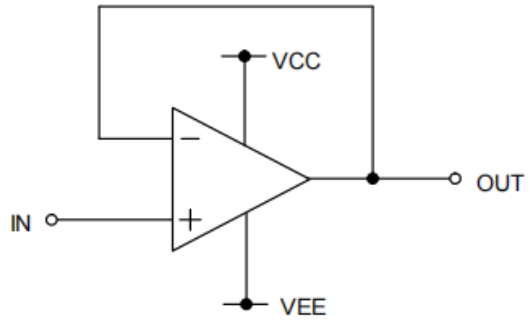


Figure 101. Test Circuit 3(Channel Separation)
(R1=1kΩ,R2=100kΩ)

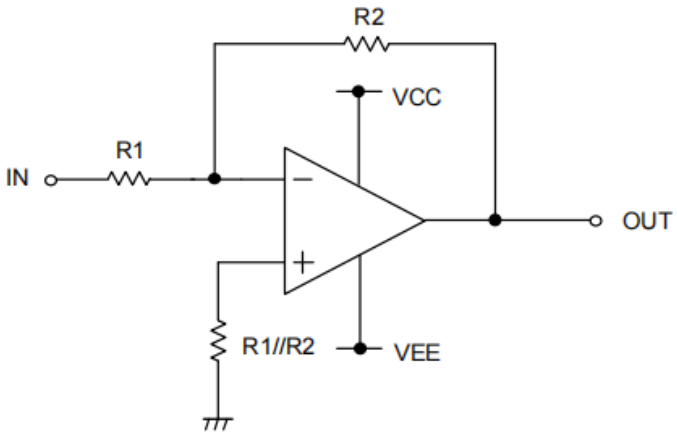
Examples of circuit

○Voltage follower



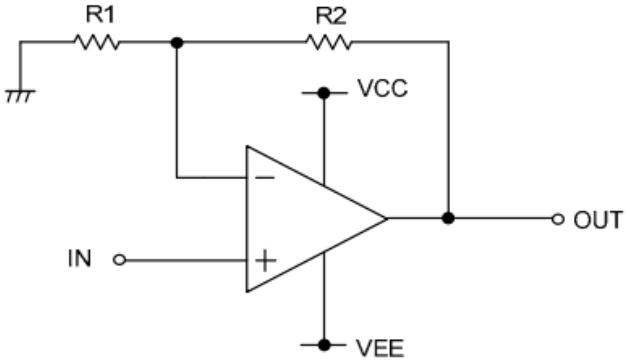
Voltage gain is 0 dB.
This circuit controls output voltage (OUT) equal input voltage (IN), and keeps OUT with stable because of high input impedance and low output impedance.
OUT is shown next formula.
OUT=IN

○Inverting amplifier



For inverting amplifier, IN is amplified by voltage gain decided R1 and R2, and phase reversed voltage is output.
OUT is shown next formula.
OUT=-(R2/R1) · IN
Input impedance is R1.

○Non-inverting amplifier

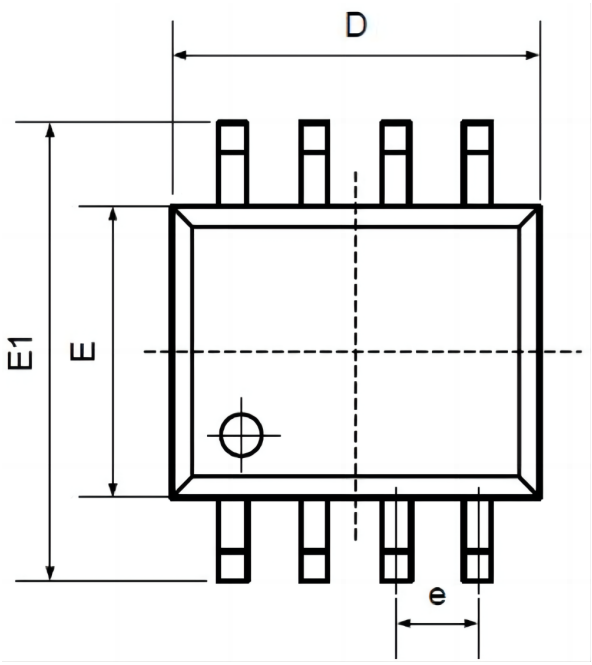


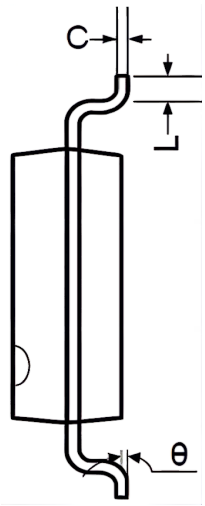
For non-inverting amplifier, IN is amplified by voltage gain decided R1 and R2, and phase is same with IN.
OUT is shown next formula.
OUT= (1+R2/R1) · IN
This circuit realizes high input impedance because Input impedance is operational amplifier's input Impedance.

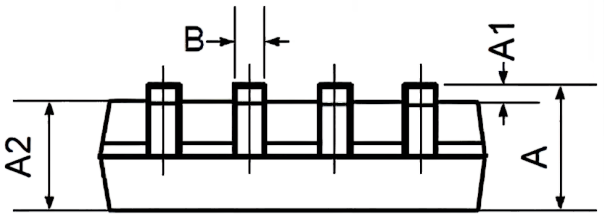
Order information

Order Number	Package	Package Quantity	Marking On The park
BA2904FV-E2-TUDI	TSSOP8	Tape,Reel,2500	BA2904FV-E2
BA2904FVM-TR-TUDI	MSOP8	Tape,Reel,2500	BA2904FVM-TR
BA2904HFVM-CTR-TUDI	MSOP8	Tape,Reel,2500	BA2904HFVM-CTR

Package SOP8

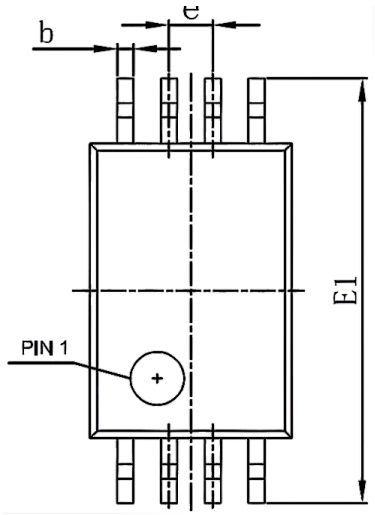


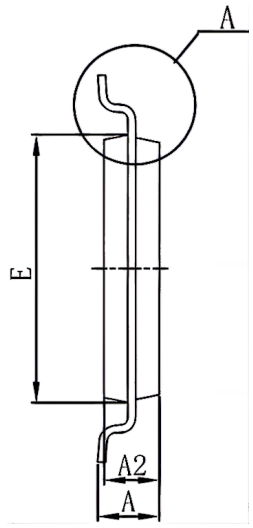


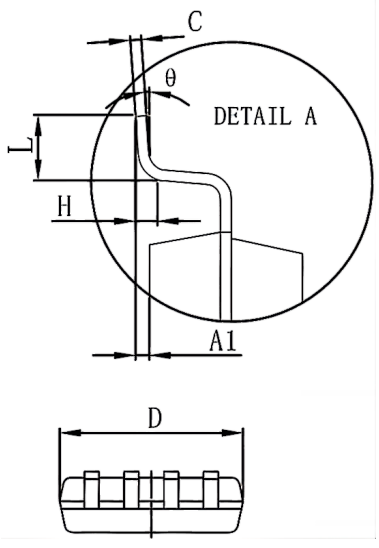


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Package TSSOP8







Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
C	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.200		0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.65(BSC)		0.026(BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°		1°	

Important statement:

●TUDI Semiconductor reserves the right to modify the product manual without prior notice! Before placing an order, customers need to confirm whether the obtained information is the latest version and verify the completeness of the relevant information.

●Any semi-guide product is subject to failure or malfunction under specified conditions. It is the buyer's responsibility to comply with safety standards when using TUDI Semiconductor products for system design and whole machine manufacturing.And take the appropriate safety measures to avoid the potential in the risk of loss of personal injury or loss of property situation!

●TUDI Semiconductor products have not been licensed for life support, military, and aerospace applications,and therefore TUDI Semiconductor is not responsible for any consequences arising from the use of this product in these areas.

●If any or all TUDI Semiconductor products (including technical data, services) described or contained in this document are subject to any applicable local export control laws and regulations, they may not be exported without an export license from the relevant authorities in accordance with such laws.

●The specifications of any and all TUDI Semiconductor products described or contained in this document specify the performance, characteristics, and functionality of said products in their standalone state, but do not guarantee the performance, characteristics, and functionality of said products installed in Customer's products or equipment. In order to verify symptoms and conditions that cannot be evaluated in a standalone device, the Customer should ultimately evaluate and test the device installed in the Customer's product device.

●TUDI Semiconductor documentation is only allowed to be copied without any alteration of the content and with the relevant authorization.TUDI Semiconductor assumes no responsibility or liability for altered documents.

●TUDI Semiconductor is committed to becoming the preferred semiconductor brand for customers, and TUDI Semiconductor will strive to provide customers with better performance and better quallity products.